

Time Series Analysis on Students' Patronage of an Electronic Library: Case Study of John Harris Library (E-Learning Centre) University Of Benin

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Abstract: *The University has unique duty of initiating, innovating, training and supporting scientific research, to shape the society. This is reinforced by the electronic libraries in academic institutions, which fosters students' literacy, ease of study and research.*

This work studies students' patronage of the e-library (E-Learning Centre) in John Harris Library, University of Benin as a function of time and make predictions and recommendations for future occurrences using time series models.

Some models of Time Series were applied and analysed using Zaitun Time Series Software to a 4 year data (2009-2012) retrieved from the E-learning Centre, John Harris Library, University of Benin and forecasts were made based on these analyses.

The results from one of the models; Holt-Winters Exponential Smoothing (Multiplicative), was found to have best described our data having the lowest Mean Squared Error (MSE) of 78521.524167 and predicted a total of 15,952 patronages for year 2013 against the historical data of 23,107 patronages for year 2009; 22,455 patronages for year 2010; 11,707 patronages for year 2011; and 16,814 patronages for year 2012. The forecast reveals a decrease in the patronage of students to the e-library centre. Suggestions were made to the Library management such as increase awareness and incentives for users as well as improvement on service delivery.

Keywords: *Time Series Analysis, Electronic Library, students' patronage*

I. Introduction

Universities are important agents in the development of human resources of any nation. The major role of a university in national development is achieved through their programmes of teaching, learning and research. Aguolu (1993) identified functions of universities inter alia:

- Conservation of knowledge
- Pursuit, promotion and dissemination of knowledge through teaching
- Advancement of knowledge through research, pure and applied and development orientation
- Provision of intellectual leadership.

According to Aliu & Emese (2011) "The university library is at the forefront in the actualisation of these functions through effective, timely and relevant information provision to serve the varied information needs of the community of users". The John Harris Library, University of Benin, Benin City having computerised virtually all its resources and services now has an electronic library to ensure that the ICT train being blazed by the University of Benin making her the best University in Nigeria is consolidated.

John Harris Library has an electronic library (Donald Partridge E-Learning Centre) where the University of Benin community, has an unfettered access to online resources such as e-books, e-journals, databases, internet services etc. that have been subscribed to by the Library Management to meet the information needs of her patrons. It is usually said that the university is as rich in terms of its quality of knowledge delivery as its library resources and services; in other words, the quality of graduates from any university is a reflection of the quality of its library resources. These library resources and services must be well processed, timely, and current; easily made accessible to her users, hence, the electronic library usually referred to as Donald Partridge E-Learning Centre, John Harris Library, was established to meet these needs. Aliu & Emese (2011).

With a student population of about 60,000 for the past five years (2008-2012), University of Benin has been blazing the ICT train making her the best university in Nigeria, University of Benin (2013). According to Ibileke (2012) "the University of Benin (UNIBEN) has emerged the leading university in Nigeria, courtesy of the July 2012 Webometric ranking. UNIBEN has emerged the leading Nigerian university for the second time". This must be consolidated.

The need to know the rate of patronage of the e-library is essential in management decision. Every successful organization or entity must plan for the future. Quite a number of statistical tools are available to facilitate this task. The focus of this work is on statistical methods used in transforming past experiences or events (data) recorded over time to forecast or make predictions for future outcomes. Such previous data are known as *Time Series*. Statistical procedure that uses such data for predictions is called *Time Series Analysis*.

In some situations, the forecast is used as a target value, while in others the forecast is used to suggest control action. For example, a sales forecast may become a target, in that workers will try to achieve sales of at least the forecast value, while forecast of a reduction in the rate of patronage of an electronic library may bring to the fore a challenge that requires the management of the e-library addressing by taking a further study to ascertain the remote cause(s) which will eventually proffer solutions leading to future increase in the patronage of the e-library.

II. Importance Of E-Learning Services In An Academic Institution

According to Eteng & Ntui (2009), "in developing countries, the application of electronic learning (e-learning) in educational system is yet to gain much ground". They defined e-learning as the "application of technology for the enhancement of teaching, learning and research". Students' learning in tertiary institutions all over the world has undergone tremendous transformation, especially since the advent of information and communication technology (ICT). They stressed that there has been a shift from the traditional approach of teacher-directed/didactic to modern methods where computer technology plays a significant role. This has improved the quality and efficiency of learning, educational management and research.

Writing on the importance of electronic library services for academic study and research, Tomescu (2009) said that "

" The option for an analysis of electronic library services for university study and research, has found a double meaning: a theoretical one, driven by the need for theoretical approaches, in the documentary area, in which the information produced changes quality, quantity and structure, with consequences on the management process, but mostly a practical one, given that the library profession have undergone numerous changes and transformations, and the ability required by the new dimensions of services are complex. Electronic services in an information university structure are complementary to the electronic services of the university itself, determined in recent years to rethink its procedures for providing the educational process."

The researchers very much agree with Tomescu (2009) that "the university role is to initiate and innovate, to train and to support scientific research, to shape the society which is reinforced by the library". Electronic services offered by university libraries, becomes the subjects of analysis, which aims at increasing access to the information, education and research opportunities, diversification of initial and continuous training programmes.

The effects of these services reveal the role of the library as a factor of instruction within the educational policies of an academic institution. The emergence of electronic formats reflects the changes taking place in libraries and centers of information and documentation, hence the trend towards the size of electronic services, Tomescu (2009).

The concept of e-library or digital library services refers to collections of electronic resources consisting of text, audio, visual, graphics and animations in nature that are accessible through the aid of digital technologies. Benefits derivable from e-learning services in an academic library are immense and include the following among others:

- Unfettered provision of access to electronic information resources to prospective information seekers
- E-learning services in any library makes research easier for scholars and also ease budgetary constraints associated with the acquisitions of print resources
- Through e-learning services problems associated with preservation are allayed.
- In addition, it is believed that e-learning will help society to make information easily available, raise its quality, and increase its diversity.

III. Statement Of The Problem

Despite the importance of the electronic library to its users, the patronage of the Donald Partridge E-learning Centre since 2008 when it commenced operation has revealed a trend over a period of four years (2009-2012) that cannot be ignored in terms of patronage. Daily, weekly, and monthly poor usage of the centre as seen from the report of the centre has given these researchers cause to worry. They therefore chose to use time series

in the analysis of data collated from the centre in order to forecast students' patronage in the future and make predictions.

IV. Aim Of The Study

The aim of this research is to ascertain the variations/fluctuations in the students' patronage of the electronic library of John Harris Library, University of Benin over the period of 2009-2012. The university has a role to initiate, innovate, train and support scientific research, to shape the society which is reinforced by the electronic library. The importance of electronic library in an academic institution, like the University of Benin, cannot be overemphasized. Having access to relevant and timely information is a necessity for students in the university and as such, the interest in knowing what becomes the future of the e-library in terms of patronage of students is one of the core reasons for this study.

V. Objectives Of The Study

The objectives of this study are to gather knowledge that will be used in forecasting future students' rate of use of the electronic library. This knowledge no doubt will enable the John Harris Library Management of the University of Benin the opportunity to appraise the Donald Partridge E-Learning Centre and also have the awareness on rate of student's patronage at the electronic library thereby helping in making informed decisions that will bring about increase in students' scholarship and performance in their academic pursuit. This eventually will lead to production of academically sound graduates worthy in learning and character that can brace up with the challenges of the 21st century.

It is also envisaged, that such forecasting will enable the university administration plan ahead for the infrastructural development and workforce to accommodate the students as all students of the university uses the electronic library.

VI. Significance Of The Study

The significance of this study cannot be overemphasized as it will among others:

1. examine variations of students' patronage of the electronic library of John Harris Library, University of Benin over the years 2009-2012.
2. investigate the appropriate time series models that could be used in making predictions accurately for this case.
3. forecast future students patronage of Donald Partridge E-learning Centre, John Harris Library, University of Benin.

It is worthy of note that non-time series data such as fluctuating Internet connectivity, energy problem, insufficient computer systems, etc. could not be included in this study. The essence of this study is not to examine *the factors responsible for increase/decrease patronage but to determine using best fit model in predicting a decrease or an increase in the students' patronage of the electronic library*. This will help the management of the electronic library in making informed decisions.

VII. Scope Of The Study

This study looks at students' patronage of the electronic library in John Harris Library, University of Benin, Benin City and applies the statistical technique of 'Time Series' towards forecasting future students' patronage rate. It covers a period of four years (2009-2012) with data collected from the Donald Partridge E-Learning Centre, John Harris Library, University of Benin.

VIII. Methodology

According to Jeong & Seong-Tae, (2010) Time series analysis is a statistical methodology for analyzing time series data in order to extract data characteristics and meaningful information and forecast. Forecasting refers to predicting likely values pertaining to future time points based on a given time series of observations.

It is necessary to remark that several models of time series have been developed to apply model time series data. Notable among these models are the simple moving average, exponential smoothing, trend projection (using least squares) and the Autoregressive Integrated Moving Average (ARIMA) models. However, exponential smoothing has proven through the years to be very useful on many forecasting situations, Hyndman, R. J., Koehler, A.B., Ord, K. J. & Snyder R.D. (2008). Against above background, the exponential smoothing and trend projection methodology will therefore be applied to students' e-library patronage historical data (2009-2012). This analysis will be carried out using Zaitun Time Series Software.

The basic goal when analyzing time series is to produce forecast of some future value of a variable, it is imperative that its predictive accuracy be determined. Usually, accuracy examines how well the model reproduces the already known data.

Time series forecasting assumes that a time series is a combination of a pattern and some random error. The goal is to separate the pattern from the error by understanding the pattern's trend, its long term increase or decrease and its seasonality, the change caused by seasonal factors such as fluctuations in use and demand Kalekar (2004).

IX. Literature Review

Falk, (2012) defined time series as “a sequence of observations that are arranged according to the time of their outcome”. For example, meteorology records hourly wind speeds, daily maximum and minimum temperatures and annual rainfall; Geophysics is continuously observing the shaking or trembling of the earth in order to predict possible incidence of imminent earthquakes; the social sciences survey annual death and birth rates, the number of accidents in the home and various forms of criminal activities; all with a view to proffering solutions to yet unforeseen future challenges.

Additional reasons were given why it is important to record and to analyse the data of a time series. Among the reasons given, is to gain a better understanding of the data generating mechanism, the prediction of future values or the optimal control of a system. Falk et al (2012) buttressed the fact that characteristic property of a time series are not generated independently, their dispersion varies in time, they are often governed by a trend and they have cyclic components. Statistical procedures that support independent and identically distributed data are, therefore, excluded from the analysis of time series. This they said requires proper methods that are summarized under time series analysis.

What each of these examples has in common is that some variable was observed at regular, known intervals over a certain length of time. Thus, the form of the data for a typical time series is a single sequence or list of observations representing measurements taken at regular intervals.

“Time series arise whenever something is observed over time: A graph of a time series often exhibits patterns, such as an upward or downward movement (trend) or a pattern that repeats (seasonal variation), that might be used to forecast future values”. Hyndman et al (2008) said that a time series may be observed either continuously or at discrete times.

X. Measure Of Forecasting Accuracy

An accuracy measure is often defined in terms of forecasting error, which is the difference of the actual and the predicted values of the series (ϵ_i). The forecasting accuracy measurement employed in this study is the

Mean Squared Error (MSE) which is given as: $MSE = \frac{\sum_{i=1}^n \epsilon_i^2}{n}$ where n is the number of forecast values for the series. The best forecast model is the model that minimizes the MSE, that is, the one with the least MSE.

Six time series models were used in forecasting the 2013 students' e-library patronage.

Table 1: Time series models and their corresponding Mean Squared Errors

S/N	TIME SERIES MODELS	MEAN SQUARED ERROR (MSE)
1	Linear Trend Analysis	327911.252770
2	Quadratic Trend Analysis	326125.682669
3	Single Exponential Smoothing	205264.771031
4	Holt Linear (Double) Exponential Smoothing	238261.640445
5	Holt-Winters Exponential Smoothing (Multiplicative)	78521.524167
6	Holt-Winters' Exponential Smoothing (Additive)	122280.806926

Data Collection

The students e-library patronage monthly data used in this study are cumulative record obtained from the John Harris E-library (E-learning Centre), University of Benin, Benin City over the period of 2009-2012. The data obtained are unpublished records of the e-library users, assuming that all users are students of the university.

Table 2: UNIBEN STUDENTS' E-LIBRARY PATRONAGE (2009 – 2012)

UNIBEN STUDENTS' E-LIBRARY PATRONAGE (2009 – 2012)				
MONTHS	YEARS			
	2009	2010	2011	2012
JAN	609	1456	757	1141
FEB	1168	1958	1221	1403
MAR	1993	1934	1130	1398
APR	2101	2212	915	1040
MAY	2056	2032	931	517
JUN	2268	1718	935	469
JUL	2244	1571	1075	270
AUG	2222	1895	1872	1155
SEP	2671	2153	2987	1722
OCT	2417	1943	2080	1542
NOV	2000	1853	1771	1050
DEC	1358	1730	1140	940

Source: Donald Partridge E-learning Centre, John Harris Library, UNIBEN.

XI. Analysis Of Data

The underlisted time series analysis and forecast on the data of students' patronage of the e-library will be carried out using Zaitun time series software applications. They are time plot, Linear Trend Analysis, Quadratic Trend Analysis, Simple (Single) Exponential Smoothing, Holts Linear (Double) Exponential Smoothing Method, Holts-Winters (Triple) Exponential Smoothing Method (Multiplicative and Additive Seasonal Model).

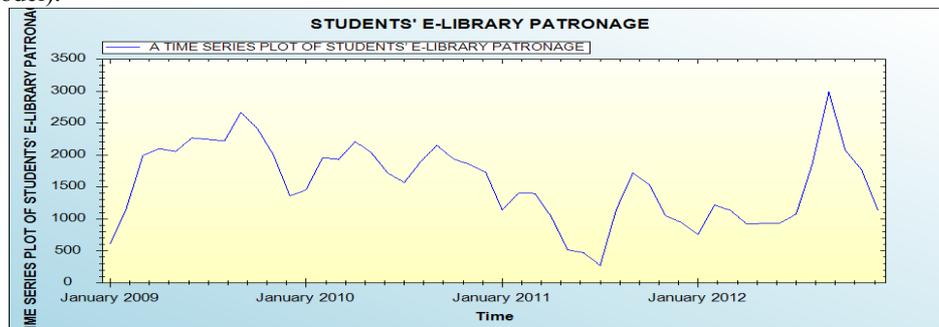


Figure 1: Time series plot of Students' E-Library patronage.

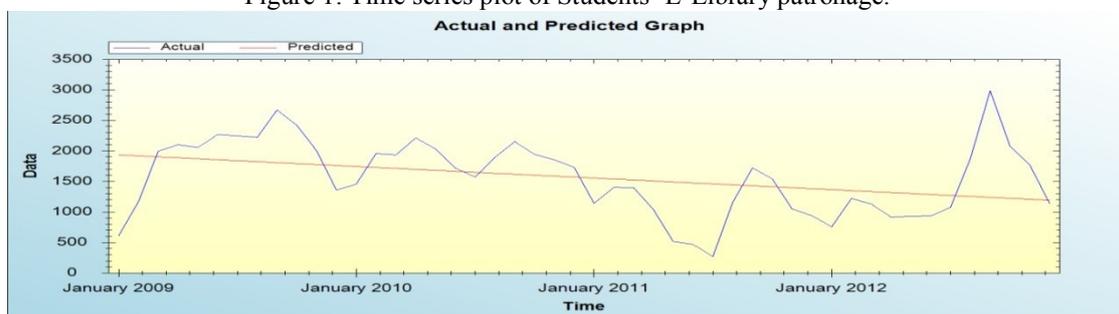


Figure 2: Actual and predicted graph of linear trend analysis

Table 3: Model Forecast for 2013

MONTHS	MODELS FORECAST FOR 2013					
	LINEAR TREND	QUADRATIC TREND	SIMPLE E.S.	HOLT'S-LINEAR E.S.	HOLT'S WINTERS E.S (MUL)	HOLT'S WINTERS E.S (ADD)
JAN	1175.92	1395.45	1206.98	1183.74	695.067	807.184
FEB	1160.13	1406.54	1206.98	1155.86	1147.56	1175.71
MAR	1144.33	1418.69	1206.98	1127.99	1335.51	1298.17
APR	1128.53	1431.93	1206.98	1100.11	1301.42	1247.52
MAY	1112.73	1446.23	1206.98	877.109	1131.02	1135.85
JUN	1096.93	1461.62	1206.98	1044.36	1106.99	1080.69

JUL	1081.14	1478.08	1206.98	1016.48	1062.05	1044.41
AUG	1065.34	1495.61	1206.98	988.61	1570.67	1528.12
SEPT	1049.54	1514.22	1206.98	960.734	1126.53	2090.13
OCT	1033.74	1533.91	1206.98	932.859	1804.8	1740.71
NOV	1017.94	1554.67	1206.98	904.984	1490.59	1462.34
DEC	1002.15	1576.5	1206.98	1072.23	2180.26	1101.33

Table 4: Historical Data 2009-2012 with Forecast Year 2013

MONTHS	HISTORICAL DATA				FORECAST YEAR 2013
	YEAR 2009	YEAR 2010	YEAR 2011	YEAR 2012	
JAN	609	1456	757	1141	695.067
FEB	1168	1958	1221	1403	1147.56
MAR	1993	1934	1130	1398	1335.51
APR	2101	2212	915	1040	1301.42
MAY	2056	2032	931	517	1131.02
JUN	2268	1718	935	469	1106.99
JUL	2244	1571	1075	270	1062.05
AUG	2222	1895	1872	1155	1570.67
SEP	2671	2153	2987	1722	1126.53
OCT	2417	1943	2080	1542	1804.80
NOV	2000	1853	1771	1050	1490.59
DEC	1358	1730	1140	940	2180.26

XII. Discussion Of Results

Based on the analysis of the monthly students' e-library patronage in John Harris Library, University of Benin using Zaitun time series analysis software; the followings were noted:

- The time series plot (Figure 1) exhibits a stochastic fairly stable downward linear trend of e-library patronage.
- In the linear trend analysis, $Y_t = 1950 - 15.798*t$ shows that there is a negative relationship between time and students' e-library patronage in John Harris Library, University of Benin, having a slope of -15.798. This explains that to every 100% increase in time, there is a 15.798% decrease in students' e-library patronage. The correlation coefficient ($R = -0.363680$) shows that there is a weak negative relationship between the variables (time and e-library patronage). Also, the actual and predicted graph in Figure 2 shows a straight line decrease in students' e-library patronage.
- The quadratic trend analysis indicates a weak negative relationship between the variables of students' e-library patronage and time ($R = -0.394651$) and 15.58% of the total variations in students' e-library patronage is explained by this model. The predicted line of the actual and predicted graph showed a curve linear decrease in students' e-library patronage.
- In the exponential smoothing analysis, variations levels of smoothing constants were tested for each of the models. This was done in order to select the most suitable smoothing parameter(s) that yield(s) the minimum mean square error (MSE) of the models. Zaitun time series provides a platform that conveniently handles this.
 1. For the simple (single) exponential smoothing, 0.9 emerged the best weight for α smoothing constant having the minimum mean square error (MSE) of 205264.15408
 2. For the Holt's Linear (Double) exponential smoothing, 0.9 and 0.1 smoothing weights emerged the best for α and β smoothing constants respectively with mean square error (MSE) of 238261.64045.
 3. For the Holt-Winters' (Triple) exponential smoothing, 0.9, 0.1, and 0.1 smoothing weights emerged the best for α , β and γ smoothing constants respectively yielding minimum mean square error for both the additive and multiplicative models.

In comparing the forecast results obtained in the single, double, Triple (additive) and triple (multiplicative) exponential smoothing models for January 2013 to December 2013, the following were observed as seen in table 3;

- i. The simple exponential smoothing (single) showed a constant rate of students' patronage 1206.98 i.e. 1207 patronages per month with a total of 14,483.73 patronages forecast for the year.

- ii. The Holt's Linear Exponential smoothing (double) forecast a high patronage of the electronic library by the students from January to April with the lowest patronage forecast. It also shows that the e-library will experience a total patronage of 12,365 in the year 2013.
- iii. The Holt-Winter's (triple) exponential smoothing (multiplicative models) showed forecasts for the year 2013 will be lowest in January (695 patronages) and highest in December (2,180 patronages) and a total of 15,952 students' patronages for the year, see Table 3 above.
- iv. Lastly, the additive model of the Holt-Winters (triple) Exponential Smoothing forecast that e-library patronages will rise as high as 2,090 patronages in September, 2013 and as low as 807 patronages in January with a total of 15,712 e-library patronages for the year 2013.

XIII. Findings

The following were revealed in this work:

- a. A total of 75,023 patronages were recorded under the period spanning 2009 – 2012.
- b. An average of 1,562 students' patronage was recorded monthly from January 2009 to December 2012.
- c. The students' patronage could be as low as 270 (July 2012) during off session period, that is during students holidays and could be as high as 2,987 (September 2011) when the university is fully in session. See table 4 above
- d. That the Holt-Winters Exponential Smoothing (Multiplicative) predicted with greater accuracy the total number of students' e-library patronage yearly in John Harris Library (E-learning Centre) having the smallest Mean Square Error (table 1) with an average of 1,329 patronages per month see table 3.
- e. The minimum forecast of students' e-library patronage for year 2013 was 695 patronages (January, Holt-Winters' Multiplicative model) while the maximum was 2,180 patronages (December, Holt-Winters' Multiplicative model). See table 3 above

XIV. Best Forecast Model For Students' E-Library Patronage Data

In this study, some time series models were applied to the analysis of students' e-library patronage data under two broad categories: trend analysis and exponential smoothing. Each of these models generated different monthly students' e-library patronage. The model accuracy analysis showed that the Holt-Winters Exponential Smoothing (Multiplicative) model forecast more accurately with a total of 15,952 patronages for year 2013 and a monthly average patronage of 1329, (Table 3).

XV. Conclusion

The purpose for setting up the John Harris Library (E-Learning Centre) also known as Donald Partridge E-learning Centre by the Donor - British-Nigeria Education Trust (B-NET) - among other things were to engender scholarship, making research simple, by providing easy access to e-resources that are affordable to students of the University of Benin. To encourage learning by providing open access to high-demand or restricted materials for multiple concurrent users, having unrestricted right to use current e-books and subscribed online journals. These are provided at a very subsidized cost to the students and as such increase patronage is to be expected.

In this work, time series analysis as a tool for looking into the future of students' e-library patronage in John Harris Library, University of Benin, was used. Some time series models were applied and analysed using Zaitun Time Series Software to a 4-year historical data (2009-2012) retrieved from the Donald Partridge E-learning Centre, and forecasts made based on these analyses.

One of the models; Holt-Winters Exponential Smoothing (Multiplicative), was found to have best described our data. The model predicted a total of 15,952 patronages recorded in year 2013. This represents a decrease in the students' e-library patronage.

This study has predicted a decrease in students' patronage of the e-library. The management of the e-library can now carry out an in-depth analysis of the remote causes for this low patronage and nip it in the bud. As the main focus of this study is to predict, vista for further investigation is thus opened and a platform built for researchers to ascertain the cause(s) of low patronage in subsequent research endeavours.

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