Journal of Physical Science and Innovation
ISSN: 2277-0119
Volume 9, No. 4, 2017

MATHEMATICAL IMPACT OF MALTHUSIAN POPULATION MODEL ON NIGERIAN GROWTH DOMESTIC PRODUCT

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ABSTRACT

The study investigates the mathematical impact of Malthusian population model on Nigerian Growth Domestic Product (GDP). Nigeria is a middle income, mixed economy and emerging market, with expanding financial, service, communications, technology and entertainment sectors. It is ranked as the 21^{st} largest economy in the world in terms of nominal GDP, and the 20^{th} largest in terms of Purchasing Power Parity. It is the largest economy in Africa; its re-emergent, though currently underperforming, manufacturing sector is the third-largest on the continent, and produces a large proportion of goods and services for the West African sub-region. The largely subsistence agricultural sector has not kept up with rapid population growth, and Nigeria, once a large net exporter of food, now imports a large quantity of its food products. An important idea regarding overpopulation as it relates to poverty is that presented by the Neo-Malthusian perspective. Thomas Malthus argued that overpopulation directly corresponds to human suffering due to the notion that human population increases geometrically while food production can only increase arithmetically. These trends, he argued, would result in a point at which a society experiences war, poverty, and famine as the need for food surpasses its availability. Malthus reasoned that the process of population growth would need to be checked by a decrease

in fertility or an increase in mortality. The Neo-Malthusianism perspective is essentially the application of Malthus' theories on current world systems in order to investigate trends and make predictions. The implications of a neo-Malthusian model are that the Earth can only sustain the agricultural needs of a limited population and that as overpopulation occurs, there are significant social and economic consequences. Neo-Malthusian perspective has also been extended beyond agricultural sustainability to describe the need and depletion of all resources. In conclusion, these interpretations suggest that overpopulation may in fact be a direct cause of poverty and starvation in societies around the world.

Keywords: Nigerian Economy, GDP, Malthusian Model and Over Population.

INTRODUCTION

Nigeria is a middle income, mixed economy and emerging market, with expanding financial, service, communications, and technology and entertainment sectors. It is ranked as the21stlargest economy in the world in terms of nominal GDP, and the 20th largest in terms of Purchasing Power Parity. It is the largest economy in Africa; its re-emergent, though currently underperforming, manufacturing sector is the third-largest on the continent, and produces a large proportion of goods and services for the West African sub region. Nigeria recently changed its economic analysis to account for rapidly growing contributors to its GDP, such as telecommunications, banking, and its film industry (Onuba, 2015).

Previously hindered by years of mismanagement, economic reforms of the past decade have put Nigeria back on track towards achieving its full economic potential. Nigerian GDP at purchasing power parity (PPP) has almost tripled from $170 billion in 2000 to $451 billion in 2012, although estimates of the size of the informal sector put the actual numbers closer to $630 billion. Correspondingly, the GDP per capita doubled from $1400 per person in 2000 to an estimated $2,800 per person in 2012 (again, with the inclusion of the informal sector, it is estimated that GDP per capita hovers around $3,900 per person). (Population increased from 120 million in 2000 to 160 million in 2010). These figures are to be revised upwards by as much as 80% when metrics are recalculated subsequent to the rebasing of its economy in April 2014 (Nigeria Rebasing GDP, 2015).

Although much has been made of its status as a major exporter of oil, Nigeria produces only about 2.7% of the world's supply (Saudi Arabia: 12.9%, Russia: 12.7%, USA:8.6%, Wikipedia, 2015) .To put oil revenues in perspective: at an estimated export rate of 1.9 Mbbl/d (300,000 m^3/d), with a projected sales price of $65 per barrel in 2011, Nigeria's anticipated revenue from petroleum is about $52.2 billion (2012 GDP: $451 billion). This accounts about 11% of official GDP figures (and drops to 8% when the informal economy is included in these calculations). Therefore, according to Rogers & Sedghi (2011) though the petroleum sector is important, it remains in fact a small part of the country's overall vibrant and diversified economy.

The largely subsistence agricultural sector has not kept up with rapid population growth, and Nigeria, once a large net exporter of food, now imports a large quantity of its food products, though there is a

resurgence in manufacturing and exporting of food products. In 2006, Nigeria successfully convinced the Paris Club to let it buy back the bulk of its debts owed to the Paris Club for a cash payment of roughly $12 billion (Center for Global Development, 2015).According to a Citigroup report published in February 2011, Nigeria will get the highest average GDP growth in the world between 2010 and 2050. Nigeria is one of two countries from Africa among 11 Global Growth Generators countries (businessinsider.com_2011). Nigeria's economy is struggling to leverage the country's vast wealth in fossil fuels in order to displace the poverty that affects about 33% of its population. Economists refer to the coexistence of vast wealth in natural resources and extreme personal poverty in developing countries like Nigeria as the "resource curse", although "resource curse" is more widely understood to mean an abundance of natural resources which fuels official corruption resulting in a violent competition for the resource by the citizens of the nation. Below is a table that shows the GDP growth and exchange rate of Nigerian naira to US Dollar from 1980-2014.

Year	Gross Domestic Produce (GDP in Billions)	US Dollar Exchange	Inflation (2000=100)	Index Per Capita Income (as % of USA)
1980	*58	1 Naira	1.30	7%
1985	*82	3 Naira	3.20	5%
1990	*118	9 Naira	8.10	2.5%
1995	*155	50 Naira	56	3%
2000	170	100 Naira	100	3.5%
2005	291	130 Naira	207	4%
2010	392	150 Naira	108	5%
2012	451	158 Naira	121	7%
2014	972	180 Naira	(no data)	11%

(Source: The World Bank Economic Report on Nigeria; May, 2013)

Neo-Malthusian Model

An important idea regarding overpopulation as it relates to poverty is that presented by the neo-Malthusian perspective. Thomas Malthus argued that overpopulation directly corresponds to human suffering due to the notion that human population increases geometrically while food production can only increase arithmetically. These trends, he argued, would result in a point at which a society experiences war, poverty, and famine as the need for food surpasses its availability. Malthus reasoned that the process of population growth would need to be "checked" by a decrease in fertility or an increase in mortality. The Neo-Malthusianism perspective is essentially the application of Malthus' theories on current world systems in order to investigate trends and make predictions. The implications of a neo-Malthusian model are that the Earth can only sustain the agricultural needs of a limited population and that as overpopulation occurs, there are significant social and economic consequences. Neo-Malthusian perspective has also been extended beyond agricultural sustainability

to describe the need and depletion of all resources. These interpretations suggest that overpopulation may in fact be a direct cause of poverty and starvation in societies around the world.

Neo-Malthusian theories have many critics and have been disputed and debated since their formulation. A major criticism of this theory is that the problem with food availability is not a result of insufficient food production but rather a result of inadequate distribution. Another prevalent criticism is that people will develop alternatives to depleted resources and will continue to adapt to their changing availability through the creation of new technologies and processes. The validity of neo-Malthusian theories continues to be debatable and it is unclear as to whether overpopulation is a cause of poverty or not. Although no definitive conclusion has yet been drawn regarding how well neo-Malthusian arguments describe the effects of overpopulation, it is an important perspective to understand and consider when investigating the correlation between population and poverty.

Malthusian Model of Population

Thomas Robert Malthus was the first economist to propose a systematic theory of population. Malthus proposes the principle that human populations grow exponentially (i.e., doubling with each cycle) while food production grows at an arithmetic rate (i.e. by the repeated addition of a uniform increment in each uniform interval of time). Thus, while food output was likely to increase in a series of twenty-five year intervals in the arithmetic progression 1, 2, 3, 4, 5, 6, 7, 8, 9, and so on, population was capable of increasing in the geometric progression 1, 2, 4, 8, 16, 32, 64, 128, 256, and so forth. This scenario of arithmetic food growth with simultaneous geometric human

population growth predicted a future when humans would have no resources to survive on. To avoid such a catastrophe, Malthus urged controls on population growth.

On the basis of a hypothetical world population of one billion in the early nineteenth century and an adequate means of subsistence at that time, Malthus suggested that there was a potential for a population increase to 256 billion within 200 years but that the means of subsistence were only capable of being increased enough for nine billion to be fed at the level prevailing at the beginning of the period(Onuba, 2015). He therefore considered that the population increase should be kept down to the level at which it could be supported by the operation of various checks on population growth, which he categorized as "preventive" and "positive" checks.

The chief preventive check envisaged by Malthus was that of "moral restraint", which was seen as a deliberate decision by men to refrain "from pursuing the dictate of nature in an early attachment to one woman", i.e. to marry later in life than had been usual and only at a stage when fully capable of supporting a family. This, it was anticipated, would give rise to smaller families and probably to fewer families, but Malthus was strongly opposed to birth control within marriage and did not suggest that parents should try to restrict the number of children born to them after their marriage. Malthus was clearly aware that problems might arise from the postponement of marriage to a later date, such as an increase in the number of illegitimate births, but considered that these problems were likely to be less serious than those caused by a continuation of rapid population increase. He saw positive checks to population growth as being any

causes that contributed to the shortening of human life spans. He included in this category poor living and working conditions which might give rise to low resistance to disease, as well as more obvious factors such as disease itself, war, and famine. Some of the conclusions that can be drawn from Malthus's ideas thus have obvious political connotations and this partly accounts for the interest in his writings and possibly also the misrepresentation of some of his ideas by authors such as Cobbett, the famous early English radical. Some later writers modified his ideas, suggesting, for example, strong government action to ensure later marriages. Others did not accept the view that birth control should be forbidden after marriage, and one group in particular, called the Malthusian League, strongly argued the case for birth control, though this was contrary to the principles of conduct which Malthus himself advocated.

Conceptual Framework of Population in Relation to Malthusian Model

After reviewing the key development and growth facts, it is clear that there is need for a theory that can generate a period of constant living standards, followed by a transition period with modest increases in the living standard, followed by a period of modern economic growth. Already, there is a model that can account for the period of modern economic growth; which is the Solow Model. It is true that the Solow Model can generate a steady state with a constant level of per capita output. One possibility is to interpret the pre-1700 era of constant livings standards as the steady state of the Solow Model absent technological change. The problem with this interpretation is that technology was not stagnant before 1700. Joel Mokyr a noted economic historian at Northwestern University has documented that numerous and important technological innovations occurred well

before 1700.In light of the historical record on technological change, we proceed to alternative theory and model of this pre-1700 era. This is the Malthusian model that goes back to Rogers & Sedghi (2011) and the classical economists.

There are two key components of the model. The first is a production function with a fixed factor of production. By fixed, wemean that its supply cannot be changed over time. Labor and capital are not fixed factors as both can be increased over time. In the Malthusian model, the fixed factor is **land**, and the second key component is the **population** growth function that is an increasing function of per capital consumption. These two elements ensure that the steady state is characterized by a constant living standard even when there is technological change.

We first proceed by studying the Malthusian model with no capital and absent technological change to help develop intuition for the model and then follow this up with an algebraic study of the Malthusian model with capital accumulation and exogenous technological change. If for example we want to use Malthusian model to estimate the population of students in Waziri Umaru Federal Polytechnic Birnin Kebbi in 2020, then we are to use differential equation population growth model. (Exponential law of population growth)

500 students in 1990
2000 students in 1997
Estimate population in 2020

Then the differential equation population growth model will be:

$$\frac{dp}{dt} = kp \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

i.e. Rate of change of population(dp) with respect to time(dt) is directly proportional to the product of population (p) with constant (k).

Now solving equation (1) using separation of variables, by dividing and multiplying both side by p and dt we will have:

$$\frac{dp}{p} = kdt \quad \ldots\ldots (2)$$

By integrating both side of equation (2), we have,

$$\int \frac{dp}{p} = \int k\,dt \quad \ldots\ldots (3)$$

$$\ln|p| = kt + c$$

$$e^{(\ln|p|)} = e^{(kt+c)}$$

Since exponential (e) and natural logarithm (ln) are inverse operations;

$$p = e^{kt+c}$$

$$p = e^{kt} \times e^{c}$$

$p = e^{kt} \times c_1$ if $t = 0$

$$p = c_1$$

$$c_1 = p_0$$

$\mathbf{p = e^{kt} \times p_0}$ This is the Malthusian model.

By applying the Malthusian model to estimate students of Waziri Umaru Federal Polytechnic Birnin Kebbi;

Where $p = 2000$, $p_0 = 500$ and $t = 7$ years

$$p = e^{kt} \times p_0$$

$$2000 = e^{k\times 7} \times 500$$

$$2000 = 500e^{7k}$$

Dividing both side by 500

$$\frac{2000}{500} = \frac{500e^{7k}}{500}$$

$$4 = e^{7k}$$

By taking the natural logarithm of both side again;

$$\ln|4| = \ln\left|e^{7k}\right|$$

$$\ln|4| = 7k$$

Dividing through by 7 to make k the subject of the formulae.

$$\frac{\ln|4|}{7} = \frac{7k}{7}$$

$$\frac{\ln|4|}{7} = k$$

$k = \frac{\ln 4}{7}$using calculator to find ln 4

$$k = \frac{1.386294361}{7} = 0.198042051$$

Therefore, referring back to our Malthusian model $\mathbf{p = p_0 e^{kt}}$

$$p = 500e^{kt}$$

To find the population of students in Waziri Umaru Federal Polytechnic by the year 2020;

$$p = ?, t = 30 \text{ years (i.e. } 2020 - 1990), k = 0.198042051$$

$$p = 500e^{30(0.198042051)}$$

$$p = 500e^{5.941261548}$$

$$p = 500 \times 380.414538$$

$$p = 190{,}207.269 = 190{,}207$$

Therefore, the estimated population of students in Waziri Umaru Federal Polytechnic by the year 2020 using Malthusian model will be one hundred and ninety thousand two hundred and seven students.

Sources of Population Data

(i) **Periodic Censuses or Enumeration:**–This is the main source of demographic statistics in many countries. It is define as the total process of collecting, compiling and publishing demographic, economic and social data pertaining at specified time or times to all persons in a country or delineated territory. The census of a population provides a satisfactory method of recording the size, distribution and other characteristics of the population at fixed interval. A census is a vast undertaking and careful and advance planning, adequate provision of resource, painstaking control and training of the enumerators are essential for its successful implementation.

(ii) **Sample Surveys or Inquiries:**–Sample surveys, seeks to collect information only from a fraction of the population. It is employed to arrive at estimates of demographic characteristics, size, distribution, mortality, fertility and migration. Demographic surveys are of two main kinds:

- **Single Round Survey:**– In single round surveys, the population is enumerated only once, at the time of the survey, when retrospective questions on demographic events are asked.
- **Multiple Round Surveys:**–In multiple round surveys (repeated surveys or follow up surveys), repeated visits are made to households in selected sample areas in order to ascertain what events have occurred during the interval between the visits. The multi-round system provides information for checking and correcting data collected during the earlier surveys but they are expensive, sampling and administrative problems loom large.

(iii) **Vital Registration Systems:**–This is another source of population statistics, it consist of continuous registration of birth, death and marriages etc. In many developing countries, vital statistics are

nonexistent. In those where they exist, the data are in adequate and defective to the extent that, they can hardly serve to measure accurately levels and trends of fertility and mortality at any given time.

(iv) **International Sources of Population Data:**–Population data are also published at the international level, apart from the individual country source and publications. The United Nations statistical office gathers together, for yearly publication demographic and statistical information from many parts of the world. This publication is known as the United Nation Demographic Yearbook. First published in 1948, the yearbook provides internationally comparable and comprehensive annual statistics on population, its size, fertility and mortality urbanization etc. Which are put to a wide range of uses by government and institutions, private organizations and international agencies.

CONCLUSION

Thomas Malthus argued that overpopulation directly corresponds to human suffering due to the notion that human population increases geometrically while food production can only increase arithmetically. These trends, he argued, would result in a point at which a society experiences war, poverty, and famine as the need for food surpasses its availability. He therefore considered that the population increase should be kept down to the level at which it could be supported by the operation of various checks on population growth. This scenario of arithmetic food growth with simultaneous geometric human population growth predicted a future when humans would have no resources to survive on. To avoid such a catastrophe, Malthus urged controls on population growth. The implications of this are that the Earth can only sustain the agricultural needs of a limited

population and that as overpopulation occurs, there are significant social and economic consequences.

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Reference to this paper should be made as follows: Zayyanu Umar & Yusuf Usman (2017), Mathematical Impact of Malthusian Population Model on Nigerian Growth Domestic Product. J. of Physical Science and Innovation, Vol. 9, No. 4, Pp. 18-32