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Time Series Analysis: A Sine-Qua-Non-Relevance to Students Patronage of an Electronic Library

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Abstract
Purpose: *This paper examined the disturbing trend of student's poor/low usage of Donald Patridge E-learning Center which has been observed over a period of four years with a view to correcting the situation using time series in the analysis of data that will be collected.*
Design/Methodology/Approach*: Time series analysis is a methodology for analyzing time series data in order to extract data characteristics and meaningful information. A foremost methodology that will be employed is forecasting which will be based on series of observed trends. To achieve meaningful result established models such as simple moving average, exponential smoothing, trend projection and the Autoregressive integrated moving Average (ARIMA) models are employed.*
Findings: *The research efforts revealed the following among others: (a) A total of 75023 patronages were recorded under the period spanning 2009 – 2012 (a) An average of 1562 student's patronage was recorded monthly from January 2009 – December 2012., (c) The minimum forecast of students' e-library patronage for 2013 was 695 patronages (January, Holt-Winters' Multiplicative model) while the maximum was 2180 patronages (December, Holt-Winters Multiplicative model) crashes.*
Practical Implications: *The application of some time series models to the analysis of students' e-library patronage data through trend analysis and exponential smoothing forecast yielded accurately with a total of 12176 patronages for year 2013 and a monthly average patronage of 1014. The implication of this development is to advice management of John Harris Library for an increased awareness advocacy especially during the orientation of new students admitted into the University, alongside improved service delivery, and enhanced internet connectivity and other incentives.*
Originality/Value *This paper by its focus on the John Harris library students patronage of the e-library services is original and should serve as a bench mark for other university libraries to monitor the usage of their libraries through the instrument of 'Time series analysis' so that the financial investment in the library project will not be a waste.*
Paper type: *Empirical*
Keyword*: Time series analysis, e-library, patronage, Exponential Trend Analysis*

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 and Emese (2011) "The university library is at the forefront in the actualization 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 computerized 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.

According to the result of *2012 Webometric ranking of Top 100 African Varsities,* University of Benin was placed first among other Nigerian universities. *University of Benin Newsletter Online* (2012) states that "the news did not quite come as a surprise to the management of the institution considering her huge and consistent investments as well as pioneering strides in ICT amongst other

Universities in the country. The recent results show a sharp improvement in the institutions rating over the past years, not only is UniBen ranked 1st in Nigeria, she also came 22nd in Africa, a position never held by any Nigerian University. Ibileke (2012) also said that "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. However, this success recorded in 2012 has been relegated to the background of poor performance and the University Authority is doing its best to find its feet once more.

According to Tenopir, Hitchcock and Pillow (2003) "Libraries of all sizes and types are embracing digital collections, however, because of our peculiar energy challenges most libraries will continue to offer both print and digital collections for many years to come. That perhaps account for reasons why purchases of journals, magazines, abstracting and indexing services are heavily weighted toward digital, while digital books (e-books) are only beginning to have a presence in library collections. Library users who do not have Internet access at home or at work use the library more than others to attend literacy classes and for children's schoolwork. Significantly therefore, more people who have access to both the Internet and the library use the Internet to do research for school" John Harris Library has an electronic library (Donald Partridge E-Learning Centre) Complimented by MTN foundation library 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 richness of its library resources. These library resources and services must be well processed, 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).

Brief History of Donald Partridge E-Learning Centre

It is worthy of note that the Donald Partridge E-Learning Centre as the electronic library of John Harris Library, University of Benin was set up by the Donor - Britain-Nigeria Educational Trust - to assist the University of Benin students (undergraduates and postgraduates) as well as members of staff of the university in their research and scholarly work by having access to electronic resources, electronic references, full text data access, Web resources, that are integral part of university education.

University of Benin provides the personnel for the center and pays the bandwidths after one year of operation. It also undertakes the day-to-day running of the electronic library through the University library Management. The center is headed by a System administrator. The Donald Partridge E-Learning Centre adds value to the role of the University Library as a key factor in e-learning delivery bringing about both traditional and electronic resources for all its users.

It is germane to remark that the E-Learning Centre of the John Harris Library is one of the sources of the University's Internally Generated Revenue (IGR). It has raked in millions of Naira to the university coffers since inception; and as such, increased patronage of the center will be highly encouraged by the university authority to ensure the continuity of the center. The mission/objective of MTN foundation library is not far-fetched from goals of the Donald Patridge e-learning center both collaborating to entrench academic excellence through Information Technology.

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.

Libraries prefer digital collections for many reasons, including, but not limited to, the following:

- Digital journals can be linked from and to indexing and abstracting databases;
- Access can be from the user's home, office, or dormitory whether or not the physical library is open;
- The library can get usage of statistics that are not available for print collections and
- Digital collections save space and are relatively easy to maintain. When total processing and space costs are taken into account, electronic collections may also result in some overall reductions in library costs (Montgomery and

King 2002).

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 programs.

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).

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, 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 center as seen from the report of the center and hence the researchers intend to use time series in the analysis of data in order to forecast students patronage in the future, make predictions based on this data.

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 Hams Library, University of Benin over the period of 2009-2012. The figures from the collected historical data will be analyzed for consistency of fluctuations and reasons for the behavior will be identified. 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 of the future of the e-library in terms of student's patronage is of a sine-qua-non relevance in this study.

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, appraise the Donald Partridge E-Learning Center and take steps in curbing the factors responsible for the low rate of patronage or improve upon the factors responsible for increased rate of patronage of students at the electronic library thereby increasing students' scholarship and performance leading to production of academically sound graduates worthy in learning and in character that can brace up with the challenges of the 21st century.

Significance of the Study

Based on the above, the study intends to:

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 each future students' patronage of Donald Partridge E-learning Centre, John Harris Library, University of Benin.

It is worth noting that non-time series data such as fluctuating Internet connectivity, energy problem, insufficient computer systems, etc. could not be included in this study.

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.

Methodology

According to Jeong & Kim, (2010) Time series analysis is a statistical methodology for analyzing time series data in order to extract data characteristics and meaningful information. A time series is a sequence of observations indexed by time, usually ordered in equally spaced intervals and

correlated Kumar, (2014). He emphasized that the most interesting and ambitious task in time series analysis is to forecast future values. As a follow-up forecasting refers to predicting likely values pertaining to future time points based on a given times series of observations. In most modern day business and even non-business transactions the importance of forecasting in all human endeavors cannot be overemphasized. That is why in some situations, the forecast is used as a target value, while in others the forecast are 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 lead to finding out the possible causes of poor patronage of such an electronic library in order to proffer solutions leading to future improvement. To this extent therefore, models abound that are community fitted meant to predict future values of a time series.

From above background, 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. Exponential Smoothing methods are the most widely used forecasting methods which arose in 1950s from the original work of Brown 1959 and Holt 1957) who were working on creating forecasting models for inventory control system. Exponential Smoothing is an intuitive forecasting method that weights the time series unequally. Kumar, et al (2014) opined that recent observations are more heavily weighted than remote observations; emphasizing that the unequal weighting is accomplished by using one or more smoothing parameters, which therefore determines how much weight is given to each observation. Exponential smoothing has therefore proven through the years to be very useful on many forecasting situations of this nature of work under study, essentially because it is based on the premise that the level of time series should fluctuate about a constant level or change slowly over time, Ostertagova and Ostertag (2012).

Against above background, the exponential smoothing and trend projection methodologies will therefore be applied to students' e-library patronage historical data (2009-2012). This analysis will be carried out using 'Zaitun Time Series Software'. This is so because most of the inadequacies of other time series software are handled in this software.

Literature Review

Falk et al (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 is said to require 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.

Measure of Forecasting Accuracy

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. An accuracy measure is often defined in terms of the forecasting error, which is the difference statistical package

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). Seven time series models will be used in forecasting the 2013 students' e-library patronage and the one with the least Mean Square Error (MSE) will give the perfect model and will be accepted.

Model Accuracy Test: Comparism of Mean Square Errors (MSE)

S/N	TIME SERIES MODESL	MEAN SQUARE ERROR (MSE)
1	Linear Trend Analysis	327911.252770
2	Quadratic Trend Analysis	326125.682669
3	Exponential Trend Analysis	0.040719
4	Single Exponential Smoothing	205264.771031
5	Holt Linear (Double) Exponential Smoothing	238261.640445
6	Holt-Winters Exponential Smoothing (Multiplicative)	78521.524167
7	Holt-Winters' Exponential Smoothing (Additive)	122280.806926

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

Analysis of Data

The students e-library patronage 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.

The under listed 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. There are time plot, trend and exponential smoothing. It will also include: Simple (Single) Exponential Smoothing Method; Holts Linear (Double) Exponential Smoothing Method; Holts-Winters (Triple) Exponential Smoothing Method (Multiplicative Seasonal Model) and Holts-Winters (Triple) Exponential Smoothing Method (Addictive Seasonal Model).

UNIBEN Students' E-library Patronage (2009 – 2012)

MONTHS	YEAR			
	2009	**2010**	**2011**	**2012**
JAN	609	1456	757	1141
FEB	1168	1958	1221	1403
MAR	1993	1934	1130	1398
APR	2101	22_12	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	1S42
NOV	2000	1853	1771	1050
DEC	1 358	1 730	1 140	Q4D
TOTAL	23107	22455	16814	11707

Table 2 Source: Donald Partridge E-learning Centre, John Harris Library, UNIBEN.

MONTHS	LINEAR TREND	QUADRATIC TREND	EXPONENTIAL TREND	SIMPLE E.S.	HOLTS LINEAR E.S.	HOLTS WINTERS E.S. (MUL)	HOLTS WINTERS E.S. (ADD
JAN	1175.92	1395.45	1078.45	1206.98	1183.74	695.067	807.184
KEB	1160.13	1406.54	1066.42	1206.98	1155.86	1147.56	1175.71
MAR	1144.33	1418.69	1054.53	1206.98	1127.99	1335.51	1298.17
APR	1128.53	1431.93	1042.77	1206.98	1100.11	1301.42	1247.52
MAY	1112.73	1446.23	1031.15	1206.98	877.109	1131.02	1135.85
JUN	1096,93	1461.62	1019.65	1206.98	1044.36	1106.99	1080.69
JUL	1081.14	1478.08	1008.28	1206.98	1016. .48	1062.05	1044.41
AUG	1065.34	1495.61	997.038	1206.98	988.61	1570.67	1528.12
SEPT	1049.54	1514.22	985.921	1206.98	960.734	1126.53	2090.13
OCT	1033.74	1533.91	974.928	1206.98	932. S59	1804.8	1740.71
NOV	1017.94	1554,67	964. 058	1206.98	904.984	1490.59	1462.34
DEC	1002.15	1576.5	953.309	1206.98	1072.23	2180.26	1101.33
TOTAL	13,068,42	17,713.45	12,176.50	14,483.76	11,348.59	15,952.47	15,712.16

NOTE:
E.S.: EXPONENTIAL SMOOTHING
MUL: MULTIPLICATIVE
ADD.: ADDITIVE
Table 3: All Models Forecast for 2013 (Best Model in Bold Face)

UNIBEN students' E-library Patronage (2009 - 2012) with Forecast Year 2013

	HISTORICAL DATA				FORECAST
MONTHS	**YEAR 2009**	**YEAR 2010**	**YEAR 2011**	**YEAR 20 12**	**YEAR 2013**
JAN	609	1456	1141	757	1078.445
FEB	1168	1958	1403	1221	1066.4206
MAR	1993	1934	1398	1130	1054.5302
APR	2101	2212	1040	915	1042.7724
MAY	2056	2032	517	931	1031.1457
JUN	2268	1718	469	935	953.3087
JUL	2244	1571	270	1075	1008.2798
AUG	2222	1895	1155	1872	997.0376
SEP	2671	2153	1722	2987	985.9209

OCT	2417	1943	1542	2080	974,928
NOV	2000	1853	1050	1771	964.0578
DEC	1358	1730	940	1140	1019.6486
TOTAL	23107	22455	11707	16814	12176

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

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:

- 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 0.36676. This explains that to every 36.6% increase in time, there is a 100% decrease in students' e-library patronage.

The correlation coefficient (R=0.394651) shows that there is a fair positive relationship between the variables. The R-Squared (0.155750) depicts that 15.5% of the total variations in students' e-library patronage is explained by the time series model. Also, the actual and predicted graph shows a straight line decrease in the predicted line of the graph.

- The quadratic trend analysis indicates a weak positive relationship between the variables of students' e-library patronage and time (R=0.394651) and also that 15.5% of the total variations in students' e-library patronage is explained by this model. The predicted line of the actual and predicted graph also shows a curve linear decrease with respect to time.
- In the exponential trend analysis, the model summary indicates a weak positive relationship between time and students' e-library patronage in John Harris Library (E-Learning Centre) (R= 0.323168) with 10.4% of the total variation in students' e-library patronage explained by the model. The predicted line shows a decrease in students' e-library patronage over the period.

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 yields 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 *a* 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 *a* and 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 7 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;

1. The simple exponential smoothing (single) showed a constant rate of students' patronage 1206.98 i.e. 1207 patronages per month with a total of 14483.73 patronages forecast for the year.
2. 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 12365 in the year 2013.
3. The Holt-Winter's (triple) exponential smoothing (additive models) showed forecasts for the year 2013 will be lowest in January (695 patronages) and highest in December (2180 patronages) and a total of 15Q52 students' patronages for the year.
4. Lastly, the multiplicative model of the Holt-Winters (triple) Exponential Smoothing forecast that e-library patronages will rise as high as 2090 patronages in September, 2013 and as low as 807 patronages in January with a total of 15712 e-library patronages for the year 2013.

Findings

The following were revealed in this work;

a) A total of 75023 patronages were recorded under the period spanning 2009 – 2012.
b) An average of 1562 students' patronage was recorded monthly from January 2009 to December 2012.
c) The students' patronage could be as low as 270 (July 2011) during off peak period, that is during students holidays and could be as high as 2987 (September 2012) when the university is fully in session.
d) That the Exponential Trend Analysis 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 with an average of 1014 patronages per month.

e) The minimum forecast of students' e-library patronage for year 2013 was 695 patronages (January, Holt-Winters' Multiplicative model) while the maximum was 2180 patronages (December, Holt-Winters' Multiplicative model) crashes.

Each of these models generated different monthly Students' E-Library Patronage forecasts for year 2013 (forecast year). In order to select the best model forecasts, the model with the least Mean Square Error (the Exponential Trend Analysis) was chosen.

Best Forecast Model of 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 exponential trend analysis model forecast more accurately with a total of 12,176 patronages for year 2013 and a monthly average patronage of 1014. (Table 1)

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, some time series models were applied and analyzed 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; exponential trend analysis, was found to have best described our data. The model predicted a total of 12,176 patronages recorded in year 2013. This represents a decrease in the students' e-library patronage.

We therefore, advice an increased awareness advocacy, especially during the orientation of new in-take of students into the university; better service delivery such as non-fluctuation of internet connectivity and other incentives, like reducing the cost of printing be implemented. Service delivery should be improved upon by the John Harris Library Management to encourage the users so that the reasons for setting up the E-Library Centre could be actualized and realized.

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