Growth Process of Nigerian Population: Validating Malthusian Theory with Mathematical Modelling

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Abstract

Nigeria is the most populous country in Africa and the seventh in the World after China, India, USA, Indonesia, Brazil and Pakistan; accounting for 2.46% of the global population. The population of the country has risen steadily from an estimated 2.5 percent in 1960s to around 3.5 percent in the recent times. This suggests a population doubling in every 22 years. Against that background, the paper validates the population growth of Nigerian population using mathematical modeling involving first order equations. The population data used span from 1950 – 2010. The study find that the predictions base on the Malthusian model are in closer agreement with the reported population data of Nigeria. It also remarks that a Malthusian model can be generated using the census data or population estimate of a country for any two different years. The socio-economic implication the result signifies that Nigeria has a high fertility rate and thus an important issue of concern. This is because population growth has a far-reaching effect on country's development and standard of living. On one hand it is argued that large population is a vital resource for economic development as it constitutes labour (human resources) for production of goods and services as well as ready market for the produced goods and services. On the other hand, where the quality of population is poor, especially labour force, it becomes burdensome and serious socioeconomic problem.

Keywords: Population, Growth, Mathematical Modelling, Malthusian Theory
JEL Code: B23, C29

Contribution/Originality
The paper is one of the few studies that applied a different model to confirmed Malthusian prediction on population growth of Nigeria. Thus, it has contributed in terms of population analysis.

1.0 Introduction

Nigeria is the most populous country in Africa and the seventh in the World after China, India, USA, Indonesia, Brazil and Pakistan; accounting for 2.46% of the global population (World Bank, 2014). The country has a population density of 193person/km2, and a fertility rate of about 6.02, with more than 51% living in urban areas (National Bureau of Statistics, 2014). Nigerian population has risen steadily from an estimated 2.5 percent in 1960s to around 3.5 percent in the recent times. This suggests a population doubling in every 22 years. The relatively low mortality of less than 13 per thousand as well as increased life expectancy contributed to this trend (National Population Commission, 2013).

From the time of Malthus T. (1798)* and onward, economists, demographers and other social scientists have been debating whether and how high fertility and rapid population growth affect

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*** Malthus Thomas (1798)** - British Economist who advocated positive human population check in order to avert economic disaster

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economic outcomes, and vice-versa. The average growth rate of real Nigerian GDP, which was 5.9 per cent in the period 1960 - 1970, rose to 8.0 per cent in 1971-1973. The Nigerian economy expanded rapidly, as oil production and export rose phenomenally. The average GDP growth rate later dropped to 3.2 per cent during 1976-80. This level was sustained in the period 1982-90 following improved performance in agricultural and industrial sub-sectors. The Nigeria economy has witnessed a robust GDP growth rates over the reform period of democratic regimes (1999 to 2011)

Building on this background, the main objective of the paper is to model the population growth of Nigerian mathematically involving first order equations. Given the astonishing and alarming increase in population of Nigeria over the last four decades, the study also validates Malthusian theory with the estimated population of Nigeria. Finally, the paper examines the economic implications of the growth and recommends policy measures.

The paper is organized as follows. The next section explains the conceptual issues of population and the Malthusian framework. Section 3 briefly describes the method and data. The final section provides a discussion of the findings and concludes.

2.0 Literature Review

2.1 Analytical Framework

One important area where economic and social statistics is essential is demography. Thus, demography is the scientific study of population. Population statistics is concerned with the study, size, structure or characteristics and development of human population. The development of human population is analyzed in terms of Population Growth Rate. The term population growth rate is defined as the percentage increase in a population over a period of time. It is calculated by subtracting the number of Deaths & Emigrants from the number of Births plus Immigrants.

Birth rate; it is the average number of the children born in a country compared to the rest of the total population. In other words, it is the number of births for every 1000 people in the country. Birth rates are affected by factors such as nutrition, fertility, social and religious beliefs - especially in relation to contraception and abortion, labour value of children, government policies, social value, the availability of contraception and cultural practices.

Death rate on the other hand, is defined as the total number of persons who die every year. It is expressed as the number of people who die each year compared to every 1000. Factors such as Medical facilities and health care, Nutrition levels, Living standard, Access to clean drinking water, Hygiene, levels of infectious diseases, Social factors such as conflicts and levels of violent crime affect death rate.

Migration is the movement of persons from one geographical location to another. Emigration and Immigration is distinguished. Emigration is when a person moves out of the country, while Immigration is when a person moves into a country. Thus, net migration is the difference between emigration and immigration. If net immigration is positive it will lead to a population increase, on the other hand, a negative net immigration will lead to a fall in population of a country. The balance among these three factors determines whether a population increases, remains stationary, or decreases in number. The excess of between births above deaths rate is define as positive increase in population (Natural Population Growth). When the net effect of migration is added to natural increase, this is referred to as Total Increase (Total Growth).

If we assume that the number of individuals entering a population (immigration), equals the number of leaving (emigration), population growth is the result of the increase of births over deaths. This relationship is summarized by a formula known as the balancing equation. It is expressed as:

$P_2 = P_1 + (B – D) + (I + E)$

Where;

P_2: Size of population for the year under consideration

P_1: Size of population in the preceding year

B: Number of births between the two dates

D: Number of deaths between the two dates.

I: Number of immigrants in the time under consideration (between P_2 and P_1)

E: Number of emigrants in the time under consideration (between P_2 and P_1)

The differences between births and deaths in a population gives the Natural Increase (or Decrease) of a population.

2.2 Malthusian Population Theory

Malthus T. (1798) was British Economist who published an essay in 1798 on 'The Principle of Population, as it affects the Future improvement of Society'. His core argument was that, while human population increase exponentially, food production increase more slowly, in a linear fashion or arithmetic series. This constraint placed severe limits on human productive behaviour and undermined the view that a completely free or perfectible society was possible.

The particular details of Malthus's theory of population in his Essay have survived; neither detailed criticism nor confrontation with the relevant demographic and resource data. Malthus overlooked the possibility of declining fertility rates resulting from higher family incomes and underestimated the possibilities for productivity improvements in agriculture. However, his central theme of global overpopulation in the face of limited material resources remains with us today. Despite the reductions in family sizes and fertility rates in the developed world, the twentieth century saw high population growth in much of Africa, Asia and Latin America. We have witnessed a population explosion that has put severe pressure on some critical global resources, despite immense improvements in the productivity of agriculture that Malthus did not envisage.

3.0 Method and Data

How do we analyze and predict the growth of a population? If we are interested in a single population, theoretically, we can think of specie as being contained in a confinement or a geographical entity (country, island etc.) and study its growth process as a one-compartment system.

Let $p(t)$ be the population at time *t*. while the population is always an integer, it is usually large enough so that very little error is allowed in assuming that $p(t)$ is a continuous function. We now need to determine the growth (injection) rate and the death (leakage) for the population.

Let us begin our model by considering a population of specie that enlarges by simple reproduction. Thus, we assume that the growth rate is proportional to the population present. This assumption is consistent with observation of natural growth of living things. As long as there are sufficient space and supply of food for the specie, we can also assume that the death rate is zero. Hence a mathematical model for a population of organism is

$$\frac{dp}{dt} = k_1 p, \quad p(0) = p_0 \quad \text{.....(1)}$$

Where; $k_t > 0$, is the proportionality constant for the growth rate and p_0 is the population at time $t = 0$. For human populations the assumption that the death rate is zero is certainly untrue. However if we assume people die only of natural causes, we might expect the death rate also to be proportional to the size of the population. Therefore we revise equation (1) to be:

$$\frac{dp}{dt} = k_1 p - k_2 p = (k_1 - k_2) p = kp \quad \text{.....(2)}$$

Where; $k = k_1 - k_2 \; and \; k_2$ is the proportionality constant for the death rate. Let's assume that $k_1 > k_2 \; and \; that \; k > 0$. This yields the mathematical model in equation below

$$\frac{dp}{dt} = kp, \quad p(0) = p_0 \quad \text{.....(3)}$$

This generally regarded as the Malthusian or exponential law of population growth. The equation is separable and solving the initial value problem for $p(t)$ give

$$p(t) = p_0 e^{kt} \quad \text{.....(4)}$$

Since the objective of the paper is to test and apply the Malthusian Population model in Nigeria, we consider the demographic profile of Nigeria. The first column in table 1 below, provides a Population of Nigeria from 1950 to 2010. In 1950, the population of Nigeria was 37.86 million and in 2000 it was 159.71 million. Using the Malthusian model we can estimate the population of Nigeria as a function of time

If we set t = 0 to be the year 1950, then by formula (4) we have:

$$p(t) = (37.86) e^{kt} \quad \text{.....(5)}$$

Where; p(t) is the population in millions. One way to obtain a value for k would be to make the model fit the data for some specific year, such as 2010 (t = 60). Therefore, we have:

$$p(60) = 159.71 = (37.86) e^{60k}$$

Solving for k gives: $k \; \frac{in\,(159.71) - in(37.86)}{60} = 0.0240$

Inserting this value in equation (5), we get:

$$p(t) = (37.86) e^{(0.024)t} \quad \text{.....(6)}$$

Table 1: A comparison of the Malthusian Model with the Nigerian Population Data (in millions)

Year	Nigerian Population[a]	Malthusian Prediction[b]
1950	37.86	37.86
1955	41.12	42.69
1960	45.21	48.13
1965	50.24	54.27
1970	56.13	61.18
1975	63.57	68.99
1980	73.70	77.78
1985	83.90	87.80
1990	95.62	98.88
1995	108.43	111.49
2000	122.88	125.70
2005	139.59	141.73
2010	159.71	159.80

Source: [a] National Population Commission, 2012.
[b] Authors' computation, 2019.

In Table 1 above, the Nigerian population as given by the national population commission is compared to the population predicted by the Malthusian model using equation (6) developed

4.0 Findings and Conclusion

From the Table 1 we can see that the predictions based on the Malthusian model are in closer agreement with the reported population data of Nigeria. From the foregoing we remark that a Malthusian model can be generated using the census data or population estimate of a country for any two different years.

The socio-economic implication of this result is that Nigeria has a high fertility rate and thus an important issue of concern. This is because population growth has a far-reaching effect on country's development and standard of living. It is argued that large population is a vital resource for economic development. It constitutes labour (human resources) for production of goods and services as well as ready market for the produced goods and services. However, this depends on the size and quality of the population. Where the bulk of the population is illiterate and consists of aged people, the economy would operate below optimal level. This would result to low productivity, low income low saving, low capital formation and low investment. Therefore the macroeconomics implication of this is that of high unemployment, poor standard of living, huge government expenditure on social services, balance of payment problems and social crimes.

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