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POPULATION GROWTH AND FOOD PRODUCTION: AN INVESTIGATION INTO THE TENACITY OF THE MALTHUSIAN DOCTRINE IN NIGERIA

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ABSTRACT
The study set out to test the Malthusian doctrine which stated that "population, when unchecked, increased in a geometrical ratio, and subsistence for man in an arithmetical ratio", using Nigeria as a case in hand. Data on human population and food production in Nigeria (1961- 2018) were collected from FAOSTAT and used. Geometric Progression and Arithmetic Progression were applied on the collected data to generate second sets of data that fitted geometric and arithmetic progression, respectively. Descriptive statistics and the student t-test technique for comparison of means of independent samples were used to achieve the objectives of this study. Results of the Student's t-tests (calculated t-value of 0.693 and computed p-value of 0.490 for food production; calculated t-value of 4.700 and computed p-value of 0.000 for population) lead to the acceptance of the null hypothesis for food production and rejection of the null hypothesis for population growth. The mean difference of 28899193.34 indicates that the mean actual population data (102501137.84) was statistically and significantly higher than the mean expected population data (73601944.50) over the study period. It was concluded that (i) food production in Nigeria over the study period increased in arithmetical progression in accordance with Malthusian doctrine, suggesting that the series of agricultural policies and programmes the Government in Nigeria since independence, barely raised agricultural food production in Nigeria beyond subsistence level, and (ii) population in Nigeria over the period of the study increased at a rate much greater than Malthusian doctrine's geometrical progression, at an exponential rate, suggesting that the policies on population, implicit and explicit, enacted in Nigeria since independence have not succeeded in significantly slowing down the rate of growth of population in Nigeria. The study recommended further studies into the relationship between demography and economic growth in Nigeria.

Keywords: Nigeria, Food production, Population growth, Malthusian doctrine.

INTRODUCTION

Nigeria's population has increased rapidly from 55 million according to the 1963 census figures, through 140 million as contained in the report of the 2006 national census to an estimated more than 170 million in 2015 (Ammani *et al.*, 2015). Nigeria's population with a growth rate of 2.8% per annum between 1952 and 1991, is one of the fastest growing populations in the world, accounting for one in every five people in sub-aharan Africa consequence of very high birth rates (Tartiyus *et al.*, 2015). The country's population is estimated to reach 400 million by 2050 (FAO, 2021). This rapid growth in population has increased substantially the demand for food in the country.

From the early years of independence, the government's policies on population, implicitly contained in the National Development Plans, were aimed at pursuing a "qualitative population policy by integrating the various voluntary family planning schemes into the overall health and social welfare programmes of the country" (FGN, 1970); and bringing "the overall growth rate of the population down to a level that will not impose excessive burden on the economy" through ensuring that the fertility rate in the country decline (FGN, 1981). Nigeria's first explicit population policy, National Policy on Population for Development, Unity, Progress, and Self-Reliance (FGN, 1988) set out to achieve a number of goals among which were reducing the population growth rate, promoting awareness of population growth and its effects on development, educating young people on population matters prior to the ages of marriage and childbearing, reducing fertility by increasing the age at marriage to 18 years, providing family planning services, and managing the special needs of infecund and subfecund couples. The second explicit population policy of 2004, National Policy on Population for Sustainable Development, stated as its goals. The protection of the health of mother and child, to reduce the proportion of women who get married before attaining 18 years of age by 50 percent by 1995 and 80% by the year 2000; to reduce the number of children a woman is likely to have during her lifetime, now over 6 to 4 per woman by year 2000 and reduce the present rate of population growth from about 3.3% per year to 2.5% by 1995 and 2.0% by the year 2000 (Shofoyeke, 2014; Odimegwu, 1998; Obono, 2003).

In the opening statement of Chapter 2 of his seminal work An Essay on the Principle of Population, Malthus (1798) stated that "population, when unchecked, increased in a geometrical ratio, and subsistence for man in an arithmetical ratio". This statement came to be known as Malthus' theory or doctrine (Galor and Weil, 2000; Hansen and Prescott, 2002; O'Rourke and Williamson, 2005; Charbit, 2009). The crux of the Malthus theory was that humankind is permanently trapped by the intersection of two laws or premises. The first concerned the rate at which human populations grow where the 'passion between the sexes' (assumed to be constant) under conditions of 'natural' fertility (early marriage and no contraception, abortion or infanticide; and normal mortality), would lead to geometrical growth in population. The second premise was that food and other resource production will grow much more slowly in an arithmetic progression. The thinking was that populations would be trapped, growing rapidly for a few generations, and then be savagely cut back by crises that would occur, manifesting itself in one (or a combination) of three 'positive' checks acting on the death rate, war, famine and disease (Macfarlane,1997; Williams, 2004; Broadberry and O'Rourke, 2010; Mayhew, 2014; Clark and Cummins, 2015). In the second edition of the book (Malthus, 1803) turned his laws of population into tendencies, likelihoods or probabilities, to which there were exceptions. Thus, the population trap became avoidable if 'preventive checks' such as 'moral restraint' (celibacy and delayed marriage) and 'vice' (contraception of all kinds, abortion and infanticide) are applied (Macfarlane, 1997; Broadberry and O'Rourke, 2010; Clark and Cummins, 2015). To these preventive checks we can now add advances in agriculture and biotechnology that ensure rapid increase in food production.

According to FAO (2021), Nigeria has 70.8 million hectares of agriculture land area with maize, cassava, guinea corn, yam beans, millet and rice being the major crops produced. At Nigeria's independence in 1960, agriculture accounted for over 70% of total food consumption (Reynolds, 1966; Ilugbuhi, 1968). However, about 20 years after Independence, it was observed that Nigeria cannot produce enough food for its fast-growing population (Abdullahi, 1981). Many challenges were identified as militating against the production and productivity of Nigeria's agricultural sector. These include; poor land tenure system, low level of irrigation farming, climate change and land degradation. Others are low technology, high production cost and poor distribution of inputs, limited financing, high post-harvest losses and poor access to markets (FAO, 2021). Over the years, the Government formulated and implemented a number of policy initiatives and programmes aimed at addressing the aforementioned challenges and increasing food production to meet domestic demand as well as an abundance of commodity crops for export (Oyatoye, 1983; Moser *et al.*, 1997; Anyanwu *et al.*, 2011; NPC, 2004; FMARD, 2011; CBN, 2015; CBN, 2016; FMARD, 2016; FMARD, 2017).

The question that arises for this study is that in spite of agricultural policies and programmes and the implicit and explicit population policies implemented in Nigeria since independence, has growth in food production and population in Nigeria differs significantly from the Malthusian doctrine? In other words, is the growth in population and food production in Nigeria since independence respectively geometrical and arithmetical in progression? Findings of this study are expected to modestly contribute to the literature on population growth and food production in Nigeria.

The following hypotheses were formulated and tested in the course of this study:

i. There is no significant difference between the mean actual population and the expected population (geometric progression) in Nigeria during the study period.
ii. There is no significant difference between the mean actual food production and the expected food production (arithmetic progression) in Nigeria during the study period.

For the purpose of this paper, the data used were categorised and operationally defined as follows: (i) Actual: actual data collected on human population and food production in Nigeria (1961- 2018) as published by FAOSTAT (FAO, 2022), and (ii) Expected: data on human population and food production in Nigeria (1961- 2018) generated for the purpose of this study, by using the base and second year data to estimate and compute subsequent years' data based on geometric and arithmetic progressions, respectively.

MATERIALS AND METHODS

Data of the Study

Data on human population and food production in Nigeria (1961- 2018) were collected from FAOSTAT (FAO, 2022) and used.

Assumption of the Study

For the purpose of this study, the sum total output of maize, millet, rice, sorghum, cassava and yam produced in the country is taken as proxy for food production in Nigeria over the period 1961-2018 based on their position as the most important food crops produced in Nigeria (FMARD, 2011; FAO, 2021).

Analytical Techniques

Descriptive statistics and the student's t-test technique for comparison of means of independent samples were used to achieve the objectives of this study. For a description of the student's t-test technique see Hogg and Craig (1995); Lehmann (1991); Keller and Warrack (2003). Geometric Progression and Arithmetic Progression were applied, as expounded by Chiang and Wainwright (2005), to the collected data to generate the expected data for human population and food production, respectively over the period 1961-2018. Data for the base year 1961 and the second year 1962 were used to calculated the respective constants, common ratio and common difference, which were further employed in computing the expected data for human population and food production, respectively, for the period 1961-2018.

RESULTS AND DISCUSSION

Figure 1 gives a graphic representation of how the 2 sets of food production data employed in this study compare with each other over the period 1961-2018. It appears that the 2 sets of data are similar as the smooth curve of the expected data almost perfectly fits that of the actual food production data. However, to ascertain whether the 2 sets of data are statistically significantly not different we test our first hypothesis.

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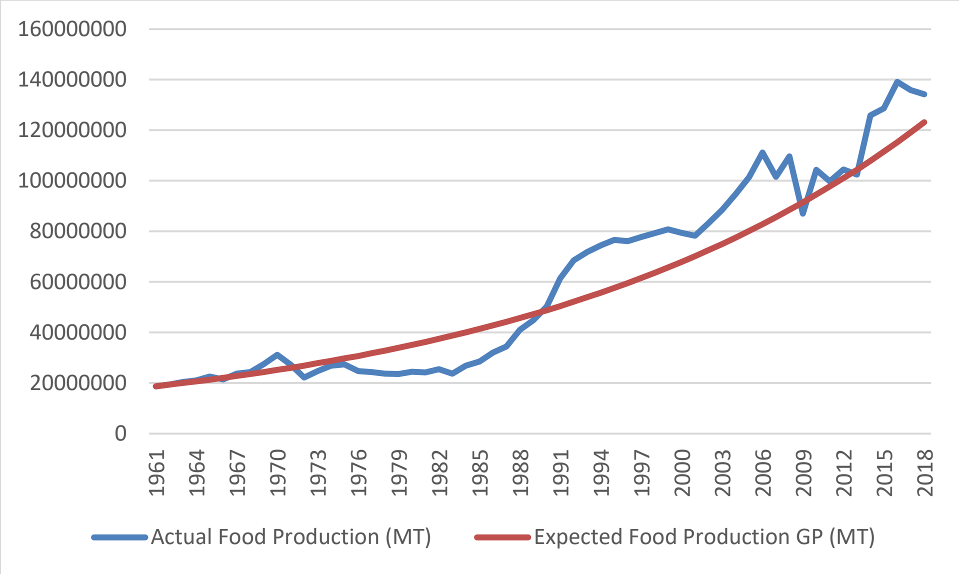

Figure 1: Graphical representation of actual and expected food production data in Nigeria (1961-2018)

Figure 2 gives a graphic representation of how the 2 sets of population data employed in this study compare with each other over the period 1961-2018. The 2 sets of data are apparently different. From 1961 to about 1974, the 2 data appeared similar, however beyond 1974 the actual population data increased more rapidly than the expected data reaching a figure of about 2 million in 2018 compared to the value of 100 million for the expected population data in 2018. This finding suggest that Nigeria's population increase exponentially rather than geometrically. To ascertain whether the 2 sets of data are statistically significantly different we go on to test our hypothesis.

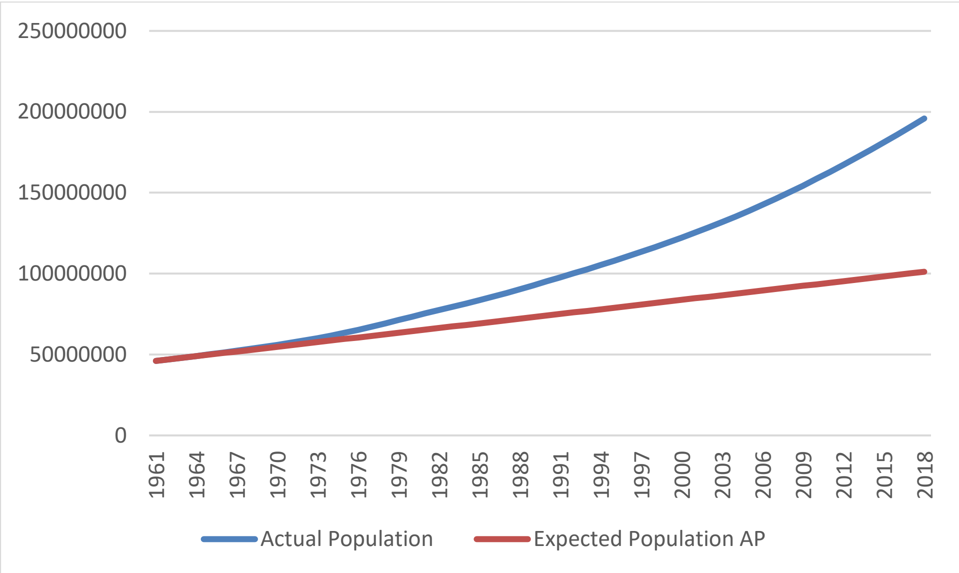

Figure 2: Graphical representation of actual and expected population data in Nigeria (1961-2018)

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Results of Levene's test and t-test for actual and expected food production and population data are presented in Table 1. The Levene's test for equality of variances was run to test the basic assumption of the t test, the homoscedasticity of the variances of the 2 sets of food production data, actual and expected. The calculated F-value (8.788) is significant when compared with the computed p-value of (0.004), which indicated that the assumption of homogeneity of variance has been violated. Consequently, the t-value calculated based on the assumption of equality of variances was dropped in favour t-value calculated based on the assumption of non-equality of variances, interestingly both values are similar. From the results of the student's t-test, the calculated t-value of 0.693 is found to be not significant when viewed in relation to the computed p-value of 0.490, hence the null hypothesis is accepted and it is thus concluded that there is a no significant difference in mean total quantity of food production in Nigeria between the actual food production data and expected food production data over the period (1961-2018). This finding further lends credence to our earlier reported finding based on graphical presentation. Thus, we can conclude that food production in Nigeria over the period 1961-2018 increased in arithmetical progression in accordance with Malthusian doctrine. This conclusion suggests that in spite of the series of agricultural policies, programmes and projects embarked upon by the Federal Government of Nigeria since independence (Oyatoye, 1983; Moser *et al.*, 1997; Anyanwu *et al.*, 2011; NPC, 2004; FMARD, 2011; CBN, 2015; CBN, 2016; FMARD, 2016; FMARD, 2017), agricultural food production in Nigeria has barely gone beyond subsistence level.

Again, the Levene's test for equality of variances was run to test the basic assumption of the t-test, the homoscedasticity of the variances of the 2 sets of food population data, actual and expected. The calculated F-value (52.651) is highly significant when compared with the computed p-value of (0.000), which indicated that the assumption of homogeneity of variance has not been violated. Thus, the t-value calculated based on the assumption of equality of variances was used.

Table 1: Results of Levene's test and t test for actual and expected food production and population data

Parameter	Assumptions	F-value	Sig.	t-value	p-value (2-tailed)	Mean difference	Standard error difference
Food production	Equal variance assumed	8.788	0.004	0.693	0.490	4422088.67	6381305.77
	Equal variance not assumed			0.693	0.490	4422088.67	6381305.77
	Equal variance assumed	52.651	0.000	4.700	0.000	28899193.34	6148166.24
Population	Equal variance not assumed			4.700	0.000	28899193.34	6148166.24

From the results (Table 1) of the student's t-test, the calculated t-value of 4.700 is found to be highly significant when viewed in relation to the computed p-value of 0.000, hence the null hypothesis is rejected and it is thus concluded that there is a highly significant difference in mean total population in Nigeria between the actual population data and expected population data over the period (1961-2018). The mean difference of 28899193.34 indicates that the mean actual population data (102501137.84) is statistically and significantly higher than the mean expected population data (73601944.50) over the study period. Thus, we can conclude that population in Nigeria over the period 1961-2018 increased at an exponential rate, a rate much greater than Malthusian doctrine's geometrical progression. This conclusion suggests that all the earlier mentioned policies on population, implicit and explicit, enacted in Nigeria (FGN, 1970; FGN, 1981; FGN, 1988; Shofoyeke, 2014; Odimegwu, 1998; Obono, 2003) have not succeeded in significantly slowing down the rate of growth of population in Nigeria. Another factor that could be implicated in rapid growth of population in Nigeria is the influx of illegal aliens into the country through its porous borders supported by shared ethnoreligious identity, and sentiment, with some indigenous Nigerian tribes.

CONCLUSION AND RECOMMENDATIONS

The study concluded that (i) food production in Nigeria over the study period increased in arithmetical progression in accordance with Malthusian doctrine, suggesting that the series of agricultural policies and programmes the Government in Nigeria since independence, barely raised agricultural food production in Nigeria beyond subsistence level, and (ii) population in Nigeria over the period of the study increased at a rate much greater than Malthusian doctrine's geometrical progression, at an exponential rate, suggesting that the policies on population, implicit and explicit, enacted in Nigeria since independence have not succeeded in significantly slowing down the rate of growth of population in Nigeria. This study recommends that further studies into the relationship between demography and economic growth in Nigeria should be undertaken.

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Table 1: Appendix on Data and Source

Year	Actual food production (MT)[a]	Expected food production GP (MT)[b]	Actual population[c]	Expected population AP[d]
1961	18726000	18726000	46063563	46063563
1962	19355000	19355193.6	47029822	47029822
1963	20433000	20005528.1	48032934	47996081
1964	21029000	20677713.85	49066760	48962340
1965	22537000	21372485.03	50127921	49928599
1966	21450000	22090600.53	51217973	50894858
1967	23701000	22832844.71	52342233	51861117
1968	24381000	23600028.29	53506196	52827376
1969	27579000	24392989.24	54717039	53793635
1970	31183000	25212593.68	55982144	54759894
1971	27228000	26059736.83	57296983	55726153
1972	22245000	26935343.99	58665808	56692412
1973	24749000	27840371.54	60114625	57658671
1974	26910000	28775808.03	61677177	58624930
1975	27435000	29742675.18	63374298	59591189
1976	24685000	30742029.06	65221378	60557448
1977	24299000	31774961.24	67203128	61523707
1978	23748000	32842599.94	69271917	62489966
1979	23657000	33946111.3	71361131	63456225
1980	24494000	35086700.64	73423633	64422484
1981	24219000	36265613.78	75440502	65388743
1982	25507000	37484138.4	77427546	66355002
1983	23732000	38743605.45	79414840	67321261
1984	26853000	40045390.59	81448755	68287520
1985	28579000	41390915.72	83562785	69253779
1986	32099322	42781650.48	85766399	70220038
1987	34514000	44219113.94	88048032	71186297
1988	41051000	45704876.17	90395271	72152556
1989	44925000	47240560.01	92788027	73118815
1990	50256008	48827842.83	95212450	74085074
1991	61472000	50468458.34	97667632	75051333
1992	68475000	52164198.54	100161710	76017592

Note on sources: [a] and [c] from FAOSTAT (2022). [b] and [d] author's estimate based on the mathematics of series and sequence as mentioned in the methodology section.

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Table 1: Appendix on Data and Source **Cont'd.**

Year	Actual food production (MT)[a]	Expected food production GP (MT)[b]	Actual population[c]	Expected population AP[d]
1993	71768000	53916915.62	102700753	76983851
1994	74441000	55728523.98	105293700	77950110
1995	76633000	57601002.39	107948335	78916369
1996	76173000	59536396.07	110668794	79882628
1997	77743000	61536818.97	113457663	80848887
1998	79337000	63604456.09	116319759	81815146
1999	80803000	65741565.82	119260063	82781405
2000	79432000	67950482.43	122283850	83747664
2001	78259000	70233618.64	125394046	84713923
2002	83267000	72593468.22	128596076	85680182
2003	88596000	75032608.76	131900631	86646441
2004	94799000	77553704.41	135320422	87612700
2005	101435000	80159508.88	138865016	88578959
2006	111154000	82852868.38	142538308	89545218
2007	101604000	85636724.75	146339977	90511477
2008	109685000	88514118.71	150269623	91477736
2009	87027858	91488193.09	154324933	92443995
2010	104322130	94562196.38	158503197	93410254
2011	99777005	97739486.18	162805077	94376513
2012	104514828	101023532.9	167228794	95342772
2013	102481020	104417923.6	171765816	96309031
2014	125823829	107926365.9	176404934	97275290
2015	128629900	111552691.7	181137448	98241549
2016	139149498	115300862.2	185960241	99207808
2017	135836952	119174971.2	190873244	100174067
2018	134189727	123179250.2	195874683	101140326

Note on sources: [a] and [c] from FAOSTAT (2022). [b] and [d] author's estimate based on the mathematics of series and sequence as mentioned in the methodology section.