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A Robust Model for Thegrowth of the Nigerian Population

Ashinze, Akudo N.
Department Of Mathematics/Statistics, Delta State Polytechnic Ogwashi-Uku Delta State, Nigeria

Abstract: *Population statistics in recent decades have revealed that the population of Nigeria is on the increase annually with about 2 to 3% growth rate. This is becoming troublesome in recent years. Among other solutions that may be proffered to curb this high population growth, is the need to adequately model the population of Nigeria, this will effectively help in population planning as well as a check on unprecedented growth of population without resources to match up the growth. This study attempts to compare various population growth model to determine the most best model for the Nigerian population. From the findings, the study concludes that the exponential model is the best growth model for the Nigerian population. This model is closely followed by the linear model. It is therefore recommended:that programmes and policies to boost per capita output of the nation should be pursued; Better education of the masses to help them understand the need to have one or two children at the most; creating awareness of the harms of overpopulation and the need for family planning aimed at reducing over population and finally need for sex education aimed at controlling fertility rate.*

Keyword: *Population projection, exponential model, linear model, Nigerian population*

I. Introduction

Population statistics in recent decades have revealed that the population of Nigeria is on the increase annually with about 2 to 3% growth rate. These statistics can be one of the reasons for poor level of both micro and macroeconomic indicators in Nigeria. These ranges from unemployment, tribal and ethnic unrest due to struggles for resource which are scarcely distributed, high maternal mortality, low life expectancy and so on. The poor values of these indicators are simply attributable to low standard of living resulting from high effect of population with low or underutilization of resources.

Population growth is the change in the size of population resulting from the differences in birth and death, which are measured both in absolute and relative terms (Gee, 1999) while Population growth rate is the average annual percentage change in population, which is affected by birth and death as well as the balance of the number of people that are coming and leaving a particular country within a specified period of time (Mundi Index. 2012). One may not be wrong to say that Nigeria is at the verge of been termed over populated as the indicators of overpopulation signals such. These effects of over population are quite severe and seen in Nigeria today.

Depletion of Natural Resources: depletion of resources is the first of these effects The Earth can only produce a limited amount of water and food per geographical space, when population is high these resources become scares in relation to demand. This leads to most of the severe environmental damage resulting from afforestation, hunting wildlife in a reckless manner, causing pollution and and so many other problems

Another indicator of over population is environmental degradation, resulting from excessive use of coal, oil and natural gas, which produces serious environmental effect such as: rise in amount of CO2 emissions leading to global warming,changing climate patterns and rise in sea level.

High Unemployment and crime rates: over population gives rise to increased unemployment as there are fewer jobs to support large number of people. Rise in unemployment gives rise to crime as people will steal various items to feed their family and provide them basic amenities of life.

High Cost of Living: As difference between demand and supply continues to expand due to overpopulation, it raises the prices of various commodities including food, shelter and healthcare. This means that people have to pay more to survive and feed their families.

Without doubt these indicators of overpopulation is seen and exist in Nigeria. These ranges from high unemployment and crime rate, environmental degradation resulting from human activities and high standard of leaving.

Among other solutions that may be proffered, there is need to adequately model the population of Nigeria, this will effectively help in population planning as well as a check on unprecedented growth of population without resources to match up the growth. This study attempt to compare various population growth model to determine the most robust model for the Nigerian population.

Purpose of the Study

The purpose of this study are:

1. To model the Nigerian population using the arithmetic, exponential and geometric growth model
2. To determine the best model using the mean square errors
3. Forecast the Nigerian population for the next five years using the best model.

II. Literature Review

Several studies have been conducted in the area of population growth and projections. This is as a result of the growing quest to check the negative impacts of population growths in Nigeria and the world at large. Some of these studies are reviewed.

Onwuka (2011) empirically tested the association between population growth and economic development in Nigeria between 1980 and 2003 and found that growth in population outweighs that of output and this has hindered the capacity of successive governments to efficiently provide social services to the people, thereby negatively affecting development. Their contention, therefore, was that curbs on population growth through appropriate policies that would integrate the country's population programmers into the mainstream development efforts are necessary. That way, higher per capita consumption of social services by the citizens would be facilitated and which ultimately would boost their access to the benefits of development.

Adewole (2013) examined the effect of population on economic development in Nigeria. Thus, Malthusian theory of population is relevant to Nigeria as a developing economy. The study examined the time series properties using the Phillips-Perron (PP) non-parametric unit root test. The analysis showed that real gross domestic product, population growth and per capita income are non-stationary at levels, but the null hypothesis of non stationarity was rejected at first difference for both test models with intercept and trend. The study revealed that population growth has positive and significant impact on economic sustainability proxied as real gross domestic product (RGDP) and Per Capita Income.

Eniayejuni and Agoyi (2011)argued on the importance of statistical knowledge of Nigeria's population, in terms of planning and development. In order to have an accurate and trustworthy data of Nigeria citizens, a biometric system for data collection is proposed as well as a centralised database for storing these data.

Olatayo & Adeboye (2013) focused on the socio-demographic analysis of the factors that lead to high birth and death rates in South Western region of Nigeria and its consequences on the economy. Their results revealed that the Crude Birth Rate(CBR) of South West was between 0.59 and 0.78 while the Crude Death Rate (CDR) was estimated to be between 0.19 and 0.24 per '000 yearly population. Using Regression analysis, their study demonstrated that both birth and death rates for the given sample period, have exerted much significant influence upon the population of South West as observed in the Coefficient of determination(R2) of 72.3% arrived at in the Regression analysis.

Olayiwola, Lawal, Amalare et al (2015) study was carried out to find the trend, fit a model and forecast the population growth rate of Nigeria. The data were based on the population growth rate of Nigeria from 1982 to 2012 and obtained from World Bank Data (data.worldbank.org). They tested both time and autocorrelation plots to assess the Stationarity of the data. Dickey-Fuller test was used to test for the unit root.the resukts show that there was an initial decrease in the trend ofthe growth rate from 1983 to 1985 and an increase in 1986 which was constant till 1989 and then slight fluctuations from1990 to 2004 and a general increase in trend from 2005 to 2012.

Ajala & Olayiwola (2013)examined the use of GIS and Remote Sensing in monitoring the growth and development pattern of Ile-Ife, Osun State, Nigeria over a period of 21 years with a view to predicting its direction of growth. In effect, their study sought to identify and explain the rate and extent of changes in the study area between 1986 and 2007; measured the rate of urban growth in the study area between 1986 and 2007; assess the impact of urban growth on land use patterns; and predict the trend of urban growth in the study area. Data for the study were generated from both primary and secondary sources. Remote Sensing Imagery of Landsat TM 1986, Landsat ETM 2002 and ALOS 2007 were used to measure the extent of growth and to show the effects of this growth on other Land use/Land cover types. Their results showed that that changes occurred in the magnitude and rate of urbanization in the study area between 1986 and 2007. They discussed their result mainly focusing on the trend of urban growth expansion and its effect to the Environment natural resources, farmland and food security and its contribution to climate change.

Folorunso, Akinwale, Asiribo, & Adeyemo, (2010) employed an artificial neural network for population prediction (ANNPP) that handles incomplete and inconsistent nature of data usually experienced in the use of mathematical and demographic models while carrying out population prediction. According to them, ANNPP uses the three demographic variables of fertility, mortality and migration which are the major dynamics of population change as the input data. The datasets were divided into train, validation and test data. The train data was presented to the supervised artificial network to approximate some known twelve target values of population growth rates. The method was also used to simulate both the validation and the test datasets as case data on the consistency of results obtained from the training session via the train data. From the sixteen different

topologies they tested on the basis of the mean square errors (MSE), standard deviation (STDEV) and epochs; topology 19-9-1 performed best than the rest. A comparison between the predictions based on the ANNPP derived growth rates and the cohort component method of population prediction (CCMPP) was compared. The results showed that ANNPP percentage accuracies ranged between 81.02 and 99.15% while that of CCMPP percentage accuracies ranged between 64.55 and 86.43%. Their results showed that artificial neural network model performed better than the demographic model.

Nwosu, Dike &Okwara (2014). Investigated the time series role of population growth on economic growth in Nigeria and how economic growth is effected through population growth. This study this extends the literature by employing a linear model to analyze economic growth fluctuations vis a vis population growth. The study employed annual secondary observation from 1960 to 2008. The empirical results were based on Augmented Dickey-Fuller (ADF) stationarity test combined with Granger Causality and Cointegration tests. Empirical results support that population growth has a significant impact on economic growth. The study also found that there is a sustainable long run equilibrium relationship between economic growth and population growth. There is also the evidence of unidirectional causality between population growth and economic growth. Policy implications of the study are provided.

Irewole, Akeem, Babalola and Kuranga (2014) modelled an equation for Nigeria population and made a projection of Nigeria population. They employed the multiple linear regression using SPSS. The equation they obtained was Y=37184.262+0.825X1+1.051X2+1.654X3, they used this equation to estimate the symptomatic value and compared with the National Population Commission value, it was discovered that Symptomatic Estimated population for Nigeria is approximately the same with National Population Commission that is . the symptomatic Estimated is 163,736,835 while that of NPC is 163,609,494, they therefore recommended that the model obtained can be used to project the Nigerian population.

Oyinloye and Fasakin (2014)analyzed the urban growth of Akure using medium resolution Landsat imageries. Landsat (MSS), Landsat Thematic Mapping(TM) and Landsat Enhanced Thematic Mapper (ETM+) images for 1972, 1986 and 2002 respectively were used in a post-classification comparison analysis to map the spatial dynamic of land cover changes and identify the urbanization process in Akure. The land cover statistical results revealed a rapid growth in the built-up area of Akure from 997.2 hectares in 1972 to about 3852.70 hectares in 2002 due to increase in population of Akure within the said period. Results of the prediction showed that the built-up area of the city has increased in size from 977.2 hectares in 1972 to 5863.66 hectares in 2022 corresponding to 500% at the rate of 13.1% per annum. Implications of growth include loss of open space, pressure on limited infrastructure, overcrowding, traffic congestion and poor standardof living. The authors recommended regular monitoring of urban area, development of small towns around the city area to avoid overcrowding, training of planners and administrators to acquire more knowledge in the use of GIS and remote sensing to enhance efficiency

III. Research Methods

The study compares three population projection models: linear model, geometric model and exponential model. The projections are made from 2006 to 2014. Using the interpolated values, the Sum of square error (SSE) for each interpolated value are then calculated. The population growth rate of 2.8 as given by 2006 population census was used in this study. The mean square errors (MSE) and root mean square errors (RMSE) are also calculated. The RMSE is the square root of the mean/average of the square of all of the error.The use of RMSE is very common and it makes an excellent general purpose error metric for numerical predictions.Compared to the similar Mean Absolute Error, RMSE amplifies and severely penalizes large errors.The population models employed here are given below:

Linear Growth Model:

If a quantity starts at size P_0 and grows by d every time period, then the quantity after n time periods can be determined using relations:

$$Pn = P_0 + nd \quad (1)$$

Geometric Growth Model:

For a population with P_t as the number of individuals at time **t**, $\mathbf{P_0}$ as the initial number of individuals, **r** as the population growth rate and **t** is the number of time intervals or generations. For a population growing at a geometric rate, the population size at any time t can be calculated as:

$$P_t = P_0(1 + r)^t \quad (2)$$

Exponential Growth Model

Given that $P_t$is the number of individuals at time t, P_0 is the initial number of individuals, e is the base of the natural logarithms, r is the per capita rate of increase, and t is the number of time intervals (here in years), for a population growing at an exponential rate, the population size at any time t can be calculated as:

$P_t = P_0 e^{rt}$ (3)

The exponential model is appropriate for populations with overlapping generations. This is because it deals with population growth as a continuous process. In this model, r is a constant and P is a variable. Therefore, as population size, P, increases the rate of population increase, dP/dt, gets larger and larger,since the constant r is multiplied by a larger and larger population size, P. Consequently, during exponential growth, the rate of population growth increases over time.

In assessing the best model for the Nigerian population, the RMSE is employed as follows:

$$\text{RMSE} = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(y - \hat{y})^2} \quad (4)$$

IV. Results And Discussion Of Findings

The results of the various population projection models are presented in table 1 below. The results give the forecast for linear, geometric and exponential models. The forecasts were made from 2007 to 2014 using 2006 as the base year.

Table 1: Projections From Growth Models

		LINEAR	GEOMETRIC	EXPONENTIAL
YEAR	**Population**	**Po +nd**	**$P0(1+r)^n$**	**$P0e^{rn}$**
2006	143338939			
2007	146,951,477	147,065,751	147,352,429	147,409,146
2008	150,665,730	150,792,563	294,704,859	151,594,929
2009	154,488,072	154,519,375	442,057,288	155,899,571
2010	158,423,182	158,246,187	589,409,717	160,326,446
2011	162,470,737	161,972,999	736,762,146	164,879,025
2012	168,833,776	165,699,811	884,114,576	169,560,878
2013	173,615,345	169,426,623	1,031,467,005	174,375,675
2014	178,516,904	173,153,435	1,178,819,434	179,327,192

The result presented in table 1 shows that the exponential growth model gave a forecast closest to the actual values. This is followed by the linear model then the geometric model. A close look at the models also shows that the forecasts present values slightly higher that the observed valued.

Table 2: Sum Of Square Errors

YEAR	ARITHMETIC	GEOMETRIC	EXPONENTIAL
2007	13,058,547,076	160,762,740,460	209,461,167,243
2008	16,086,609,889	20,747,270,563,238,100	863,412,408,933
2009	979,877,809	82,696,053,919,537,500	1,992,331,302,321
2010	31,327,230,025	185,749,393,496,118,000	3,622,416,528,603
2011	247,743,116,644	329,810,622,979,553,000	5,799,855,366,592
2012	9,821,736,621,225	511,626,622,493,861,000	528,678,299,284
2013	17,545,391,993,284	735,909,470,640,246,000	578,103,040,352
2014	28,766,799,713,961	1,000,605,152,196,600,000	656,567,515,640
SSE	**56,443,123,709,913**	**2,867,144,747,051,900,000**	**14,250,825,628,969**
MSE	**7,055,390,463,739**	**358,393,093,381,487,000**	**1,781,353,203,621**
RMSE	**2,656,198**	**598,659,414**	**1,334,673**

Table 2 gives the sum of square errors (SSE), Mean square error (MSE) and root mean square error (RMSE) for the forecasts. TheRMSE result shows that the exponential growth model gave the least RMSE of 1,334,673 followed by the linear model with RMSE of 2,656198 and then the exponential growth with RMSE of 5965414.

Table 3: Forecasts For The Linear And Exponential Distribution

YEAR	LINEAR	EXPONENTIAL
2015	176,880,247	184,419,311
2016	180,607,059	189,656,023
2017	184,333,871	195,041,436
2018	188,060,683	200,579,771
2019	191,787,495	206,275,371
2020	199,241,119	218,156,355

Since the best models are the exponential and linear growth models respectively, the corresponding forecast are then presented in table 3. The forecasts are from 2017 to 2020. In 2015 a forecast of 176880247 and 184419311 for linear and exponential model respectively are presented. While a forecast of 199,241,119 and 218, 156,355 are respectively presented for 2020. The extrapolated values points to the fact that the Nigerian population in on the increase. The evidence of high population earlier presented may suggest that Nigeria is near the point of over population. This may be attributable to the fact that the needed economic boost to match the population is not available.

V. Conclusion And Recommendations

The study compares three population growth model for the Nigerian population to determine the most efficient in forecasting the Nigerian population. The root mean square error was used as the basis for comparison. Based on the results presented so far, the study concludes that the exponential model is the best population growth model for the Nigerian population. This model is closely followed by the linear model. It is therefore recommended as follows: in line with Nwosu, Dike and Okwara, (2014), the study recommends programmes and policies to boost per capita output of the nation; Better educationof the masses to help them understand the need to have one or two children at the most; creating awareness of the harms of overpopulation and the need for family planning aimed at reducing over population and finally need for sex education aimed at controlling fertility rate.

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