

Analysis and Forecasting of University Student Population Using Autoregressive Integrated Moving Average Model

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ABSTRACT

Population projections are essential in the management of learning institutions. Policies adopted by University administrations derive their basis from population trends. Majority of decision like introduction of programs and infrastructural decisions are easily made with the aid of population forecasts. With the increasing demand for higher education currently being experienced in Kenya, vast number of students are being enrolled into tertiary education systems including universities, colleges and polytechnics. Student population is proving to be a vital issue in institutions of higher learning. In this research the student population of University of Kabianga from the year 2009 to 2013 was modeled using Box-Jenkins Autoregressive Intergrated Moving Average Model technique. The student population was further forecasted to the year 2023 using ARIMA (1, 2, 0) model. The model was validated using various tests among them: Akaike Information Criterion (AIC), graphical techniques like time series plots, Schwarz Bayesian Criterion (SBC) and p-values. Results indicate that the student population will grow to 32,421 by the year 2023 when only time is considered as a factor. The results further depict a positive steady increase of student population for University of Kabianga over the next ten years. The study also explores briefly the resources in terms of capacity and space available to support current and forecasted population.

Key Words: Population, Forecasting, Autoregressive Integrated Moving Average, Model

1.0 INTRODUCTION

The census conducted by Kenya National Bureau of Statistics (KNBS) in 2009 revealed that Kenya had a population of 38.6 million; by 2012 the country's population had reached 43 million with a population growth rate of 3% (KNBS, 2010). According to an article released by the Ministry of Devolution and Planning in 2011, if the country was to achieve vision 2030, managing the rising population ought to be the main focus of all institutions nationwide. The ministry also added that this increase in population is accompanied by increasing number of fairly learned and hardworking individuals. The Kenyan government is committed to promoting educated and well trained youth in a bid to encourage self-employment for the population which entails; the establishment of more learning institutions and expansion of already existing ones to accommodate the growing population. Free primary education and issuance of student loans and bursaries to needy students are among the many policies adopted by the government in a bid to promote education in the country. Numerous tertiary institutions have been established in the country to cater for the increasing demand in post-secondary education. University of Kabianga is one among many learning institutions that have risen to the occasion to absorb as many students as possible yearly through gradual expansion of its facilities. The student population has since grown to 9,949 in the year 2013 and if the current trend continues then it is highly likely that the university is headed for a vast demographic change in the near future. Population trends are of great significance for an institutions planning and formulation of policies. Depending on the past and current trends, an organization may need to make adjustments to its long-term strategies to cater for future occurrences (Gatacha, 2012). Rapid increase in population is proving to be problematic, especially if institutions resources are limited. Organizations risk facing resource shortages which may have adverse effects on its operations. Precautionary measures ought to be taken to plan for resource use and allocation. In the 2009 census carried out in Kenya by KNBS, 198,119 students were recorded as being in the university and 1.7 million more at secondary school level this meant that population in tertiary institutions would most likely rapidly increase in the near future if those in secondary schools had any prospects of furthering their education (KNBS, 2010). Lack of preparedness in learning institutions may result in shortage of resources when these students join campus. The general objective of this study was to forecast the population of University of Kabianga using Autoregressive Integrated Moving Average model to the year 2023 to be accomplished through realization of the following specific objectives.

- i. To fit an ARIMA model to the data on student enrollment in University of Kabianga.
- ii. To analyze the population growth pattern of University of Kabianga.
- iii. Explore the significance of population forecasts to institutions.

2.0 LITERATURE REVIEW

2.1 Status of Higher Education in Kenya

Kenya has experienced rapid expansion in the higher education sector. From the time the country gained independence in 1963 to 1984 when 7-4-2-3 education system was adopted, it entailed seven years of primary education, four of lower secondary education, two years of upper secondary and finally years of University (Buchmann, 1999). During this period there was one university in the country with a student population of 7,624 (CHE, 2008). This number increased to six by 1990 when the education system changed to 8-4-4 to provide eight years of primary, four years of secondary school and four of university with total student population of 11,110, which had again increased to thirty with total population of 145,000 students in the year 2008. This system of education bears major similarities to that of the British though the government of Kenya is bent on developing an education model that will best address economic and social need of citizens in the country. The country currently enrolled 6300 student in the year 2013 alone. Very little has been done in forecasting of population in institutions of higher learning though from the upward change in enrollment and population figures, it is clear that this population is likely to rapid increase in the future.

2.1.1 Commission for Higher Education in Kenya

The Commission for Higher Education (CHE), is a body corporate created by an Act of Parliament, Universities Act Cap 210B in 1985 (CHE, 2008). It was mainly created to address the hurdles associated with rapid increase in student population and other national education needs. CHE is mandated with the responsibility of making policies and provisions that improves the quality of higher education in the country. The commission has four major functions: Assurance, control, assessment, and audit which are combined to provide quality assurance in higher education. In order to ensure quality assurance, CHE developed two set of rules: The Universities (Establishment of Universities, Standardization, Accreditation and Supervision) Rules 1989; and the Universities (Coordination of Post Secondary School Institutions for University Education) Rules 2004. The university rules stipulate that a sponsor of a university is required to have academic resources including land, physical facilities, finances, staff, library services and equipment (CHE, 2013). In addition to this, universities are required to have at least ten years infrastructural plan and adequate resources to support the existing student population; these include but are not limited to land, water and tuition space which are subject to audit to ensure the physical resources are in conformity with the commissions guidelines (CHE, 2013).

2.1.2 Growth of University of Kabianga

University of Kabianga is one of the public universities in Kenya that has joined in the quest to provide quality higher education in the country. Before 2013 it was known as Kabianga University College, a constituent college of Moi University. Having met all provisions and university requirements of CHE as well as international standards, Kabianga University College was finally awarded a charter in June 2013 to become a fully-fledged public university with five Schools; Education and Social Sciences; Business Studies and Economics; Agriculture and Biotechnology; Natural Resource Management; and Science and Technology. Training in the university is offered at Certificate, Diploma, Bachelor's degree, Master's degree and doctorate levels.

2.2 Population forecasting versus Population projection

Population forecasting entails estimation of the most probable future population size tendencies alongside certain demographic indicators including the distribution of population by gender and age. It requires in depth understanding of the roles played by determinants of population growth as well as calculating future variations of such determinants using a suitable method (Gale encyclopedia of public health, 2002). There are a wide range of methods that can be used to forecast population including a simple curve extrapolation which extends trends to project the future or even more complex models that are more suited in instances where there are multiple variables to be examined. The cohort-component method which is preferred by most analysts is used to compute future population paths while considering the assumptions about future tendencies for mortality, fertility and migration rates (World Population prospects, 1999). On the other hand, projections "are calculations of future conditions that would exist as a result of adopting a set of underlying assumptions" Though the terms forecast and projection are frequently used as synonyms they somewhat differ in meaning. A number of projections can be used to forecast population. A forecast is therefore referred to as a medium variant projection which is the most probable future course or path, less likely lower and higher trajectories act as a guide for evaluating uncertainties surrounding the identified trend.

2.3 Forecasting Assumptions

Population forecasting is done whilst considering a number of assumptions. Walonick (1993) stated the following as the major assumptions made when forecasting population:

1. Forecasts are subject to a degree of uncertainty which only clears once the forecast has passed. This means that whatever methodology is applied one can never state with absolute certainty what is expected of the future.
2. Factors such as technological advancements affect population growth though they cannot be forecasted. Such elements in population forecasting are known as blind spots and are not easily accounted for.
3. Forecasts made enable policymakers formulate social policy which when effected have a tendency of changing the accuracy of forecasted information.

2.4 Significance of population forecasting

According to the Gale encyclopedia of health (2002), information from population forecasts play a vital role in planning, decision making and policy formulation. Various individuals and institutions depend on future population forecasts to make final and fundamental decisions. They include scientists, policymakers and planners both in privately owned industries and also in the public sector for instance the government. The needs of various users of population projections can only be addressed by estimation and forecasting of population. Every country in the continent has a bureau that is entrusted with the responsibility to provide projections to potential users (e.g., the Kenya National Bureau of Statistics in Kenya) which is why national census is carried out worldwide and on a regular basis. On a much larger scale the United Nations and the World Bank provide national and global projections for all countries (Gale encyclopedia of public health, 2002). Population forecasts thus have a major impact on government planning and the formulation of labor policies, this is according to a research carried out by Gatacha in 2011.

2.4.1 Population Forecasts in Planning

Future demand for human necessities like food, water and energy can be estimated with the aid of national and global demographic trends. Planners in the areas of housing, transportation, land use, environmental conservation and those working in developing areas require population projections. The state requires this information to plan for water supply, new learning institutions, and hospitals among other social amenities. Population forecasts are essential for individuals in the private sector in their analysis of real estate demand and market analysis for new commercial development. In the Netherlands, Wiebols and 't Hooft are listed as the founders of demographic approach to studies of population size, future course, and organization that led to town planning of Netherlands in the 1930s (Henk, 1999).

2.4.2 Population forecasting in policy formulation

The use of population projections in policy making is limitless. Changes in various sectors of the economy such as pension, healthcare, housing transportation and division of labor have been made possible from awareness of population ageing made possible by forecasts. Demographic information set is the combination of population forecasts with actual population trends. Predictions about the outcome of different policy alternatives can be made using demographic data set and other non-demographic data available to policymakers. Policymakers have at their disposal a set of policy alternatives from which they can base decisions on. In his book *Forecasting, An appraisal for policymakers and planners*, Ascher, (1979) examined records over fifty years in population trends and emphasized the vitality of forecast to policymakers. In his research he found that accuracy and bias in population forecasting were of great relevance to potential users of population projections among them policymakers.

2.5 Forecasting using ARIMA Model

In theory ARIMA models are classified as the most general form of models for forecasting time series events. Radha (2005) refers to ARIMA models as benchmark models in time series analysis. Studies have shown that compared to other stochastic models, the model is more accurate, entails use of less data with fewer coefficients. In the analysis of future data ARIMA model has proven its viability when it comes to giving adequate results due to its predictive performance (Radha, 2005). As such, the model is commonly applied in the forecast of time series occurrences as reviewed in a number of studies; in forecasting energy production and consumption, air quality observation, tourist arrival, government securities, and exchange rates, among other time series events. The general transfer function for ARIMA was first applied by Tiao and Box (1975) hence it popularly passes on as Box-Jenkins model. Forecasting of time series events using this model was made possible by Box and Jenkins in 1976 when they provided guidelines for making a series stationary. The two further suggested use of autocorrelation and partial autocorrelation functions (ACFs & PACFs) for determining suitable values of p and q which is easily achieved with the help of various programs at the available to the analyst. ARIMA model has been used by many other researchers in the forecasting of population. As mentioned earlier in this study, Gatacha

(2011) forecasted population of Kenya; she modeled population from the year 1960 to 2009 using the Box Jenkins methodology and further forecasted to the year 2029 that Kenya's population would be approximately 65.08 million (Gatacha, 2011).

3.0 RESEARCH METHODOLOGY

3.1 Research Design

This study uses evaluative research methodology; it is concerned with projecting student population for University of Kabianga to the year 2023 and relating the forecasted figure to resource availability and utilization. Formative evaluation is used in order to derive solutions on how best resources can be utilized to sustain the population of students.

3.2 Sample Size

A sample is a proportion of the target population whose conclusions can be generalized to the entire population. It is a representative of the entire population which inferences can be drawn from. Data used as sample is the data set for student enrollment per programme and considers three out of the five academic levels from the year 2009 to 2013. Due to unavailability of records for previous years, the sample used in this study was thus the same as the target population.

3.3 Data Analysis

Data collected in this study was analyzed using GRETl statistical software version 1.1.10 used to run time series data and forecast student population. Although the data collected is for five observations recorded annually, it was expanded with the help of the software used for purposes of analysis to total 60 observations recorded monthly. This does not however mean that University of Kabianga admits students on a monthly basis. ARIMA model was used to run the data. The model is a combination of the autoregressive (AR) and moving average (MA) schemes. The merging of the two schemes resulted to an equation of the following general form:

$$Y_t = \phi_1 X_{t-1} + \phi_2 X_{t-2} + \dots + \phi_p X_{t-p} + e_t - \theta_1 e_{t-1} - \theta_2 e_{t-2} - \dots - \theta_q e_{t-q} \quad (1)$$

Where: Y_t is the dependent variable at time t

$X_{t-1}, X_{t-2}, \dots, X_{t-p}$ are response variables at time lags $t-1, t-2, \dots, t-p$

$\phi_1, \phi_2, \dots, \phi_p$ are coefficients of past variables

$e_{t-1}, e_{t-2}, \dots, e_{t-q}$ are past errors

and $\theta_1, \theta_2, \dots, \theta_q$ are coefficients of past errors

The above equation simply means that any given series X_t can be modeled as a combination of past errors e_t or past values X_t or both. Four steps are to be followed when analyzing data using ARIMA model. Firstly, the original series X_t is to be transformed in order for it to become stationary in its mean and variance. Stationarity condition is achieved when the series becomes constant in its mean and variance. Secondly, is the specification of order p and q ; this is done by selecting the order that has the least values of log-likelihood, AIC, SBC and Hannan-Quinn. Thirdly, is the estimation of the parameters $\phi_1, \phi_2, \dots, \phi_p$ and/or $\theta_1, \theta_2, \dots, \theta_q$ using non-linear optimization procedure which will minimize sum of square roots. Finally the seasonal series is modeled practically and the of the order of the models specified. This stage includes carrying out diagnostic checks that show random residuals after which the model can be adopted for purposes of forecasting. The data was subjected to first and second log-differencing in order to attain the stationarity condition necessary for ARIMA. Summary statistics containing estimates of the parameters for the chosen model was obtained from the output resulting from running the data in GRETl software. Stationarity transformations also involved plotting time series ACF plots and a review of descriptive summary statistics. Suitability of the model is achieved through Akaike Information Criterion (AIC), Schwarz Bayesian Criterion (SBC), Log-likelihood Estimation and Hannan-Quinn Information Criterion. Diagnostic checks are carried out with the aid of tests for normality of residuals.

4.0 EMPIRICAL RESULTS AND DISCUSSION

4.1 Model Identification

Model identification involves checking for stationarity using time series plots summary statistics and autocorrelation functions and graphs as provided below:

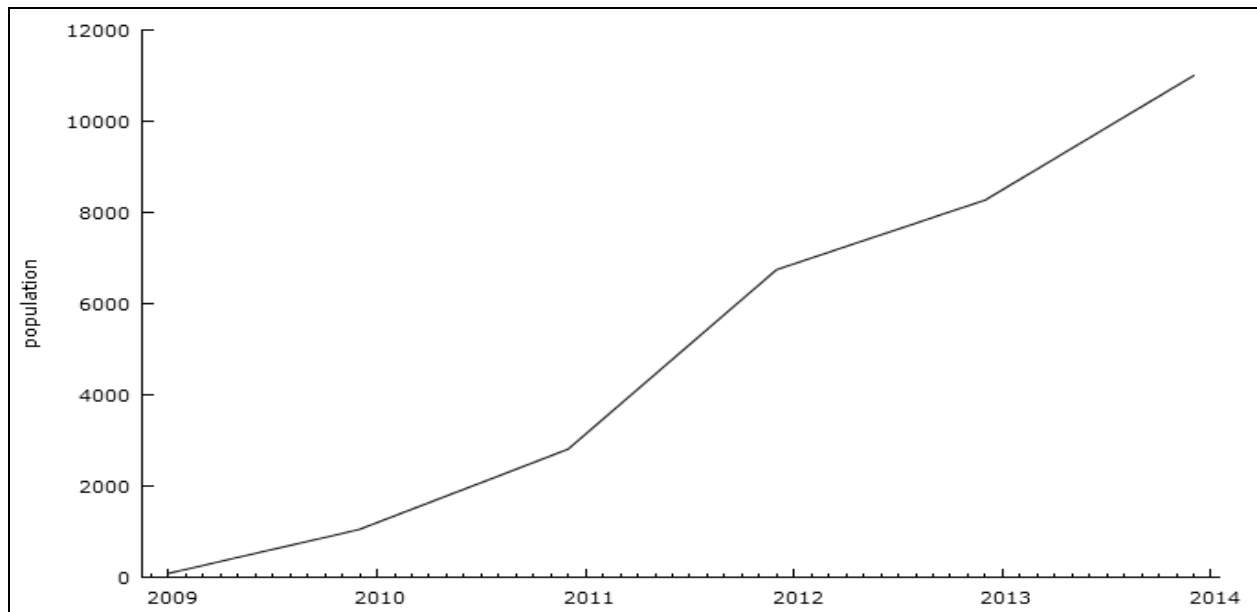


Figure 1: Time series plot for population

The Figure above depicts a time series plot for data on student population from the year 2009 to 2013. The plot shows a rapid increase in population due to increase in time. Through visual inspection it is clear that the data values do not have constant mean and variances hence population data is non-stationary. In order to attain stationarity condition the data is subjected to log differencing that is student population as a variable is subjected to the first log differencing.

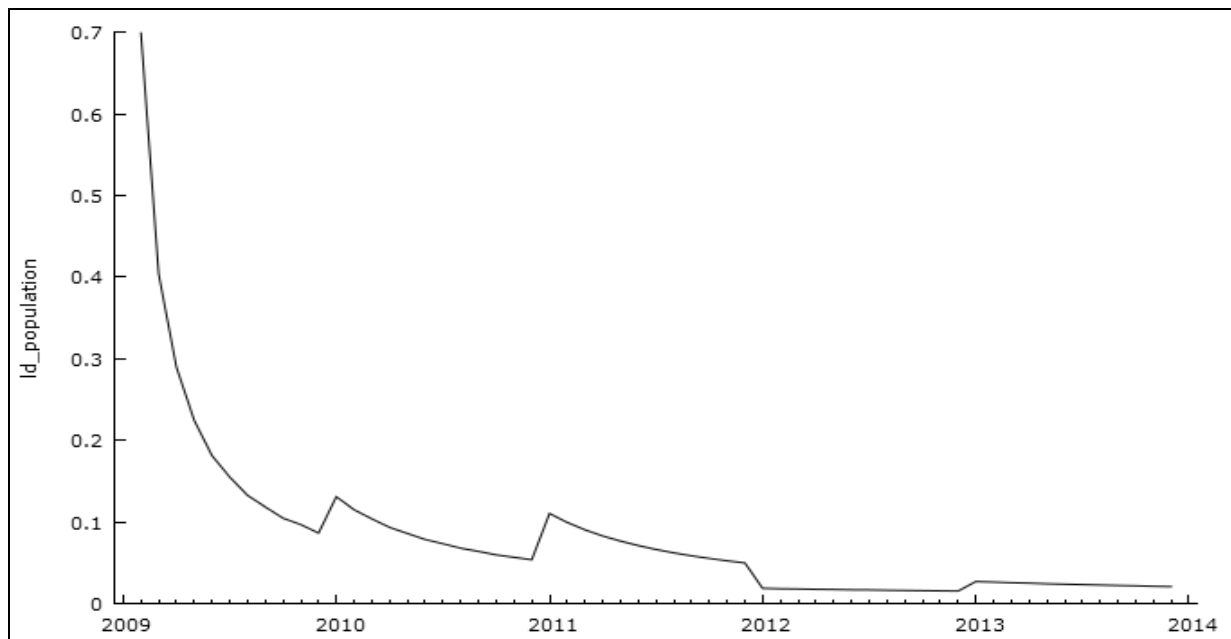


Figure 2: First log-differencing time series plot

Figure 2 depicts a change in time series plot after subjecting student population variable to the first log-difference; population in this case decreases with increase in lags. However mean and variance of the series is still non-constant hence this plot still shows a non-stationary trend, data is therefore differenced a second time to generate a time series plot with second log-differencing.

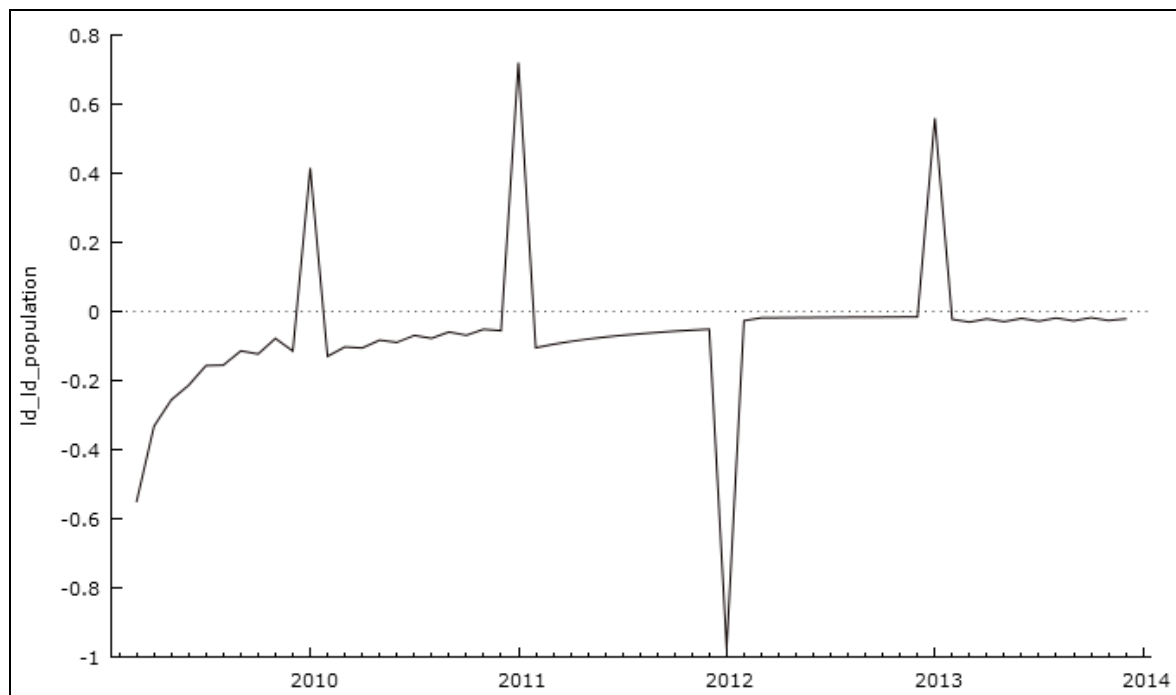


Figure 3: Second log-differenced time series plot

By visual inspection of Figure 3 it is clear that applying a second log-difference generates data that has constant mean and variance. At this stage the stationarity condition has been achieved. On the X-axis there's a sharp fall in 2012 resulting from a decline in number of students enrolled into the institution in the year 2012.

4.2 Summary Statistics for student population

The analysis uses 60 observations with a mean of 4967.30, median of 4942.00 and standard deviation of 3499.83 which means that total annual student population fluctuate from the estimated mean by 3499.83. Kurtosis is -1.4273 and a positive skewness of 0.10858 which means that most of the observations lie on the right. Jarque-Bera test gives a value of 5.21106, with p-value 0.073864.

4.2.1 Autocorrelation Function (ACF)

Visual inspection and observation is not sufficient a test for stationarity, ACFs is also used to check for stationarity as shown in the following Figures:

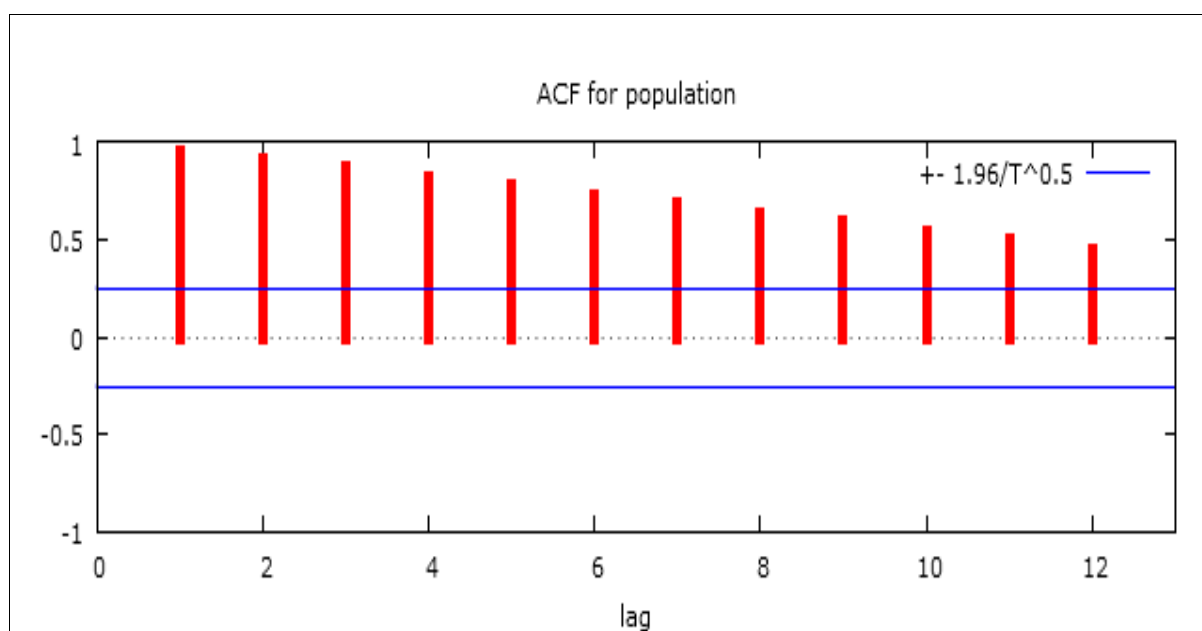


Figure 4: Student Population ACF

Figure 4 shows autocorrelations declining slowly as the number of lags. This property is common for non-stationary process we therefore find the first log difference and plot a new ACF as in Figure 5. Log differences have to be applied for as long as the process is non-stationary to the point when it finally meets the stationarity conditions.

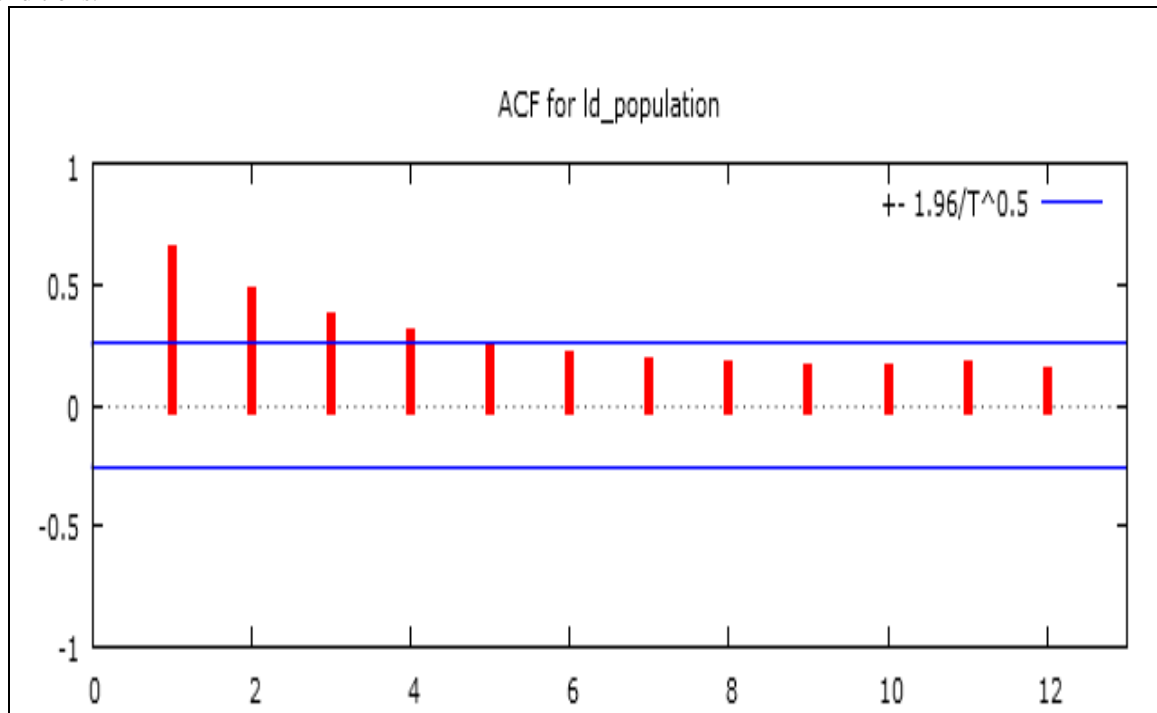


Figure 5: First log-differenced ACF plot

Applying the first log differencing continues to generate a non-stationary process as evidence in the decline of autocorrelation with subsequent increase in lags. The second ACF and PACF graphs show little change in the process. To achieve stationarity the process has to be subjected to a second log-differencing as with the case of time plots and the new graph drawn from the second differencing.

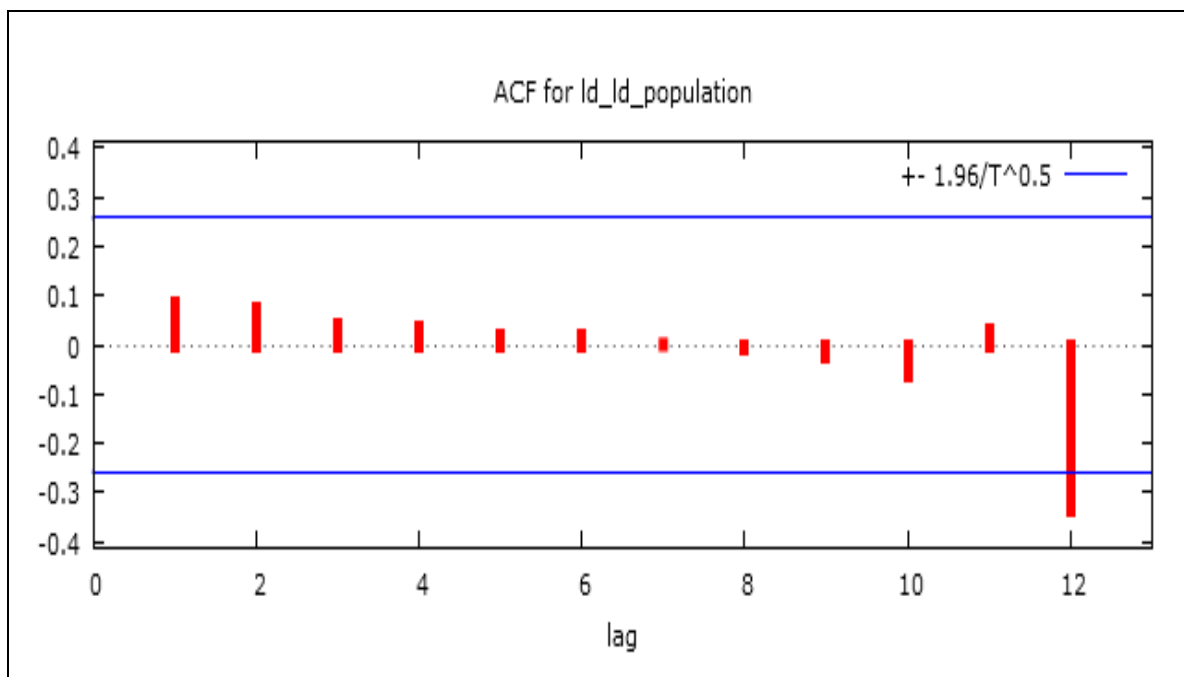


Figure 6: Second Log-differenced ACF plot

Figure 6 shows a difference in the pattern taken by autocorrelations with respect to increase in lags. White noise process possesses a similar pattern. Since it is a property of stationarity, the process has therefore attained the condition for stationarity. The model identification stage has thus revealed that for Arima methodology to be used the original data has to be log- differenced twice. This implies that the process under investigation attains stationarity at the second log-differencing ($I=2$).

4.3 Model Estimation and Testing

4.3.1 Results of Estimation

Ordinary Least Squares method is used to generate results for the model. Results are summarized in Table 1:

Table 1: Results of Estimation

Dependent Variable: Student Population				
Variable	Estimation	Standard Error	Z	p-value
Intercept	2.37	5.038	0.476	0.634
AR1	-0.0029	0.1302	-0.0219	0.9825

According to the results AR2, MA1 and MA2 coefficient are zero and autoregressive coefficient of order 1 is provided as well as standard error and z value. The p-value estimated above is not statistically significant at 5% level of significance.

4.3.2 Comparison to other ARIMA Models

Table 2: Comparison to other ARIMA Models

	ARIMA (2, 2, 2)	ARIMA (2, 2, 1)	ARIMA (1, 2, 2)	ARIMA (2, 2, 0)	ARIMA (0, 2, 2)	ARIMA (1, 2, 1)	ARIMA (0, 2, 1)	ARIMA (1, 2, 0)
Log likelihood	-292.59	-293.01	-293.01	-294.07	-294.07	-293.06	-294.07	-294.07
Schwarz Criterion	609.55	606.32	606.33	604.38	604.38	602.38	600.31	600.31
Akaike Criterion	597.19	596.02	596.03	596.14	596.14	596.14	594.13	594.13
Hannan-Quinn	602.00	600.03	600.04	599.35	599.35	597.35	596.54	596.54
Ljung-Box Q'	18.73	19.99	19.99	21.04	21.04	20.18	21.0	21.04

ARIMA model (1, 2, 0) is measured against other models as in table 3, criterion for model suitability being the one with least figures of all. This condition is tested using Log Likelihood, Bayesian Schwarz, Hannan-Quinn and Akaike criterions. In all cases ARIMA (1, 2, 0) surpasses rival models making it the most suitable. ARIMA model has thus transformed to AR (1) model.

4.3.3 Fitting the best Model

Having met all conditions for best fitting model, ARIMA (1, 2, 0) is considered best for forecasting the student population for University of Kabianga. The model fitted with values from results of estimation given in Table 1 now appears as follows:

$$Y_t = 2.37 - 0.0029X_{t-1} + e_t$$

The negative estimate for θ_1 , means that lags bear an inverse relationship with previous variables in previous periods.

4.4 Diagnostic Checks

Data is tested for normality and uses the statistics: Doornik-Hansen test, Shapiro-Wilk W, Lilliefors test and Jarque-Bera test. Normal QQ plot is also drawn and residual kurtosis as well as skewness of the series reviewed as summarized below:

Table 3: Test for normality

Statistic	Estimate	p-value
Doornik-Hansen test	95.156	2.17338e-021
Shapiro-Wilk	0.637717	1.05653e-010
Lilliefors test	0.363444	~ 0
Jarque-Bera test	209.302	3.55399e-046

Jarque-Bera test has an estimate of 209.302 with p-value that rejects the null hypothesis of normality in the residuals. All other statistics have p- values less than 5% implying residuals in the series do not satisfy normality condition. For normality Skewness of series has to be zero which is not the case for this data. Kurtosis for the series is 9.2996 while Skewness is found to be -0.17690 meaning most data points lie on the left hand side of the normal distribution. Model independence was evaluated through inspection of sample residual autocorrelations to see if they resemble those of white noise which they do as observed in Figure 6. The Durbin Watson Statistic for this series is 1.7335 which is nearing 2, hence the series is free of negative or positive autocorrelation.

4.5 Forecasting student population

ARIMA (1, 2, 0) is used to forecast student population to the year 2023 that is over a period of ten years with 2015 as the starting point. Since the program used gives cumulative population projections from the year 2009, manual computations are done to come up with actual population figures for the given period. Actual figures take into consideration the aspect of completion of studies for the students entering the system after an average of four years since the enrolment year. This means that although new students are enrolled into the institution every year, all leave the institution approximately four years after joining. Actual population figures are therefore obtained after subtracting cumulative figures of four years preceding the current year from the cumulative population of the current year. In the year 2015 it is expected that population will exhibit a slight decrease and then continue with an increasing trend for subsequent years. This decrease may be attributed to any number of unforeseeable events. This decrease may also be just an estimation arising from the use of past trend in population as observed in the year 2012 when the institution recorded a decrease in the number of students enrolled. A resulting time plot is derived in Figure 7. The graph shows expected upward trend in population growth for the institution.

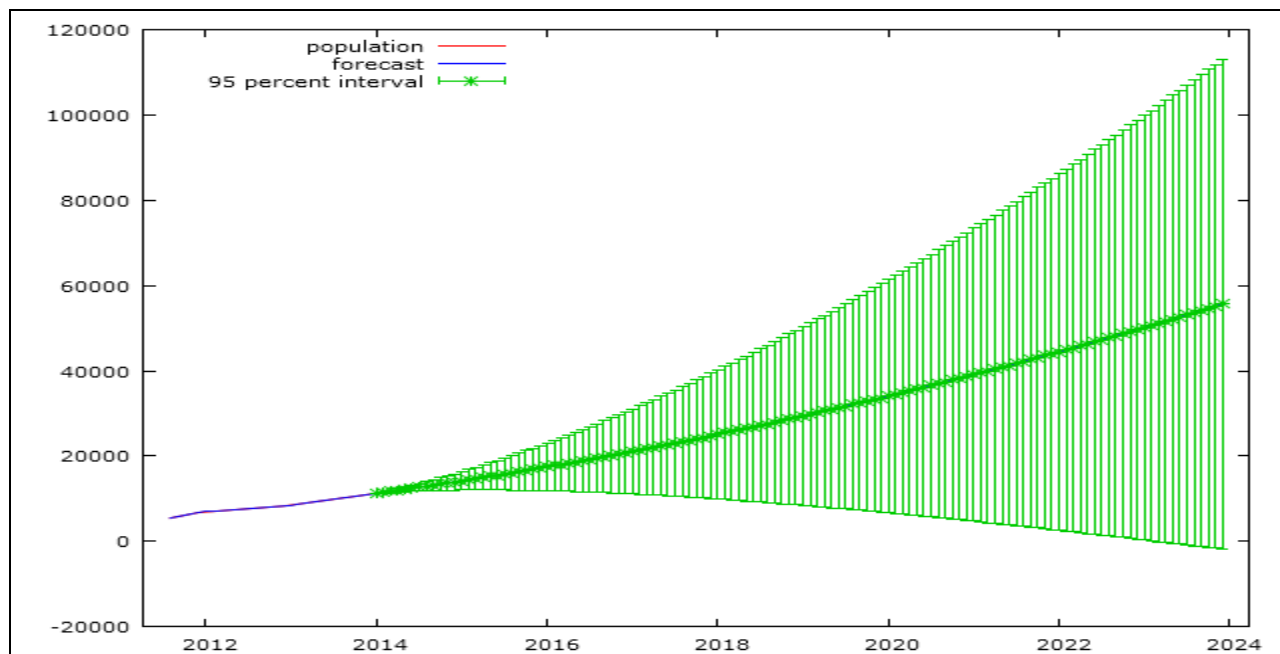


Figure 7: Student population forecasting plot

The p-value for population with time as the independent variable is obtained as $6.56e-016$ which is less than 5% level of significance. It is therefore statistically significant and rejects the null hypothesis of no relationship between time and student population in University of Kabianga. From the graph above it is visibly clear that there is an upward trend in population as time increases. There is therefore a positive relationship between time and population. This means that with increase in time population increase is to be expected in University of Kabianga.

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusion

The study found that there is a significant relationship between time and student population. Given that this relationship is positive, it is expected that the population of University of Kabianga will keep on increasing with increase in time. Furthermore population is expected to reach 32,421 by the year 2023 if all other factors apart from time are held constant. This implies that it is possible the population may not hit the 32,000 mark if all other factors are put into play. Factors such as the institutions policies on student enrolment as mentioned in chapter two of this research in particular those that state cut-off points for enrolling for certain programs may limit growth. However since this forecast is based on only three campuses of University of Kabianga. it is then possible that the opening of new campuses or expansion of the already existing ones may lead to a higher actual figure. This is because the additional space allows for more students to be enrolled in University of Kabianga. Other external factors like government policies on institutions of higher learning could also have an impact on the outcome of this prediction.

5.2 Recommendations

University of Kabianga currently has hostels that serve as accommodation facilities; the hostels can shelter less than 5000 students per semester. All other students reside outside the institution in the over 200 private hostels around the school or their homes. Though there may not be an immediate threat to the issue of accommodation, the institution ought to make local arrangements with the surrounding community to invest heavily in student hostels. Failure to do so may result in a crisis that may in turn have a negative impact in population growth for University of Kabianga characterized by a decrease to a level that can be accommodated. An alternative is for the institution itself to construct more buildings meant to shelter the expected population in the future. Currently the university has enough lecture halls for studies in the three campuses. However the institution ought to add more infrastructures in anticipation of a triple increase in population as according to the findings of this research.

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