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Population Compartments and Food Security in Nigeria

[1]**Onyinye Ifeoma Ochuba** & [2]**Ebikabowei Biedomo Aduku**
[1&2]*Department of Economics, University of Africa,*
Toru orua, Bayelsa State, Nigeria

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Corresponding Author: Onyinye Ifeoma Ochuba

Abstract

This study examines the relationship between population compartments and food security in Nigeria using quarterly time-series data, covering the period from 2003 to 2022. The population compartments considered were the infant population, the working-age population, and the retired-age population. Ford security, on the other hand, was measured by the average dietary energy adequacy and the prevalence of undernourishment. The data was analyzed using the Non-linear Autoregressive Distributed Lag (NARDL) co-integration technique. It was found that the infant population and the retired age population have a negative and significant effect on the average dietary energy adequacy proxy for food availability and a positive and significant effect on the prevalence of undernourishment proxy for food accessibility, both in the long run and short run. It was also found that both in the long run and short run, the working-age population has a positive and significant effect on the average dietary energy adequacy and a negative and significant effect on the prevalence of undernourishment. Nigeria should focus on investing significantly in family planning and enhancing productive health, which could cut down the fertility level. And, with more commitment to ensuring child survival and broad implementation of universal health coverage, the working-age population will increase relative to the other population compartments considered in this study. Also, the working-age population and the retired-age population should be encouraged to go into agriculture. This can be achieved through rigorous sensitization on the relevance of agriculture and providing the enabling environment to support the growth of agriculture in the country.

Keywords: *Population Compartments, Food Security, Infant Population, Working-age Population, Retired-age Population*

Background to the Study

World over, population surge and food production have been the subject of intellectual debate. This debate predates the classical economists' era of the 17th century, but was popularized by Thomas Malthus's thesis of 1798. Since then, there have been arguments and counterarguments concerning the accuracy of Malthus's predictions. World governments have also initiated strategies and proactive measures, such as treaties, declarations, and action plans, aimed at ensuring that food production matches population growth. For instance, the Millennium Development Goals (MDGs) and the Sustainable Development Goals (SDGs) have the eradication of hunger as one of their focal points (United Nations, 2021). Also, the Food and Agriculture Organization's (FAO) emergency programs and the global food security strategies are some examples of international efforts geared towards the eradication of hunger globally.

In Nigeria, its government has formulated some policies aimed at addressing food security; they include the 2016 National Plan of Action on food and nutrition, the Zero Hunger by 2030 initiative, and other relevant policies. Despite these efforts, FAO reported that in 2021, between 720 and 811 million persons faced hunger globally, while projecting a worsening trend by 2030 (Food and Agriculture Organization [FAO], 2022). Still on its findings on the state of food security and nutrition in the world, FAO identified Nigeria, Ethiopia, South Sudan, and Yemen as countries with the worst food security challenge in the world, or put differently, the world hunger spot (Food and Agriculture Organization, 2022). A recent inflation report in Nigeria puts the nation's inflation rate at over 16% with food and energy costs constituting the bulk of the spike (The Nation, 2022). The high cost of food in the country negates the basic dimensions of food security which are availability and accessibility, thereby putting Nigeria in a disadvantaged position in the global fight against food insecurity. Food security, as defined by FAO, "is said to exist when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food which meets their dietary needs and food preferences for an active and healthy life" (FAO, 2003).

Amidst these facts, Nigeria's population has continued to grow unabated, with a current population of over 200 million people. This population is estimated to hit over 400 million persons by 2050 at a projected growth rate of 1.93% (United Nations, 2021). These figures confirm the predictions by the United Nations that there will be a population surge in West Africa, with countries like Nigeria having the highest population figures, encouraged to advance measures to ensure that food production matches the population growth (Osabuohien et al., 2018b). This population increase is directly linked to a high birth rate and low uptake of birth control measures by families in Nigeria (Owoo, 2020). Using 2019 as the base year, the age bracket 0-14 years forms 43.7% of the entire population, 15 -65 years forms 53.6%, while 65 years and above constitutes only 2.7% of the entire nation's population.

Studies have over time proven that there exists an inverse relationship between food security and population growth. Osu (2017), Dias et al. (2017), and Oguntegbe et al. (2018) all found that a unit growth in population gave rise to multiple decreases in the units of available food. However, the impact of various age compartments on the element of food availability, by extension, food security, has not received adequate attention. This study investigates how different age-based population compartments influence food security in Nigeria, focusing on indicators of availability and accessibility using time-series data from 2003 to 2022. The remaining sections of this study are organized as follows: after this introduction, there is a review of relevant literature, followed by the methodology, presentation, and discussion of findings, and finally, conclusion and recommendations.

Literature Review

Conceptual Clarification

Food Security

Food, as defined by MedicineNet, is any substance consumed by living organisms, whether plants or animals, to provide nutritional support for their bodies (MedicineNet, 2021). Food security, as defined by the United Nations during its food conference in 1974, is the "availability at all times of adequate world food supplies of basic foodstuffs to sustain a steady expansion of food consumption and to offset fluctuations in production and prices" (FAO, 2003). In light of this, food-secured persons can be defined as those who have access to adequate food at all times for an active, secure existence (Owoo, 2020). This implies that those persons have a ready supply of nutritious food and the assured capacity, without relying on emergency food supplies, and other coping mechanisms to get adequate food in a socially acceptable manner. There are four basic dimensions to food security they are Availability, Accessibility, Utilization, and Stability. The Availability axiom insists that individuals must have access to high-quality, nutritious food and quantities sufficient to provide needed vitality for healthy living. The accessibility dimension talks about the affordability of the available foods. Are individuals and households able to get the needed foods in the right quantity, at the right price, and in the right condition? The utilization dimension of food security considers how efficiently individuals can utilize the food supplied. Stability in this context is generic. It refers to the absence of fluctuations in the food supply, general safety and security of the environment, political and economic stability as well as psychological stability. Until the individual feels safe and secure, every other factor that influences food security is secondary.

Age Demarcation and Food Security

It has been established that food security is not only a generic index but an individualized one because individuals of various age brackets and other social denominators have special nutritional needs (Ahungwa et al., 2020). Against the fact that various age group has various micronutrient requirements, Wiesmann et al., (2009) developed the Dietary Diversity Scores (DDS), which measure the micronutrients consumed by individual members of the household against the required micronutrients every 24 hours. It takes into account unique foods or food groups consumed by individuals over a given period.

Theoretical Review

The Malthusian Population Theory

An Italian political writer and Statesman, Giovanni Botero, first studied food availability and forces governing population growth in his thesis in 1588, where he stressed that the population was growing without limits and was pressing so hard on the means of subsistence, which gave rise to perpetual poverty and starvation (Botero, 1985). This thesis was later popularized by Thomas Malthus in 1789, who collaborated with Botero's stands and added that population growth can be checked in two ways: the 'Positive Check', which advocates the use of starvation, plagues, or wars to reduce the number of people pressing on available resources. The second way is the 'negative or preventive check', which advocates abstinence from marriage and procreation (Rothbard, 2010). Arguably, this method examines the (dis)equilibrium between population and food availability. It is established that for equilibrium to exist, the growth rate of food supply should not be lower than the population growth rate in a nation at any given moment, or else disequilibrium would occur.

A study (Unat, 2020) observed that the Malthusian argument that population growth would result in global crisis and disaster as a result of technological solutions to food supply is invalid. Rather, technology has grown beyond lips and bounds to affect every facet of human development, including population control. A related study (Effiong, 2019) confirmed that Nigeria has experienced both 'positive checks and the 'preventive checks'; however, the Nigerian population does not grow in geometrical progression as propounded by Malthus. This is because individuals and families now adopt different birth control measures, which give them the required grip on population control. It was, however, found that the optimal population growth rate that is consistent with Nigerian economic development is 2.50% (Okijie & Ubong, 2021), which is approximately in tandem with the country's current population growth rate of 2.53%. Amidst this finding, Nigeria ranked 110 out of 127 in the global hunger index in 2024 (Global Hunger Index Organisation, 2024). This position is not unrelated to the huge population displaced as a result of security challenges, climate change, the disappearance of different agricultural plants and animal species, and illegal immigrants that have greeted Nigeria in the recent past. The cumulative impacts of the above are increased food demand, which results in high food prices. Nevertheless, the identified food security challenges are not solely the aftermath of population growth as predicted by Malthus, but rather other factors that were unaccounted for by both Botero and Malthus.

Empirical Literature

The debate on population and food security is ongoing. In a recent study by Aiyedogbon et al. (2022), they investigated the effect of population on food security in Nigeria with data from 1986 to 2020. Using the Cochrane-Orcutt iterative method on Ordinary Least Squares, the study found that population growth harmed agricultural output. However, both population and agricultural production growth are essential for economic growth in the country. It therefore suggests that the government should increase its spending on agriculture to boost its output as well as introduce policies to encourage small families, which will check population growth. In a related study, Kousar et al., (2021) examined the impact of population and urbanization on food security using time series data from 1990 to 2019. Employing Autoregressive Distributed lag (ARDL), the study found that population growth and urbanization have a significant and positive relationship with food insecurity, suggesting that a percentage growth in any of the variables will result in worsening food insecurity. It, therefore, suggests that the government should adopt measures to control the population and also plan vertical urbanization to prevent the shortage of agricultural land.

In contrast, Okijie & Ubong (2021) found that a population growth rate of 2.50% is sustainable for economic growth in Nigeria. Using data obtained from World Development Indicators on crude birth rate and infant mortality rate for periods between 1970 and 2017 and employing the Ordinary Least Squares (OLS) method and threshold regression analysis, the paper concludes that the identified population growth rate will be ideal given available resources and required level of economic development. Underscoring the importance of demographic considerations in food security discussion, Owoo (2020) found that 14 million Nigerians, including infants, are malnourished. With data from the World Bank's living standard measurement survey of Nigeria, adopting spatial patterns of food security and fixed effects regression, the study found that larger households have worse food security challenges. Also, children from large households suffer from worse nutritional deficiencies. It therefore advocates policies to link family planning with food security. These findings were corroborated by Ahungwa et al. (2020). It, however, added that in addition to the size of the household, the age and gender of the head of the household are critical in determining their state of food security.

Acknowledging the negative impact of population on food security, Hyacinth (2020) probed the impact of mechanized farming and export-oriented agricultural business on food availability. Using questionnaires that were purposively distributed, the study confirmed that inadequate access to land, poor road infrastructure, insecurity, and inadequate funding are the major factors inhibiting food availability in Nigeria. Collaborating on the institutional gap in food security administration in Nigeria, Osabuohien et al. (2020) observed that food security governance in Nigeria has not adopted any solution to food shortage that is not political. This, according to them, has hindered the achievement of adequate food for all. They also found that the increase in population has increased the number of undernourished people to 74.8%, this is as many people are chasing after the little food available.

Underscoring the importance of strong institutions to achieve improvement in the food supply, Osabuohien et al. (2019), using ARDL with data from the Central Bank of Nigeria(CBN), FAO, and WDI, found that enhancing agricultural credit and production will improve food security, thereby reducing the number of undernourished people. Supporting the findings that the age and gender of the household's head affect food security outcomes, Muhammed and Ahmad Sidique (2019) added that households headed by the elderly are more food secure, given that they are more honest and can be trusted. Using OLS and Multinomial log for data from the National Bureau of Statistics for the period 2012 to 2018, the study confirmed a negative relationship between children and food security, indicating that the more the number of children in a household, the more food insecure the household is. It suggests more government and charity donations towards improving the food security status of families.

In their study, Oguntegbe et al. (2018) used an instrumental variable approach to data on the food production index, population growth rate, per capita GDP, Arable land, life expectancy, and gross school enrollment for a period between 1980 to 2011, the study found that one percent increase in population would decrease food output by 29.9 units. it, therefore, suggests that legislation against polygamy, promotion of birth control, as well as promotion of primary school enrollment should be vigorously pursued to stem the current tide of a population surge.

In summary, researchers have invested in studies on the impact of population on food security, the direction of the relationship, factors that contributed to the observed outcome, and what can be done to reverse the trend. Again, the popular Malthusian population theory has come under serious scrutiny, with some scholars agreeing with the Malthusian line of thought, while others agree with some aspects of it, while pointing out variations from his conclusions with what obtains in their study jurisdiction. The present study will add to the existing literature by providing a comparison between population growth in Nigeria and accessibility and availability dimensions of food security as provided by FAO. Also, it will boost current findings on the relationship between various age groups and food security in Nigeria.

Methodology

Variables and Data

The analysis of food security is commonly carried out on three components, which are adequate and stable supply, access to the supply, and the ability to utilize the supply to get nourishment. For this study, access to the supply (food accessibility) and the ability to utilize the supply to get nourishment (prevalence of undernourishment) are the components of food security considered. Food accessibility is measured by average dietary energy adequacy, while the ability to utilize the supply to get nourishment is measured by the prevalence of undernourishment. The population compartments, on the other hand, considered are the infant population, the working-age population, and the retired population. Other variables include personal remittances and the consumer price index. The data is a quarterly time series that covers the period from 2003Q1 to 2022Q4. The data for the consumer price index is sourced from the Central Bank of Nigeria – CBN statistical bulletin, various issues, while the data for the rest of the variables were sourced from the World Development Indicators – WDI.

Model Specification

To enable us to estimate the effects of positive and negative changes in population compartments on food security, we consider the Non-linear Autoregressive Distributed Lag (NARDL) co-integration technique as a more appropriate technique. This technique will enable us to determine the long and short-run positive and negative changes in the parameters of interest and their impact on food security. In line with the objectives of the study, the following functional form of the model is specified;

$$\text{FOODSECURE} = f(INFAPOP,\ WORKAPOP,\ RITIRPOP,\ PREMITT,\ CPI) \quad (1)$$

Where FOODSECURE is food security, *INFAPOP* represents the infant population (0 – 14 years) – measured by the number of infants per 10,000 population, *WORKAPOP* is working age population (15 – 65 years) – measured by the number of working age persons per 10,000 population, and *RITIRPOP* is the retired age population (over the age of 65 years) – measured by the retired age persons per 10,000 population. The standardization of the population compartments would enable fairer interpretation and comparisons between the infant population, working-age population, and retired-age population compartments. Besides, *PREMITT* in equation (1) is defined as personal remittances, while *CPI* is defined as the consumer price index – to measure macroeconomic stability. For this study, food security (FOODSECURE) is disaggregated into food accessibility – proxied by average dietary energy adequacy, and the ability to utilize the supply to get nourishment – measured by the prevalence of undernourishment. Therefore, in our estimation, average dietary energy adequacy is used as the dependent variable. Thereafter, average dietary energy adequacy will be substituted with the prevalence of undernourishment, and the estimation will be carried out again. On these bases, we re-specify equation (1) as:

$$\text{FOODSECURE} = f(INFAPOP^{+}\ INFAPOP^{-}, WORKAPOP^{+}\ WORKAPOP^{-}, RITIRPOP^{+}\ RITIRPOP^{-}, PREMITT, CPI) \quad (2)$$

The econometric model is presented as:

$$\text{FOODSECURE} = \varphi_0 + \varphi_1{}^{+}INFAPOP^{+} + \varphi_2{}^{-}INFAPOP^{-} + \varphi_3{}^{+}WORKAPOP^{+} + \varphi_4{}^{-}WORKAPOP^{-} + \varphi_5{}^{+}RITIRPOP^{+} + \varphi_6{}^{-}RITIRPOP^{-} + \varphi_7 PREMITT + \varphi_8 CPI + \varepsilon_1 \quad (3)$$

Where $INFAPOP$ is the infant population, defined as $INFAPOP = INFAPOP_0 + INFAPOP_t{}^{+} + INFAPOP_t{}^{-}$. The $INFAPOP_t{}^{+} + INFAPOP_t{}^{-}$ is the process of partial sum variation, capturing the positive (+) and negative (–) changes in the infant population. $WORKAPOP$ is the working age population, defined as $WORKAPOP = WORKAPOP_0 + WORKAPOP_t{}^{+} + WORKAPOP_t{}^{-}$. The $WORKAPOP_t{}^{+} + WORKAPOP_t{}^{-}$ captures the process of partial sum variation, which are positive (+) and negative (–) changes in the working-age population. Similarly, $RITIRPOP$ is a retired age population, defined as $RITIRPOP = RITIRPOP_0 + RITIRPOP_t{}^{+} + RITIRPOP_t{}^{-}$. The $RITIRPOP_t{}^{+} + RITIRPOP_t{}^{-}$ are the process of partial sum variation, capturing the positive (+) and negative (–) changes in the retired age population.

$$INFAPOP^{+} = \sum_{m=1}^{k} \Delta INFAPOP_{(\mathrm{m})}{}^{+} = \sum_{m=1}^{k} max\left(\Delta INFAPOP_{(\mathrm{m})}, 0\right);\ INFAPOP^{-} = \sum_{j=1}^{k} \Delta INFAPOP_{(\mathrm{m})}{}^{-} = \sum_{j=1}^{k} min\,(\Delta INFAPOP_{(\mathrm{m})}, 0) \quad (4)$$

$$WORKAPOP^{+} = \sum_{m=1}^{k} \Delta WORKAPOP_{(\mathrm{m})}{}^{+} = \sum_{m=1}^{k} max\left(\Delta WORKAPOP_{(\mathrm{m})}, 0\right);\ WORKAPOP^{-} = \sum_{j=1}^{k} \Delta WORKAPOP_{(\mathrm{m})}{}^{-} = \sum_{j=1}^{k} min\,(\Delta WORKAPOP_{(\mathrm{m})}, 0) \quad (5)$$

$$RITIRPOP^{+} = \sum_{m=1}^{k} \Delta RITIRPOP_{(\mathrm{m})}{}^{+} = \sum_{m=1}^{k} max\left(\Delta RITIRPOP_{(\mathrm{m})}, 0\right);\ RITIRPOP^{-} = \sum_{j=1}^{k} \Delta RITIRPOP_{(\mathrm{m})}{}^{-} = \sum_{j=1}^{k} min\,(\Delta RITIRPOP_{(\mathrm{m})}, 0) \quad (6)$$

The '+' and '–' superscripts in the equations represent positive and negative processes around a threshold of zero, defining positive and negative shocks in NFAPOP, WORKAPOP, and

RITIRPOP, respectively. It indicates that the series' first difference is expected to be distributed normally with zero mean. With the inclusion of the control variables (PREMITT and CPI) as previously defined, we specify the equation for estimation, which is a nonlinear (p; q) ARDL equation displaying a combination of short and long-run positive and negative changes as:

$$\text{FOODSECURE} = \varphi_0 + \varphi_1 \text{FOODSECURE}_{t-1} + \varphi_2{}^{+} INFAPOP_{t-1}{}^{+} + \varphi_3{}^{-} INFAPOP_{t-1}{}^{-} + \varphi_4{}^{+} WORKAPOP_{t-1}{}^{+} + \varphi_5{}^{-} WORKAPOP_{t-1}{}^{-} + \varphi_6{}^{+} RITIRPOP_{t-1}{}^{+} + \varphi_7{}^{-} RITIRPOP_{t-1}{}^{-} + \varphi_8 PREMITT_{t-1} + \varphi_9 \text{CPI}_{t-1} + \sum_{m=1}^{K} b_1\, \Delta\text{FOODSECURE}_{t-m} + \sum_{m=1}^{K} (\beta_1{}^{+} NFAPOP_{(\mathrm{t-m})}{}^{+} + \beta_2{}^{-} NFAPOP_{(\mathrm{t-m})}{}^{-}) + \sum_{m=1}^{K} (\beta_3{}^{+} WORKAPOP_{(\mathrm{t-m})}{}^{+} + \beta_4{}^{-} WORKAPOP_{(\mathrm{t-m})}{}^{-}) + \sum_{m=1}^{K} (\beta_5{}^{+} RITIRPOP_{(\mathrm{t-m})}{}^{+} + \beta_6{}^{-} RITIRPOP_{(\mathrm{t-m})}{}^{-}) + \sum_{m=1}^{K} b_2\, \Delta PREMITT_{t-m} + \sum_{m=1}^{K} b_3\, \Delta \text{CPI}_{t-m} + \varepsilon_1 \quad (7)$$

where K_i is the lag order and other variables remain as previously defined? The measurement of equation (7) may reveal the implicit co-integration problem, which could lead to an ambiguous interpretation of the asymmetric coefficients. As a result, the coefficients of equation (7) are subject to restrictions as,

$\varphi_1{}^{+} = {}^{-\varphi_2{}^{+}}/{\varphi_1}$; $\varphi_2{}^{-} = {}^{-\varphi_3{}^{-}}/{\varphi_1}$; $\varphi_3{}^{+} = {}^{-\varphi_4{}^{+}}/{\varphi_1}$; $\varphi_4{}^{-} = {}^{-\varphi_5{}^{-}}/{\varphi_1}$; $\varphi_5{}^{+} = {}^{-\varphi_6{}^{+}}/{\varphi_1}$; and $\varphi_6{}^{-} = {}^{-\varphi_7{}^{-}}/{\varphi_1}$

The aforementioned is the long-run impact of positive and negative changes in the infant population (*NFAPOP*), working age population (*WORKAPOP*), and the retired age population (*RITIRPOP*) on food security – average dietary energy adequacy, and the prevalence of undernourishment. $\sum_{m=1}^{K} \beta_i{}^{+}$ in equation (7) measures the short-run impact of positive changes in the infant population, working-age population, and retired-age population. While $\sum_{m=1}^{K} \beta_i{}^{-}$ is the short-run impacts of negative changes in the infant population, working-age population, and retired-age population. Essentially, this modelling captures not just the long-run relation but also the short-run impacts of positive and negative changes in the population compartments – the infant population, the working-age population, and the retired age population on food security. The error correction model for equation (7) is given as follows:

$$\Delta\text{FOODSECURE} = \sum_{m=1}^{K} b_1\, \Delta\text{FOODSECURE}_{t-m} + \sum_{m=1}^{K} (\beta_1{}^{+} INFAPOP_{(\mathrm{t-m})}{}^{+} + \beta_2{}^{-} INFAPOP_{(\mathrm{t-m})}{}^{-}) + \sum_{m=1}^{K} (\beta_3{}^{+} WORKAPOP_{(\mathrm{t-m})}{}^{+} + \beta_4{}^{-} WORKAPOP_{(\mathrm{t-m})}{}^{-}) + \sum_{m=1}^{K} (\beta_5{}^{+} RITIRPOP_{(\mathrm{t-m})}{}^{+} + \beta_6{}^{-} RITIRPOP_{(\mathrm{t-m})}{}^{-}) + \sum_{m=1}^{K} b_2\, \Delta PREMIT_{t-m} + \sum_{m=1}^{K} b_3\, \Delta \text{CPI}_{t-m} + b_6 ECM + \varepsilon_1 \quad (8)$$

where the short-run coefficients are denoted by $b_i, (i = 1, 2, 3, \ldots, 5)$, while, $\beta_i{}^{+}$, and $\beta_i{}^{-}$, $(i = 1, 2, 3, \ldots, 6)$ represent the adjustment changes in the short run. b_6 is the coefficient of the error correction term? As pointed out earlier, the dependent variable, food security (FOODSECURE) is disaggregated into food accessibility – proxied by average dietary energy adequacy, and the ability to utilize the supply to get nourishment – measured by the prevalence of undernourishment. Therefore, in the estimation of the equations, the average dietary energy adequacy is used as the dependent variable. Thereafter, average dietary energy adequacy will be substituted with the prevalence of undernourishment, and the estimation will be carried out again.

The nonlinear ARDL technique is predicated on the idea that all of the model's variables can be integrated in order 0 or 1, or I(0) or I(1), rather than any of the variables being integrated in order 2. This is because the generated F-statistics for the cointegration test will be invalid and the result may be deceptive if there are order 2 variables. To ensure that none of the variables is integrated of order 2, but rather can be pure order 0 or 1, or a combination of orders 0 and 1, the variables will be evaluated for unit root before the estimation of the nonlinear ARDL model. To evaluate the orders of integration of the variables in this regard, the augmented Dickey-Fuller (ADF) and the Kwiatkowski–Phillips–Schmidt–Shin (KPSS) test for stationarity would be adopted.

After that, the OLS estimation method would be used to estimate the nonlinear ARDL equations. Best Linear and Unbiased Estimator (BLUE-estimator) is the characteristic of the OLS estimator. Using Akaike information criteria for lag order selection, the test for lag order is used to arrive at the final specification of the NARDL model by eliminating irrelevant lag orders. Then, using the bounds test approach developed by Shin et al. (2011) and Pesaran et al. (2001), a cointegration test would be conducted based on the estimated NARDL. This is a Wald F-test used to compare the alternative of cointegration to the null hypothesis of no cointegration of the variables. if cointegration is found, the error correction model would be estimated to find the impact of the long- and short-term changes of the independent variables in the model, and conclusions would be made.

Results

Unit Root and Cointegration Tests

The Augmented Dickey-Fuller (ADF) and the Kwiatkowski, Phillips, Schmidt, Shin (KPSS) unit root test were used to test the stationarity of the variables. The test results are reported in Table 1.

Table 1: Augmented Dickey-Fuller and Kwiatkowski, Phillips, Schmidt, Shin (KPSS) unit root test results

Variable	Augmented Dickey-Fuller (ADF) Result		Kwiatkowski, Phillips, Schmidt, Shin (KPSS) Result		Lag Order	~I(d)
	Level	1st Difference	Level	1st Difference		
PUN	-0.730	-4.380*	0.152	0.141*	2	I(1)
ADESA	-3.880	-	0.119*	-	2	I(0)
IPOP	-0.772	-3.682*	0.155	0.135*	2	I(1)
WPOP	- 1.342	-4.914*	0.205	0.129*	2	I(1)
RPOP	-1.767	-4.891*	0.167	0.088*	2	I(1)
CPI	-2.145	-4.480*	0.183	0.082*	2	I(1)
REMIT	-2.285	-4.977*	0.145	0.069*	2	I(1)
	The null hypothesis is that the variable contains a unit root		**The null hypothesis is that the variable is trend-stationary**			

Where * denotes significance at 5% and the rejection of the null hypothesis of the presence of unit root. The optimal lag lengths were chosen according to Akaike's Final Prediction Error (FPE), and Akaike's information criteria. The ADF 5% critical value a t the level and 1 st difference is -3.600. The Kwiatkowski, Phillips, Schmidt, Shin (KPSS) 5% critical values, on the other hand, at level and 1st difference is 0.146. The trend is included in both the Augmented Dickey -Fuller and Kwiatkowski, Phillips, Schmidt, and Shin (KPSS) unit root test models estimated.

Source: Computation by the researchers

The Augmented Dickey-Fuller test found average dietary energy adequacy significant at the level. However, none of the other variables are significant at this level. As a result, we reject the null hypothesis of the presence of a unit root for average dietary energy adequacy while accepting the null hypothesis for the other variables. The acceptance of the null hypothesis for the variables (except average dietary energy adequacy) explains our decision to take the first difference of the other variables. Thus, the test was repeated after the first difference was taken, and the results for all variables appeared statistically significant. The null hypothesis, therefore, is rejected at the 1st difference, indicating that the variables are stationary at 1st difference. Thus, according to the Augmented Dickey-Fuller and Kwiatkowski, Phillips, Schmidt, and Shin tests, all variables are integrated of order 1, I(1), except average dietary energy adequacy, which is stationary at order 0.

Effects of Positive and Negative Changes in Population Compartments on Food Security

The aim is to determine the effects of positive and negative changes in population compartments on food security. Before reporting the main result, the cointegration result is presented. The Asymmetry cointegration test approach was adopted to obtain the cointegration test, presented in Table 2.

Table 2: Asymmetry Cointegration test Statistics

Critical Values (0.1 -0.01), F-statistic, Case 3							
90%		95%		97.5%		99%	
I(0)	I(1)	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)
2.45	3.52	2.86	4.01	3.25	4.49	3.74	5.06
Critical Values (0.1 -0.01), t-statistic, Case 3							
90%		95%		97.5%		99%	
I(0)	I(1)	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)
-2.57	-3.66	-2.86	-3.99	-3.13	-4.26	-3.43	-4.60
F -6.9881							
t 5.2219							

Source: Computed by the researchers

At the 5% level, the F-value in absolute terms exceeds both the order 0 and order 1 critical values. It is, therefore, significant at the 5% level. Thus, we reject the null hypothesis of no cointegration. Also, at the 5% level, the t-value in absolute terms exceeds both the order 0 and order 1 critical values. As a result, we reject the null hypothesis of no cointegration. This indicates that the variables in the model are cointegrated. That is, there is a long-term relationship between the variables in the model. We present the long-run and short-run asymmetry test statistics in Table 3.

Table 3: Long-run and short-run asymmetry test statistics for population compartments and food security

	Taken average dietary energy adequacy as the dependent variable				**Taken the prevalence of undernourishment as the dependent variable**			
	(1) Long-run asymmetry		**(2) Short-run asymmetry**		**(3) Long-run asymmetry**		**(4) Short-run asymmetry**	
	F-stat	**p-value**	**F-stat**	**p-value**	**F-stat**	**p-value**	**F-stat**	**p-value**
INFAPOP	0.242	0.013	0.105	0.021	0.192	0.022	0.217	0.009
WORKAPOP	1.013	0.002	2.117	0.000	0.127	0.015	1.047	0.000
RITIRPOP	2.037	0.000	1.211	0.003	1.202	0.001	0.101	0.059
PREMITT	1.164	0.004	2.006	0.061	0.013	0.110	1.266	0.000
CPI	0.925	0.051	2.614	0.000	0.011	0.074	1.926	0.000

Source: Computed by the researchers

The F-statistics and the corresponding probability values for the infant population, working-age population, and retired-age population in columns (1) and (2) are statistically significant at the 5 per cent level. This means the presence of long-run and short-run asymmetries. Personal remittances in column 1 showed significant asymmetry in the long run, and the consumer price index have significant asymmetry only in the short run. This implies that the variables in the model for average dietary energy adequacy have a significant asymmetry. Similarly, the model for the prevalence of undernourishment showed the presence of long and short-run asymmetries for the infant population, and working-age population as indicated by the significant probability values in columns (3) and (4). Retired age population has significant asymmetry only in the long – in column (3), while personal remittances and consumer price index have significant asymmetry only in the short-run – in column (4). This implies that the variables in the model for the prevalence of undernourishment have a significant asymmetry. With the establishment of asymmetry for the variables in the model for average dietary energy adequacy, and the prevalence of undernourishment, the results for the long-run and short-run positive and negative effects are presented and analysed in Table 4.

Table 4: Long-run effects of positive and negative changes in population compartments on food security

	Taken average dietary energy adequacy as the dependent variable						**Taken the prevalence of undernourishment as the dependent variable**					
Exogenous variables	**(1) Long-run effect [+]**			**(2) Long-run effect [-]**			**(3) Long-run effect [+]**			**(4) Long-run effect [-]**		
	Coef.	**F-sta**	**p-val.**	**Coef.**	**F-sta**	**p-val.**	**Coef.**	**F-sta**	**p-val.**	**Coef.**	**F-sta**	**p-val.**
INFAPOP	-0.113	2.243	0.036	-0.337	5.471	0.000	0.207	4.144	0.000	0.092	3.009	0.000
WORKAPOP	0.241	4.272	0.000	-1.916	3.197	0.000	0.611	2.061	0.041	0.847	4.177	0.000
RITIRPOP	-0.621	3.821	0.000	-1.211	2.143	0.039	-0.332	3.217	0.000	-0.809	4.009	0.000
PREMITT	1.205	1.104	0.967	-2.456	2.952	0.001	0.425	0.380	0.299	-0.304	1.091	0.161
CPI	-0.751	2.047	0.044	-1.104	3.188	0.000	0.098	2.994	0.000	0.110	2.535	0.042

Source: Computed by the researchers

Average dietary energy adequacy, in the long run, is explained by the long-run estimates for the infant population, working-age population, retired-age population, personal remittances, and consumer price index. The coefficient for the infant population when there is a positive change is -0.113 with an F-value of 2.243 and a significant P-value of 0.036 in column (1). The significant F-value guides us to reject the null hypothesis that the infant population when there is a positive change has no significant effect on the average dietary energy adequacy in the long run. This means that an increase in the infant population has a negative and significant effect on food security. On the other hand, a negative change in the infant population brings about a 0.34% significant increase in the average dietary energy adequacy as shown in column (2). As regards the working-age population, the result shows that an increase in it results in about 0.24% significant increase in the average dietary energy adequacy in column (1). Similarly, when there is a negative change, the working-age population leads to a 1.92% increase in the average dietary energy adequacy in column (2). An increase in the retired age population results in a 0.62% significant reduction in the average dietary energy adequacy in column (1), while a negative change inspires a 1.21% reduction in the average dietary energy adequacy in column (2). On the other hand, with a positive change in the long run, the effect of personal remittances on the average dietary energy adequacy is positive and insignificant, as shown in column (1). Specifically, a percentage increase in personal remittances brings about a 1.20% insignificant increase in the average dietary energy adequacy in the long run. However, as shown in column (2), a negative change in personal remittances leads to a 2.46% significant reduction in the average dietary energy adequacy. For the consumer price index in column (1), a positive change in the long run has a 0.75 per cent negative and significant effect on the consumer price index, while a negative change results 1.10% significant increase in the consumer price index.

Also, the prevalence of undernourishment, in the long run, is explained by the long-run estimates for the infant population, working-age population, retired age population, personal remittances, and consumer price index. A positive change in the infant population leads to a significant reduction in the prevalence of undernourishment by 0.21% in column (3), while a negative change in the infant population brings about a 0.09% significant reduction in the prevalence of undernourishment in column (4). A positive change in the working-age population explains about a 0.61% significant increase in the prevalence of undernourishment in column (3), while a negative change in it instigates a 0.85% significant reduction in the prevalence of undernourishment. On the other hand, a positive change in the retired age population contributes 0.33% significant decrease in the prevalence of undernourishment in column (3), while a negative change in the retired age population leads to about 0.81% significant increase in the prevalence of undernourishment in the long. Positive changes in personal remittances have a 0.43% insignificant positive effect on the prevalence of undernourishment in column (3), while a negative change in personal remittances contributes about 0.30% significant reduction in the prevalence of undernourishment. The impact of a positive change in the consumer price index on the prevalence of undernourishment is positive and significant, while a negative change in it leads to a 0.11% significant reduction in the prevalence of undernourishment in the long run.

The results for the short-run effects of positive and negative changes in the explanatory variables are also presented and analysed in Table 5.

Table 5: Short-run effects of positive and negative changes in population compartments on food security

	Taken average dietary energy adequacy as the dependent variable						**Taken the prevalence of undernourishment as the dependent variable**					
Exogenous variables	**(1) Long-run effect [+]**			**(2) Long-run effect [-]**			**(3) Long-run effect [+]**			**(4) Long-run effect [-]**		
	Coef.	**F-sta**	**p-val.**	**Coef.**	**F-sta**	**p-val.**	**Coef.**	**F-sta**	**p-val.**	**Coef.**	**F-sta**	**p-val.**
INFAPOP	-0.231	3.251	0.000	0.599	4.088	0.000	0.170	3.600	0.000	0.120	2.939	0.000
WORKAPOP	0.065	3.971	0.000	0.164	2.913	0.000	1.022	2.693	0.004	1.016	3.184	0.000
RITIRPOP	-0.210	2.990	0.000	-0.161	3.944	0.000	-1.002	3.007	0.000	-0.113	2.700	0.003
PREMITT	0.087	0.961	0.784	-1.157	2.702	0.002	0.155	1.981	0.362	-1.102	1.619	0.991
CPI	1.083	3.940	0.000	-0.224	3.458	0.000	1.008	3.797	0.000	0.377	3.418	0.000

Source: Computed by the researchers

Average dietary energy adequacy in the short run is explained by the short-run estimates for the infant population, working-age population, retired age population, personal remittances, and consumer price index. A positive change in the infant population in the short run has a significant 0.23% negative effect on the average dietary energy adequacy in column (1), while a negative change in it results in a 0.60% significant decrease in the Average dietary energy adequacy in column (2). On the other hand, a positive change in the working-age population brings about a 0.07% significant increase in the average dietary energy adequacy in column (1), while a negative change in the working-age population results in a 0.16% significant decrease in the average dietary energy adequacy. However, a positive change in the retired age population contributes to a 0.21% significant reduction in the average dietary energy adequacy in column (1), and a negative change contributes about 0.16% significant increase in the average dietary energy adequacy in column (2). A positive change in personal remittances has a positive and insignificant effect on the average dietary energy adequacy in column (1), and a negative change in it also increases the average dietary energy adequacy significantly by 1.16%. Both positive and negative changes in the consumer price index led to a significant increase in the average dietary energy adequacy in columns (1) and (2).

In column (3), a positive change in the infant population leads to a 0.17% significant increase in the prevalence of undernourishment, while a negative change in it results in a 0.12% significant reduction in the prevalence of undernourishment in column (4). A positive change in the working-age population has a positive and significant effect on the prevalence of undernourishment in column (3), while a negative change in the working-age population has a negative impact on the prevalence of undernourishment in column (4). A positive change in the retired age population, on the other hand, has a negative impact on the prevalence of undernourishment in column (3), while a negative change in it brings about a 1.11% significant reduction in the prevalence of undernourishment in column (4). Positive changes in personal remittances and the consumer price index have a positive effect on the prevalence of undernourishment in column (3), while a negative change in personal remittances results in an insignificant increase in the prevalence of undernourishment, and a negative change in the consumer price index bring about 0.38% significant decrease in the prevalence of undernourishment in column (4).

The diagnostics of the models for the average dietary energy adequacy and the prevalence of undernourishment are presented in Table 6. Column (1) reports the diagnostics of the models for the average dietary energy adequacy, while column (2) presents the diagnostics of the models for the prevalence of undernourishment.

Table 6: Diagnostics of the models for average dietary energy adequacy, and the prevalence of undernourishment

	(1) Average dietary energy adequacy	(2) Prevalence of undernourishment
R-squared	0.7220	0.7132
F-statistic	15.28 (p = 0.0000)	13.19 (p = 0.0000)
Portmanteau test (chi2)	0.11 (p = 0.9481)	0.15 (p = 0.8955)
Breusch/Pagan heteroskedasticity test (chi2)	0.1390 (p = 0.9023)	0.1461 (p = 0.7527)
Ramsey RESET test (F)	0.0126 (p = 0.2100)	0.1180 (p = 0.5548)
Jarque-Bera test for normality (chi2)	10.90 (p = 0.0001)	11.89 (p = 0.0000)

Source: Computed by the Researchers

The R^2 coefficients in columns (1) and (2) showed that the infant population, working age population, retired age population, personal remittances, and the consumer price index explained about 72.20% change in the average dietary energy adequacy, and 71.32% change in the prevalence of undernourishment. The remaining percentage change in the average dietary energy adequacy and the prevalence of undernourishment is explained by other variables that are not part of the study. The F-statistics in both columns are significant, therefore, implying that the explanatory variables have a joint significant effect on the average dietary energy adequacy and the prevalence of undernourishment. The Portmanteau test Chi-square value is insignificant in both columns. Therefore, we accept the null hypothesis of no serial correlation in both columns. This means that the models for the average dietary energy adequacy, and the prevalence of undernourishment are free from serial correlation. The insignificant Breusch/Pagan heteroskedasticity test Chi-square values in both columns guide us to accept the null hypothesis that the independent variables have constant variance. This means that the error variance distribution is homoscedastic. Also, the insignificant Ramsey RESET test statistics in both columns mean that the model for the average dietary energy adequacy, and the prevalence of undernourishment are specified correctly. On the other hand, the significant Jarque-Bera test Chi-square Statistics in columns (1) and (2) means rejecting the null hypothesis of normal distribution.

Implications of the Findings

The findings regarding the infant population imply that in the long run, the number of infants per 10,000 populations is a significant determinant of food security. An increase in the number of infants per 10,000 population puts food security at risk by reducing physical and economic access at all times, to sufficient, safe and nutritious food that meets the average dietary energy adequacy needs and the ability to utilize the supply to get nourishment. However, a reduction in the number of infants per 10,000 population will spur food security. In essence, an excessively growing infant population is a disadvantage to food security and, there is a need to monitor and control the growth of the infant population to ensure food security, especially in the long run. Similarly, the number of retired age per 10,000 population is a significant determinant of food security. An increase in the number of retired age per 10,000 population would mean a reduction in food security. However, an increase in the number of working-age persons per 10,000 population contributes significantly to food security. This implies that the more the number of working-age persons per 10,000 population, the higher the food security in terms of physical and economic access at all times, sufficient, safe and nutritious food to meet the average dietary energy adequacy needs and the ability to utilize the supply to get nourishment.

On this basis, all things being equal, it is safe to say that countries with higher working age (active) populations compared to other population compartments such as infant and retired age (dependent) populations could have higher food security than countries whose population is dominated by dependent population compartments. This means encouraging the growth of the active population as well as encouraging them to be active in agriculture, etc. Also, a positive change in personal remittances, though instigates food security, does not play a significant role in food security but a negative change significantly reduces food security. This could mean that personal remittances are not channeled to investments that could propel food security, rather it is used majorly for food consumption. Price increases especially in the long run jeopardize food security, but a decrease to a reasonable level is necessary to ensure food security.

Conclusions and Recommendation

The study examines the relationship between population compartments and food security in Nigeria using the Non-linear Autoregressive Distributed Lag (NARDL) co-integration technique. Several findings were made. Based on the findings, it is concluded that the population compartments are significant determinants of food security in Nigeria. Excessive infant and retirement-age populations imperil the efforts to ensure food security in the country. Whereas, the working-age population strengthens food security. The findings explain the present realities of food insecurity in Nigeria. The population, according to the demographic statistics bulletin of the National Bureau of Statistics (2018), lies mainly between the ages of 0 – 14 years, *delineating a young population with, a high rate of fatality and dependency*. This means a large dependent population with high unemployment also in the agricultural sector, resulting in the current food crisis the country is facing.

Nigeria should focus on investing significantly in family planning and enhancing productive health, which could cut down the fertility level. And, with more commitment to ensuring child survival and broad implementation of universal health coverage, the working-age population will increase relative to the other population compartments considered in this study. Also, the working-age population and the retired-age population should be encouraged to go into agriculture. This can be achieved through rigorous sensitization on the relevance of agriculture, and providing the enabling environment to support the growth of agriculture in the country.

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