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REVISITING POPULATION GROWTH AND FOOD PRODUCTION NEXUS IN NIGERIA: AN ARDL APPROACH TO COINTEGRATION

Purpose. *This study focused on the relationship between the increasing population and level of food growth in Nigeria.*

Methodology / approach. *Agriculture's contribution to GDP was used to proxy food production alongside population growth rate. The ARDL Model was used to estimate both long and short run population-food growth relations over a 35-year period of 1982–2016. The Augmented Dickey-Fuller, Philip Peron and Kwiatkowski-Philips-Schmidt-Shin stationarity tests were carried out to ensure the stationarity of the variables.*

Results. *The results showed that the variables are integrated of mixed order. The Bounds test established cointegration between population growth and food production in Nigeria which validated the Malthusian theory. However, the estimates revealed that population growth had a positive and significant relationship with food growth in both the long and short run. This implies that increase in population is yet to take a negative effect on availability of food against Malthus postulation.*

Originality / scientific novelty. *This study is the only study on the validation of Malthusian theory of population which employed a rigorous means to establish the order of integration of the variables required for the validation test. It also looked at the place of agriculture in the midst of growing population.*

Practical value / implications. *This outcome is a call to intimate the populace on the dangers of population explosion on one hand and on another hand, the government to ensure provision of adaptable and adoptable technology in the agricultural sector to ensure that food production increases as Nigeria is blessed with the land and weather to make this happen.*

Key words: *ARDL, Food Production, Population Growth, Malthus Theory, Nigeria.*

Introduction and review of literature. Nigeria, a developing nation has the potentials to develop in several areas of the economy such as education, agriculture, industry, service, health and science and technology. It should also be noted that her population growth cannot be overlooked. Coming with these developments is increase in population which if not managed – turned around for proper development strides – negatively impacts on the overall growth of the nation, especially as it may turn out to be a tool for civil unrest as seen in some growing countries today. Using an annual growth rate of 3.5 % over the 140 million people recorded in the last census, Nigeria with a population of about 182 million people has more than half of the people below 30 years of age [1]. While the positive of this population

demography showed that there are more active Nigerians available for productivity in various economic sectors, the negative is that more than half of the entire population is still physiologically and biologically growing and thus will require food in the right quantity and quality. Should productivity of the agricultural sector not be commensurate with population growth, coupled with the constantly rising unemployment in Nigeria, the dangers of food supply not keeping up with population growth spoken of by the renowned Mathematician, Thomas Malthus is imminent.

Malthus looked into the future in his work "An Essay on the Principle of Population" by postulating that population growth will so much increase that food growth will not be able to supply the required food in quantity, more especially. In his work [2], aside the major and popular postulation of food supply not being able to meet up with population growth, he made two laws which are hardly being spoken of in the literature. These laws he called the fixed laws of nature. He stated the laws to be (1) that food is necessary for the existence of man and (2) that the passion between the sexes is necessary and will remain nearly in its present state. These natural laws have given birth to about 6 billion people in the world out of which about 182 million of them are in Nigeria. He noted that assuming these laws were granted to be true, the power of population is indefinitely greater than the power to produce food for man and concluded by saying population, if unchecked, increase in a geometric ratio. He then advised that by the law of nature which makes food very crucial to the continuous existence of man, the effects of these two unequal powers must be kept equal. However, though he believed population is the phenomenon to be checked, it seems Malthus closed his thoughts to other factors that could have otherwise made food available to the growing population.

It seems he limited his thoughts around the events in the Great Britain at that time. Though the population may be growing, and in fact more than food supply, it has not been empirically proven that food supply actually grows "arithmetically" while population grows "geometrically". He didn't take into consideration the fact that the same population will grow its own food for survival. While he was right in his submission about the law of diminishing marginal effect of population growth on land availability, i.e, as population grows, it occupies more and more of the land available and as land, a natural resource is in fixed quantity, its availability for agricultural activities becomes inadequate, he didn't take into consideration the invention of agricultural technology that can allow for production of more foods on a smaller space of land. He also limited the food supplied to the people to food grown from within, not considering the prosperity of nations that can afford them to import even foods that they cannot produced thereby taking care of growth in population.

It is in the light of the foregoing that it became necessary to understudy the population-food growths relations in Nigeria. As the most populous African nation, she cannot afford food crises in the midst of growing active population that could lead to civil unrest. The position of Nigeria among the comity of nations – especially in Africa, is that if Nigeria sneezes the rest of Africa will catch cold.

Malthus' essay on principle of population and its implication on society welfare

in 1798 has raised couple of fundamental questions empirically among development economist who design policy framework. Thus, a clear understanding of the Malthusian claim is pertinent in every country for adequate policy formulation/design and subsequently, implementation. Malthus' essay in 1798 was an invitation to numerous studies see [3–6]. Ali et al. [7] investigated the impact of population growth on economic development in Bangladesh using time series data from 1981 to 2014. The Multivariate analysis found significant and negative relationship between population growth and measures of economic advancement. The study claimed that rapid population growth is a problem in Bangladesh since it has the tendency to reduce savings and investment by extension. It was concluded that the development of independent media and liberal education will go a long way to sensitize people on a smaller family size that is ideal. In India [8] studied the relationship between population growth and economic development using data between 1980 and 2013. The study established significant and positive unidirectional relationship running from economic development to population growth.

Incorporating unemployment rate and expenditure on health and education [9] employed ARDL to examine presence of long run relationship among the variables in Pakistan. The results of the study indicated that population growth impact significantly on economic development and negatively on unemployment rate in Pakistan. They concluded that government should utilize the additional workforce (from unemployment) efficiently as a policy tool to achieve high and desired level of growth.

Similarly [10] found a negative relationship between population growth and measures of economic development. The study noted that population growth has become a critical issue that discourages economic development and must be addressed seriously and squarely in order that the country my have respectable economic growth. Thuku et al. [11] investigated the impact of population change on economic growth in Kenya. Using time series data from 1963 to 2009 and applying Vector Auto Regressive technique, population and economic growth were found to have a long run relationship, and they were positively correlated. Population growth rate was found to have a positive impact on economic growth within the study period. It was concluded from the study that Kenya population has the tendency to promote economic growth and subsequently economic development in due course.

To validate the Malthusian postulation in Nigeria [12] used time series data covering the period from 1960 to 2016. The study used food production, agricultural land, population growth rate and growth in the agricultural sector of the economy as its variables. Employing the Bounds test for the long-run relationship among the variables, and ARDL to estimate the long and short run dynamics of the variables, it was discovered that in the long-run, population growth and food production move proportionately while population growth poses a depleting effect on food production in the short-run, thus validating the incidence of Malthusian impact in Nigerian economy in the short-run. The Granger causality test further indicates the unidirectional relationship of causality moving from population growth rate to

agricultural land.

Limiting the structure of the model to the tendencies of the Malthusian theory by using only agricultural production and population growth [13] researched on the impact of a growing population on agricultural output in Nigeria using annual time series data from 1986 to 2016. Employing the Johansen co-integration test, the study discovered a long-run relationship between agricultural production and population growth in Nigeria. The study also discovered an indirect relationship between agricultural output which was used as the dependent variable, and population growth rate. Okwori et al. [14] could not validate the theory of Malthus within the period between 1982 and 2012. The study found out that population growth had no significant impact on economic development in Nigeria within the study period.

Further studies on the validation of the Malthusian theory in Nigeria such as [15] also affirmed the Malthusian postulate in a multiple regression framework. Their study accounted for several food crops and their impact on population growth. The study empirical findings revealed a significant tradeoff between population growth and each food crop investigated. Onwuka et al. [16] also shed light on the theme and posited that population has not kept pace with economic growth. The study also accounted for the oil and agricultural sectors in her econometric framework. Empirical findings revealed a positive relationship between oil and agricultural sectors in her econometric framework. Thus [16] also validated Malthusian theory via an empirical investigation as seen between periods 1980–2003.

Nigeria is the most populous African nation with about 187 million people and still growing. This growing population inhibits the arable lands that are required for food production to keep the teeming population alive. It is therefore imperative that we understudy this economic phenomenon in the bid to look into the future and make recommendations to save Nigeria from possible food draught for her citizens.

The purpose of the article. This study focused on the relationship between the increasing population and level of food growth in Nigeria. This study hence sought to answer the following questions: (i) Is there a long run relationship between food production and population growth? (ii) Is Malthus vision of food-population growth relationship valid in Nigeria?

Data and Methodology. *Data.* In order to examine the dynamic relationship between population growth and food production, popularly known in the literature a Malthusian hypothesis, the study leverages on time series data from 1982–2016. The data used were retrieved from the bulletin of the National Bureau of Statistics of Nigeria and the World Bank data base CD-ROM 2018. The time span of the data is restricted based on data availability. In table 1 is the description of variables.

Method. In line with [12] and the fundamentals of the Malthusian theory of population which was predicated on the inability of food growth to satisfy the food need of a growing population, we limited this study to examine how population growth interacts with food growth. The general model for our study was stipulated as:

$$InAGDP = \beta_0 + \beta_1 POP + \varepsilon_I \quad (1)$$

Table 1

Description of Variables

Variable	Description
InAGDP	Natural logarithm of agriculture's contribution to GDP as proxy for food production.
POP	Population growth in percentage.

Source: authors' compilation.

To avoid spurious regression estimates, the unit root test was carried out to ascertain the stationarity of the variables. The ADF test was carried out by estimating:

$$\Delta Y_t = \propto + \rho Y_{t-1} + \sum_{i-1}^{j} Y\Delta Y_{t-j} + U_t \quad (2)$$

The unit root test was done employing the Augmented Dickey Fuller. Phillip-Perron unit root test which is non-parametric unit root test was also carried out to further ascertain the stationarity properties and maximum order of integration of the variables. This study also employed the use of KPSS stationarity test as confirmatory test to validate the ADF and PP unit root test. However, worthy of mention is that the KPSS stationarity test has a reverse null hypothesis against which is in converse to ADF and PP. From the estimates, the variables are of mixed integration. Autoregressive Distributed Lag Model was employed to examine and ascertain the presence of cointegration in the economic relationship of food and population growths.

Results and discussion. The results of the unit root tests are as reported in table 2. While the AGDP was stationary after first difference, the POP was stationary at levels. The KPSS results are in harmony with the findings of ADF and PP. Thus, we submit that the series are integrated of mixed order.

Table 2

Unit root test

Variable	ADF Statistics		Phillip-Perron Statistics		KPSS Statistics		Order of Integration
	Levels	1st Difference	Levels	1st Difference	Levels	1st Difference	
AGDP	0.14	-5.74**	0.14	-5.74**	0.68**	0.028	I(0)
POP	-4.70**	-2.56**	-1.35	-3.87**	0.28	0.101	I(1)

Note. **at 0.05 percent level.

Source: authors' computation via [10].

From the foregoing, the mixed nature of the integration of the indicated that the Autoregressive Distributed Lag (ARDL) Model by [17] which was further extended by [18] was suitable for this study because it is capable of estimating both long and short run relationships of variables in a single model. The ARDL functional relationship is stated as follow:

$$InAGDP = \beta_0 + \beta_1 POP + \varepsilon_i \quad (3)$$

Where β_0 is the constant term and β_1 is parameter coefficient.

The general ARDL model to estimate the long and short run estimates was

stated as:

$$\Delta InAGPD = \beta_0 + \sum_{i=1}^{n} \beta_1 \Delta InAGDP_{t-i} + \sum_{i=0}^{n} \beta_2 \Delta POP_{t-i} + \partial_1 InAGDP_{t-1} + \partial_2 POP_{t-1} + \epsilon_i \quad (4)$$

Bounds Test for Long Run Relationship. To test for the presence of cointegration between food growth and population growth in Nigeria, Bounds test was employed. If the F-stat is below the I (0) bound, it indicates no presence of cointegration, hence, the null hypothesis of no cointegration is accepted. If F-stat is above I (1), it indicates the presence of cointegration, hence, the null hypothesis is rejected. However, if the F-stat is between the I (0) and I (1) bounds, the decision on the presence of cointegration becomes inconclusive. The result of cointegration test is stated in table 3.

Table 3

Bounds Test Result

Restricted Intercept and no Trend	Lower Bound	Upper Bound
1 %	6.027	6.760
5 %	4.090	4.663
10 %	3.303	3.797
F-stat: 5.813 at k=1	-	-

Source: authors' computation via [10].

From the estimate, the F-stat is higher than the upper bounds critical value, at 5 % significance level. It is therefore concluded that there is a cointegration between food growth and population growth in Nigeria. This is not unexpected. Whether population grows or not, the existing people must survive. Hence, the people rely on the food products from plants and animals to survive. This thus validates the postulation of Malthus who related the two economic variables, emphasizing that they both influence one another now and in the long run.

Long and Short Run Estimates of Food-Population Growth Relation in Nigeria. The long and short run estimates of population-food growths relation in the context of Malthusian hypothesis was estimated based on AIC selection of ARDL (1,1) model. The long run estimates revealed that population in Nigeria had significant and positive relationship with food growth. The implication of this is Nigeria's population growth is yet to get to the point of inflection where it becomes dangerous to food production. It may not be unconnected from the fact that though Nigeria still struggles with technological enhancement of her agricultural sector, there seems to be food available to households and this may be due to the growing peasant and backyard farming in the country. This is a reflection of households especially the rural dwellers taking care of their own food needs to avoid dependence on the government that may not be forthcoming.

Economic implication thus implies that for every 1 % increase in population growth, it will require 1.3 % increase in food growth to feed the population growth. According to Malthus, while population grows geometrically, food supply grows arithmetically. It is not likely that 0.3 % difference between population growth and food growth will be adequate to feed the obvious increase in the population. This

further affirmed that Malthus' hypothesis is valid, though this estimate did not empirically reflect a geometric and arithmetic kind of relationship between population and food growths as emphasized by Malthus.

The error correction term ECT (-1) value which was negative and significant further confirmed the presence of cointegration in the relationship between food growth and population growth (Table 4). There is no much difference in the influence of population growth and food supply in the short run with 1 % increase in population size of Nigeria in the short run requiring about 1.4 % growth in food supply. The questions that requires answers is can 0.4 % growth in food feed the numerical 1 % change in population? And what are the efforts that must be put in place to ensure this food growth?

Table 4

Long and Short Run Estimates of Malthusian Theory of Population in Nigeria

Long Run Estimates				
Variable	Coefficient	Std. Error	t-stat	p-value
POP	1.3048	0.6113	2.1343	0.0414**
Constant	4.4009	1.5578	2.8251	0.0085***
Short Run Estimates				
D (POP)	1.3932	0.6197	2.2482	0.0323**
ECT (-1)	-0.3753	0.1532	-2.4496	0.0206**

Note. **denotes 5 % significance level.

Source: authors' computation via [10].

Residual Diagnostic Test. The result of the residual diagnostic test is present in table 5.

Table 5

Residual Diagnostic Test

Ramsey RESET Test			
F-stat	1.3235	Prob. F(1,30)	0.2590
Breusch-Godfrey Serial Correlation LM Test			
F-stat	0.2542	Prob. F(2, 29)	0.7773
Breusch-Pagan-Godfrey Heteroskedasticity Test: White			
F-stat	0.2740	Prob. F(5, 28)	0.9235

Source: authors' computation via [10].

From table 5 above estimates, the model selected for this study was properly specified as reported by Ramsey RESET test and free from serial correlation and heteroscedasticity. This indicates that the model for this study is fit to use to model policy direction for food growth in Nigeria.

Stability Test. CUSUM and CUSUMSQ tests proposed by Brown, Dublin and Evans (1975) were used to examine the stability of the model. The tests which were applied to the residuals indicated stability in the coefficients over the sample period. According to [19], if the plot of the cumulative sum goes outside the area of 5 % critical lines, the coefficients are found not to be stable. The graphs are presented below (Figure 1, 2):

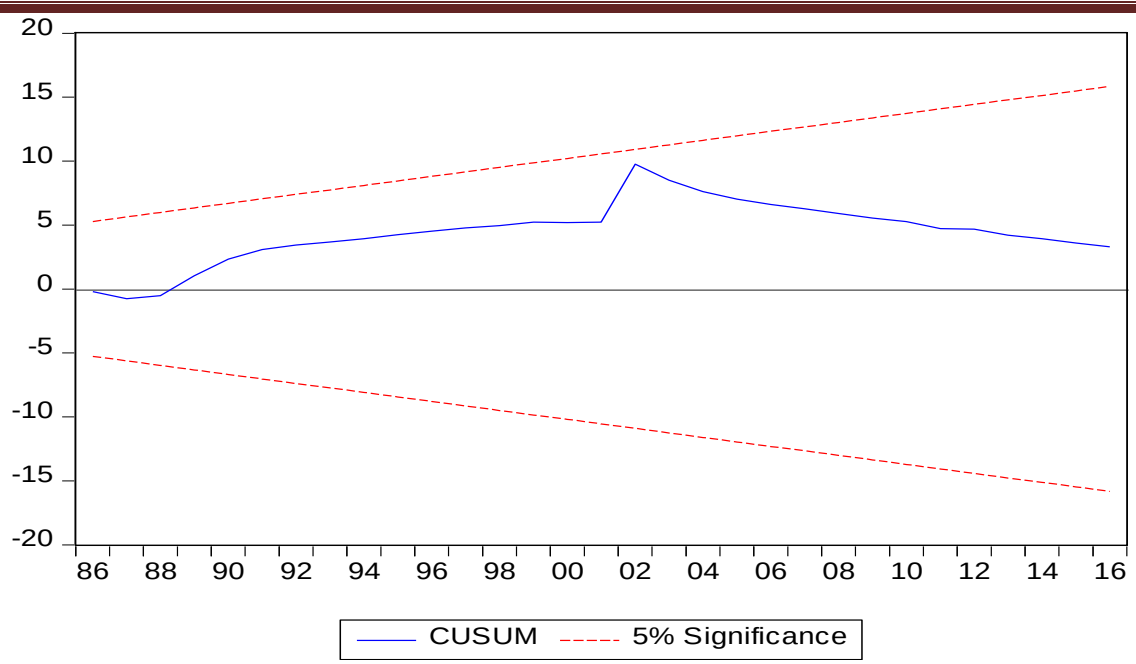

Fig. 1. CUSUM

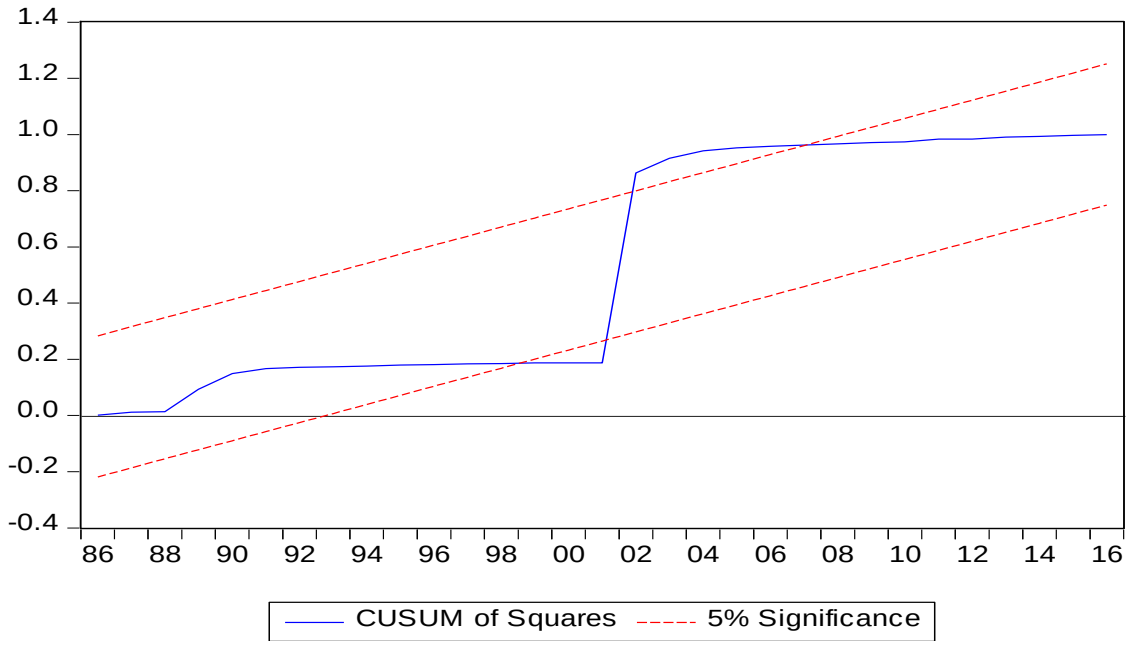

Fig. 2. CUSUMSQ

The figure 1 above revealed that the mean is stable with the statistic within the 5 % critical region. However, the CUSUMSQ is not entirely stable with the statistic pushing out between 1999 and 2001 and between 2002 and 2006. This may not be unconnected from the fact that Nigeria has been politically unstable and was just returning to democratic governance and all attention was on transition with little or no attention to the feeding of the teeming population of Nigeria.

Conclusion. The increasing nature of the population of Nigeria and the perceived rise in food importation necessitated this study in the bid to search into the future to ensure that it is taken care of from today. The Malthusian theory of population was tested for the purpose of validating it within the economic framework

of Nigeria being the most populous African nation. Time series data on agriculture's contribution to GDP and population growth between 1982 and 2016 were used for the purpose of this study. The estimates from the study revealed that there is a positive long run and short run significant relationship between food production and population growth in Nigeria. This confirms the validity of the Malthus population theory in Nigeria which is fundamentally based on the two laws of nature of importance of food in the existence of man and the fact that the passion between the sexes is necessary and will remain nearly in its present state. Thus, there is exist in Nigeria a potential danger on food supply in the future to fully satisfy the needs of the population which of course will keep growing.

While the fundamentals of Nigerian culture is not largely in support of limiting the number of persons per household, the nation also has huge potentials to increase her agricultural productivity for the teeming population. The lands are available, the weather is favorable and the population is of working ages. Should the government be ready and also possess the political will to turn around the nation from being food subservient, adopt adequate technology for agricultural development, design and implement farmer-friendly, national, rational and holistic agricultural policy to encompass input distribution, provision of adequate agribusiness capital investment and development of a workable guarantee price mechanism that will ensure that the farmers have profit for their hard work, Nigeria will become food secure.

Therefore, this study recommends that agriculture be given adequate attention. The Federal Government should develop sustainable agricultural development policy framework devoid of political ambiguities and celebrities, the kind of policy that will outlive the initiator – a sustainable agricultural development. Coupled with this, the Central Bank of Nigeria who is the custodian of the Agricultural Credit Guarantee Scheme, ACGS, should rejig the policy framework to ensure that the agricultural loans from the scheme get to the real farmers and in good amount. It is rational to provide for example ₦1,000,000 to 100 farmers than to provide ₦100,000 to 1,000 farmers because any ambitious agricultural development initiative is capital intensive. A proper pay-back system of such loans should also be designed with respect to enterprise peculiarities to make sure that such capital is recycled among other farmers. Also, though it may experience stiff resistance based on cultural tendencies, public sensitization should be embarked upon to educate the people on the need to keep family sizes within economic realities per household.

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