

REVIEW ARTICLE

AGRICULTURAL NITROUS OXIDE EMISSIONS, NUTRITIONAL FOOD PRODUCTION AND LIFE EXPECTANCY IN NIGERIA

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ABSTRACT

The impact of nutritional food production and the harmful health effect of fertilizer applications on life expectancy in Nigeria motivated this study. The study applied the framework of ARDL with annual data that covers the period from 1980 to 2020. Findings indicated that in the short-run and the long-run, food production index had a positive and significant impact on life expectancy, while the effect of agricultural nitrous oxide emissions was negative though not significant. In the short-run and the long-run also, both GDP per capita and government expenditure on health had positive and significant impact on life expectancy. However, while government expenditure on education had a positive but insignificant effect on life expectancy, food importation had a negative but insignificant impact. Consequently, the study contends that government should continue to intervene in the cultivation of local food crops that are rich in nutrients through various incentives to small holder farmers. Equally, the rampant use of fertilizers in the cultivation of food crops, especially synthetic fertilizers should be reduced, while the importation and consumption of all manner of processed foods should be checked.

KEYWORDS

Life expectancy; Food production; Nitrous oxide emission; government health expenditure; GDP per capita; ARDL

1. INTRODUCTION

The pursuit of improved life expectancy of the citizens is the preoccupation of every responsible government. The Organization for Economic Co-operation and Development (OECD, 2011) noted that in order to measure the health status of citizens, a major approach adopted is life expectancy at birth. Life expectancy is influenced by several factors such as poverty, health status and income level (Aigheyisi, 2020). Equally observed that the average life expectancy of a country is influenced by a country's economic development (Trpkova-Nestorovska and Levkov, 2019). The role of income level in improving life expectancy has been emphasized in several quarters. For instance, in 2008, in some rich countries such as New Zealand, Australia, Singapore, Japan, Hong Kong and Macao life expectancy exceeded 80 years. However, this contrasts with the situation in other rich countries such as the Great Britain and Sweden that had lower life expectancies (Hassan et al., 2017).

Nigeria is a major oil exporter and among the biggest economies in Africa. In 2014, the country rebased her economy by incorporating some sectors that were hitherto not included in the calculation of the gross domestic product (GDP). This exercise placed the country as the biggest economy in Africa within the period. Despite this, life expectancy in Nigeria is among the lowest in Africa and even within the ECOWAS countries. Poverty has been identified as the major factor responsible for low life expectancy in Nigeria. It is in realization of this that successive governments over the years have championed some poverty alleviation programmes. Since the return to democratic governance in 1999, several of such programmes have been executed such as the Poverty Alleviation Programme (PAP)

between 1999-2000, the National Poverty Eradication Programme (NAPEP) put in place in 2001 and in recent times the N-Power Programme. Notwithstanding these laudable programmes, the picture still remains the same as poverty still ravages the country; contributing to low life expectancy.

Several factors have been identified in literature to influence life expectancy with diverse outcomes even studies carried out in the same country. In particular, the contribution of food to improved longevity has found some research attention across different countries. In studies that focused on the impact of the consumption of local foods on life expectancy, and found that the consumption of Nordic diet enhanced life expectancy (Roswall et al., 2015). Life expectancy was also found to improve with the consumption of Japanese diet as a study revealed and this found further support in a study for Japan by (Okada et al., 2018; Abe et al., 2020). By using different indicators of life expectancy, some studies in Nigeria have revealed diverse outcomes. Recent study indicated that improved access to safe water and basic sanitation system impacted positively on life expectancy (Etikan et al., 2019). However, while the impact of government expenditure on health is positive but not significant, the impact of private expenditure on health was negative. Findings showed that per capita income, government expenditure on health and income inequality were the major determinants of life expectancy in Nigeria (Arikpo et al., 2019). This found revealed that government health expenditure, per capita income and literacy rate had positive and significant effects on life expectancy (Agbatogun, et al., 2019). In another study for Nigeria, findings indicated that while productivity in agriculture and health expenditure improved life expectancy, real per capita income, unemployment and

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inflation reduced it (Aigheyisi, 2020). Others observed that while food poverty depressed life expectancy in Nigeria, capital formation, food importation and total labour force improved it (Agu et al., 2020).

In other countries, some studies have also shown that several factors influence life expectancy. In Pakistan, observed that while urbanization and food supply improved life expectancy, the rate of illiteracy and rise in economic misery adversely impacted on it (Shahbaz et al., 2015). While supporting the positive impact of GDP per capita on life expectancy for Iran, also found a positive impact of food availability. A cross-country study involving developing countries observed that education and GDP improved life expectancy (Hassan et al., 2017). These findings found that the educational attainment and real per capita income to contribute positively to life expectancy in a study for the United States (Ketenci and Murthy, 2018). In another study for Iran, confirmed that food production index, urbanization and per capita public health expenditure improved life expectancy, while both illiteracy rate and misery index retarded it (Golkhandan, 2019). Previous research found that per capita income and the number of medical staff determined life expectancy in a study involving 17 regions of Spain (Cervantes et al., 2019). Another cross-country study involving twelve Southeastern European countries supported the positive impact of per capita income on life expectancy. This found further support in a study involving Albania, Bosnia, Macedonia, Montenegro and Serbia by (Miladinov, 2020). In Turkey, a study showed that only urbanization was found to Granger cause life expectancy (Gulcan, 2020). A study revealed that government health care expenditure improved life expectancy in a study involving 196 countries and 4 territories (Galvani-Townsend et al., 2022). A cross-country study involving low income and food deficit countries revealed that food production index and government expenditure on health had a positive and significant impact on life expectancy, while the impact of GDP per capita was negative (Nzeh et al., 2023).

This study therefore joins the ongoing debate on the factors that affect life expectancy by focusing on the impact of nutritional food production and the effect of fertilizer application on life expectancy in Nigeria. As has been revealed by some empirical studies, the consumption of nutritional food has direct impact on peoples' life span since the nutrients in these food crops are directly supplied to human body. Most Nigerian citizens suffer food shortage and with relatively high population in the country, food supply is often not adequate. To improve food availability, food importation is high until in recent times when the government placed a ban on the importation of basic staple foods such as rice. The only option left to increase food supply is to encourage domestic food production which entails mainly increased use of fertilizers. However, consistent fertilizer application gives rise to agricultural nitrous oxide emission which is harmful to health and thus capable of affecting life expectancy. Fig. 1 below which captures the co-movement in the trend of food production index and agricultural nitrous oxide emissions supports the claim that improving food production leads to increasing application of fertilizers which is capable of increasing agricultural nitrous oxide emissions. This study therefore sets out to determine whether food production in Nigeria improves life expectancy and also to verify the implication of agricultural nitrous oxide emission on life expectancy.

1.1 Brief Profile of Nigeria

The major edible crops grown in Nigeria include: cashew nuts, millet, cassava beans, rice, groundnuts, cocoa, beans, plantains, corn, melon, palm oil, rice, cocoyam, sorghum, soybeans, yams and bananas. Crop production in Nigeria is shaped by regional differences in climate condition. In the southern part of the country, rainfall is relatively heavy, thus permitting the cultivation of staple root crops, such as cocoyam, cassava, yams and sweet potatoes. In addition to these, tree crops such as oil palm and cacao are also grown in the area. While cacao is grown mostly in the southwestern part of the country, oil palms are grown majorly in the southeast and the south-south regions. The northern region of the country experiences more dry season compared to the southern region, compelling it to cultivate staples such as cowpeas, guinea corn, millet, rice and groundnuts. Lying between the south and the north is the middle belt that cultivates staples such as millet, cassava, cowpeas, yams, rice and corn.

As a way to improve productivity in agriculture, farmers in Nigeria have embraced the application of fertilizers. Such quest to improve crop yield has always been the major reason for government intervention in fertilizer provision and distribution in each farming season. However, fertilizer application in farming encourages the emission of agricultural nitrous oxide which poses health hazards. In Figure 1, it is observed that there is a co-movement of food production index and agricultural nitrous oxide emissions in Nigeria within the sample period. The implication of this

similar pattern of movement in the two variables is that emission of agricultural nitrous oxide arising from fertilizer application increases with food production. That is to say that, as fertilizer application in the country rises with the increase in food production, the rise in fertilizer application encouraged the emission of agricultural nitrous oxide which portends health hazards.

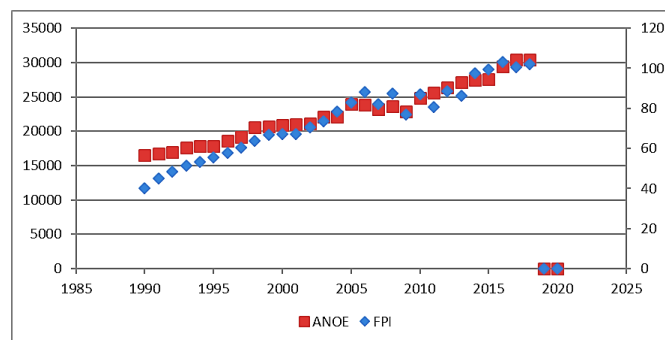


Figure 1: Trend in food production index and agricultural nitrous oxide emissions

Note: ANOE - agricultural nitrous oxide emissions, FPI - food production index

Source: Computed using data from WDI

With respect to life expectancy, we compared the trend in this variable under the military regimes and the civilian regimes in Nigeria. The rationale for this comparison is owing to the perception of Nigerians that the military regimes performed poorly in uplifting the living standard of Nigerians. In 1983, there was a military incursion into the administration of the country after few years of a new democratic era. The military rule ended in 1999 when a new civilian government was ushered in. Evidence in Figure 2 shows that after 1985, life expectancy declined massively and continuously up to 1995 when it began to improve. Within the periods of the military era, the highest life expectancy attained was 46 years. In Figure 3, life expectancy under the civilian regime gradually improved and got to 52 years on the average in 2020. This graphic picture supports the perception of the people that military regimes in Nigeria did not improve the living standard of the populace.

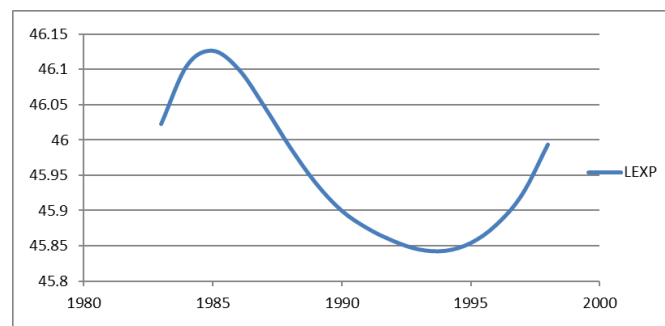


Figure 2: Trend in life expectancy during the military era

Note: LEXP - life expectancy

Source: using data from WDI

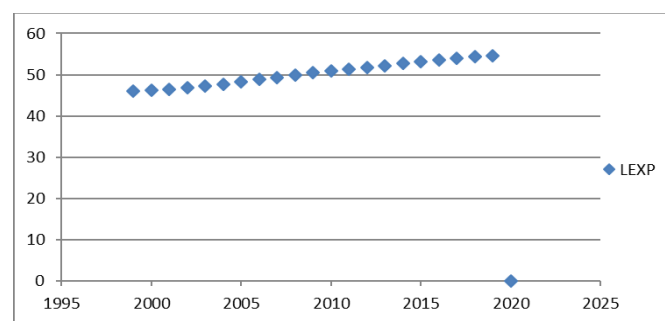


Figure 3: Trend in life expectancy during the civilian era

Note: LEXP - life expectancy

Source: using data from WDI

In Table 1, we compared the life expectancy of some selected countries in the Economic Community of West African Countries (ECOWAS). The ECOWAS is a 15 member regional economic bloc formed in 1975 comprising Nigeria, Ghana, Mali, Benin, Guinea and others. Within the sample period, it is revealed that the country with the highest life expectancy is Cape Verde with an average life expectancy of 74 years. This is followed by Ghana with an average life expectancy of 64 years, while Nigeria had the least life expectancy with an average of 52 years. Apart from Cape Verde, none of the countries sampled had life expectancy

exceeding 65 years. With respect to per capita income, Table 2 indicates that Cape Verde had the highest per capita income within the sample period. The high per capita income in Cape Verde robbed off on her citizens as evidenced in its high life expectancy. This result contrasts with the scenario in Nigeria which had the second highest per capita income among the countries, yet its life expectancy was the lowest within the sample period. This supports the argument we raised earlier that despite the relatively high GDP per capita in Nigeria, its life expectancy remains low.

Table 1: Life Expectancy in Some Selected ECOWAS Countries

Yr.	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Nigeria	50.9	51.3	51.4	51.7	51.7	51.8	52.0	52.3	52.5	52.91	52.8
Mali	56.3	56.7	57.0	57.3	57.9	58.3	58.7	59.1	59.3	59.6	58.6
Guinea	56.7	57.0	57.4	57.7	57.8	58.1	58.7	59.1	59.3	59.7	59.3
Ghana	61.1	61.6	62.0	62.4	63.0	63.1	63.8	64.0	64.1	64.7	64.1
Cape Verde	73.4	74.2	74.4	75.0	75.2	74.62	75.74	76.5	75.7	76.0	74.8
Côte d'Ivoire	55.0	55.5	56.1	56.7	57.2	57.7	58.0	58.4	58.8	59.3	59.0
Burkina Faso	56.4	57.1	57.6	57.8	58.3	58.8	59.3	59.5	60.0	60.0	59.7
Benin	58.3	58.4	58.7	58.9	59.1	59.3	59.5	59.8	60.1	60.4	60.0

Table 2: GDP Per Capita in Some Selected ECOWAS Countries

Yr.	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Nigeria	2397.3	2455.7	2490.2	2585.6	2677.4	2679.5	2570.9	2527	2512.0	2505.4	2401.4
Mali	708.9	708.4	682.2	677.8	703.2	723.5	741.7	756.4	767.5	779.3	745.8
Guinea	683.9	704.7	728.3	738.8	747.3	756.4	816.8	878.1	910.6	937.7	959.4
Ghana	1375.0	1530.3	1631.9	1708.8	1715.8	1711.2	1728.1	1827.2	1899.8	1981.6	1951.0
Cape Verde	2845.7	2923.2	2919.7	2910.0	2894.9	2891.8	2994.1	3068.9	3172.9	3318.9	2801.0
Côte d'Ivoire	1640.3	1520.3	1602.9	1739.1	1858.6	1941.5	2027.9	2121.6	2210.3	2289.3	2276.8
Burkina Faso	563.9	583.6	602.7	618.8	626.6	632.1	650.4	671.2	696.0	716.0	710.4
Benin	962.8	962.7	980.0	1020.5	1054.1	1041.6	1045.1	1072.3	1111.2	1153.7	1164.7

2. METHOD OF ESTIMATION

The order of integration of the series (unit root) was conducted using both the Augmented Dickey-Fuller (ADF) and the Phillip-Perron (PP) tests. Having ascertained the order of integration, the study examined the long-run relationship (cointegration) among the series. This study employed the auto regressive distributed lag (ARDL) bounds test by Pesaran, Shin and Smith (2001) to establish the long-run relationship and also examine both the short-run and the long-run impact of nutritional food production and agricultural nitrous oxide emissions on life expectancy. The justification for the choice of ARDL is that it can be used even though the series are integrated of order one, *i.e.* $I(1)$ or integrated of order zero, *i.e.* $I(0)$ or whether they are an admixture of $I(1)$ and $I(0)$. We used lag 2 as the optimal lag in the estimation of the ARDL model as suggested by the results of the various information criteria in appendix iii. Through the ARDL, a dynamic error correction model (ECM) is derived by way of a simple linear transformation. The ECM enables the integration of the short run dynamics with the long run equilibrium without loss of the long run information.

2.1 Model Specification

We develop the following functional relationship between life expectancy and the explanatory variables:

$$LEXP_t = \phi_0 + \phi_1 FPI + \phi_3 LANOE + X_t + \varepsilon_t \quad (1)$$

where X_t represents other explanatory variables and $\varepsilon =$ error term.

Consequently, the ARDL form of equation 1 is specified as follows:

$$\begin{aligned} \Delta LEXP_t = & \gamma_0 + \sum_{i=1}^p \gamma_1 \Delta LEXP_{t-i} + \sum_{t=0}^p \gamma_2 \Delta FPI_{t-1} + \sum_{t=0}^p \gamma_3 \Delta LANOE_{t-i} \\ & + \sum_{t=0}^p \gamma_4 \Delta FOODIMP_{t-i} \\ & + \sum_{t=0}^p \gamma_5 \Delta GDPPC_{e-1} + \sum_{t=0}^p \gamma_6 \Delta GEXED_{t-i} + \sum_{t=0}^p \gamma_7 \Delta GEXPH_{t-i} + \gamma_8 LEXP_{t-1} \\ & + \gamma_9 FPI_{t-1} + \end{aligned}$$

$$\gamma_{10} LANOE_{t-1} + \gamma_{11} FOODIMP_{t-1} + \gamma_{12} GDPPC_{t-1} + \lambda_{13} GEXED_{t-1} + \gamma_{14} GEXPH_{t-1} + \varepsilon_t \quad (2)$$

while $\psi_1, \psi_2, \gamma_3, \gamma_4, \gamma_5, \gamma_6$ and γ_7 are the coefficients of the short-run parameters, $\gamma_8, \gamma_9, \gamma_{10}, \gamma_{11}, \gamma_{12}, \gamma_{13}$ and γ_{14} are the long-run parameter coefficients.

By comparing the computed F-statistic with the upper critical bound $I(1)$ and the lower critical bound $I(0)$, we evaluated the cointegrating relationship among the series. If the computed F-statistic is greater than the upper critical bound, cointegration is established. On the other, if the computed F-statistic falls below the lower critical bound, the series are not cointegrated. If the series are cointegrated, the following ECM is specified:

$$\begin{aligned} \Delta LEXP_t = & \gamma_0 + \sum_{i=1}^p \gamma_1 \Delta LEXP_{t-i} + \sum_{t=0}^p \gamma_2 \Delta FPI_{t-1} + \sum_{t=0}^p \gamma_3 \Delta LANOE_{t-i} \\ & + \sum_{t=0}^p \gamma_4 \Delta FOODIMP_{t-i} \\ & + \sum_{t=0}^p \gamma_5 \Delta GDPPC_{e-1} + \sum_{t=0}^p \gamma_6 \Delta GEXED_{t-i} + \sum_{t=0}^p \gamma_7 \Delta GEXPH_{t-i} + \delta ECM_t + \ell_t \end{aligned} \quad (3)$$

where $\delta =$ represents the coefficient of error correction model

2.2 Data Type and Source

The study used annual data over the period from 1980 to 2022. The variables used in the study are life expectancy, food production index, agricultural nitrous oxide emissions, food import, GDP per capita, government expenditure on education and government expenditure on health. In this study, food production index is used as a proxy for nutritional food production. The World Bank Development Indicators (WDI) define food production index to comprise all edible food crops that contain nutrients. In another vein, agricultural nitrous oxide emissions, according to WDI are emissions generated from the application of fertilizers, both synthetic and none synthetic. Both life expectancy and agricultural nitrous oxide emissions are in log form.

Table 3: Data Sources and Measurement

Variable	Abbreviation	Measurement	Source
Log of life expectancy	LEXP	Total number of years from birth	WDI
Food production index	FPI	2014-2016 as base year	WDI
Log of agricultural nitrous oxide emissions	LANOE	Thousand metric tons of CO2 equivalent	WDI
Food import	FOODIMPT	% of merchandise imports	WDI
Gross Domestic Product per capita	GDPPC	Annual percentage growth	WDI
Government expenditure on education	GEXED	Billions of Naira	CBN Statistical Bulletin
Government expenditure on health	GEXPH	Billions of Naira	CBN Statistical Bulletin

3. RESULTS AND DISCUSSION

3.1 Results of Pre-diagnostic Tests

In Table 4, we found that the mean and the median of the variables are very close, signifying that the variables are symmetric. Government expenditure on education had the highest mean, while the variable with

the lowest mean is GDP per capita. The mean value of government expenditure on education is higher than the mean value of government on health which shows that government spends more on education than on health. Equally, the mean value of food production index is higher than the mean value of food import. Government expenditure on education was also found to have the highest range, indicating that it exhibited high volatility comparatively within the sample period.

Table 4: Results of Descriptive Statistics

	LEXP	FPI	LANOE	FOODIMPT	GDPPC	GEXED	GEXPH
Mean	48.16	64.91	4.30	12.89	0.80	113.9	67.07
Median	46.26	67.04	4.32	15.76	1.63	43.61	16.64
Maximum	54.33	103.2	4.48	30.56	12.45	465.3	296.4
Minimum	45.63	24.06	4.10	0.00	-15.45	0.16	0.04
Std. Dev.	2.88	24.68	0.11	8.98	5.21	146.0	91.04
Skewness	0.89	-0.16	-0.20	-0.31	-0.96	1.10	1.19
Kurtosis	2.25	1.81	1.90	1.98	5.25	2.73	3.00
Jarque-Bera	5.78	2.31	2.12	2.19	13.62	7.67	8.87
Probability	0.05	0.31	0.34	0.33	0.00	0.02	0.01
Sum	1782.2	2401.8	159.14	477.24	29.88	4215.6	2481.6
Sum Sq. Dev.	300.4	21939.8	0.472	2904.5	979.19	767743.3	298401.4
Observations	37	37	37	37	37	37	37

The next preliminary test we carried out is the test of the order of integration of the series which was conducted to ensure that the series are stationary. We used both the augmented Dickey-Fuller (ADF) and the Phillip-Perron (PP) tests to achieve this and the results were evaluated at

the 5% and 10% levels of significant. Results in Table 5 reveal that under both the ADF and the PP, apart from the GDP per capita, none of the series achieved stationarity at level. However, after first differencing, they all attained stationarity.

Table 5: Results of Stationarity

Variables	ADF		PP	
	Level	First Difference	Level	First Difference
LEXP	-2.9(0.22)	-2.6 (0.07)**	-2.9(0.22)	-2.9(0.87)
FPI	-2.9(0.49)	-1.9(0.00) *	-1.9(0.35)	-1.9(0.00) *
LANOE	-2.9(0.95)	-2.9(0.00) *	-2.9(0.96)	-2.9(0.00) *
FOODIMPT	-2.9(0.12)	-2.9(0.00) *	-2.9(0.10)	-2.9(0.00) *
GDPPC	-2.9(0.01)*	-2.9(0.00) *	-2.9(0.01)*	-2.9(0.00) *
GEXED	-2.9(0.99)	-2.9(0.07) **	-2.9(1.00)	-2.9(0.00) *
GEXPH	-2.9(1.00)	-2.9(0.00) *	-2.9(1.00)	-2.9(0.00) *

and ** indicate the rejection of the null hypothesis at 5% and 10%

Table 6: ARDL Result of Cointegration

Test Statistic	Value	K
F-statistic	36.2	6
Critical Value Bounds		
Significance	I(0) Bound	I(1) Bound
10%	2.12	3.23
5%	2.45	3.61
2.5%	2.75	3.99
1%	3.15	4.43

3.1.1 Short and Long-run Results

With the result showing that the series are cointegrated, the study went ahead to investigate both the short and the long-run impact of the explanatory variables on life expectancy. Starting with the short-run results in Table 7, findings revealed that food production index had a significant and positive impact on life expectancy. If food production index increased by one unit, life expectancy improved by 0.2 percent. In another vein, the study found that agricultural nitrous oxide emissions impacted negatively on life expectancy even though the impact is not significant. Food importation was also found to contribute negatively to life expectancy but the result is not significant. In the short-run also, GDP per capita was found to marginally improve life expectancy. If GDP per capita rose by one unit, life expectancy improved by 0.2 percent. While government expenditure on education was found not to significantly impact on life expectancy, government expenditure on health positively

impacted on it. The result of the error correction model revealed that the coefficient of the ECM is negative and statistically significant, confirming the existence of a long-run relationship among the variables. The result implies that the system returns to equilibrium after a shock at a speed of 5 percent.

Table 7: Results of Short-run ARDL

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(FPI)	0.002	0.0009	3.10	0.00
D(LANOE)	-0.29	0.209	-1.40	0.17
D(FOODIMPT)	-0.0003	0.0003	-0.78	0.44
D(GDPPC)	0.002	0.0007	3.65	0.00
D(GEXED(-1))	0.0001	0.0001	1.35	0.19
D(GEXPH)	0.0005	0.0002	2.02	0.05
ECM(-1)	-0.05	0.009	-5.41	0.00

The long-run results in Table 8 indicated that food production index had a significant and positive impact on life expectancy. If food production index rose by one unit, life expectancy improved by 7 percent. This result is in line with the short-run result indicating that nutritional food production contributes to life expectancy in both the time horizons. The study also found agricultural nitrous oxide emissions to exhibit a negative influence on life expectancy even though the result is not significant. While the result of food importation was not found to significantly impact on life expectancy, GDP per capita was found to have a significant and positive impact on life expectancy. Findings equally indicated that while one period lag of government expenditure on education produced a negative but insignificant impact on life expectancy, government expenditure on health had a positive and significant impact on it.

Table 8: Results of Long-run ARDL

Variable	Coefficient	Std. Error	t-Statistic	Prob.
FPI	0.07	0.02	2.80	0.01
LANOE	-5.79	4.24	-1.36	0.19
FOODIMPT	0.002	0.007	0.28	0.77
GDPPC	0.11	0.03	3.34	0.00
GEXED	-0.005	0.005	-1.12	0.27
GEXPH	0.03	0.008	3.65	0.00
C	66.83	16.79	3.98	0.00

3.2 Discussion of Findings

Finding of the study revealed that food production index had a positive and significant impact on life expectancy in Nigeria both in the short-run and in the long-run. This result finds support in the findings by studies that found dietary consumption to enhance longevity (Roswall et al., 2015; Okada et al., 2018; Abe et al. 2020). The finding also corresponds to the finding in Nigeria by Aigheyisi (2020), even though the study used productivity in agriculture to proxy food production. The result equally finds support in a study for Iran by (Golkhandan, 2019). The implication of the result is that the production of local food crops that are rich in nutrients contributed to improved life expectancy in Nigeria within the sample period. Varieties of these food crops are cultivated across the regions of the country and their cultivation is mainly on subsistence basis which means that they are mainly consumed domestically. In another vein, the study found that in both the short-run and long-run, agricultural nitrous oxide emissions impacted negatively on life expectancy, though the result is not significant. By implication, the application of fertilizers in the cultivation of edible crops produced negative health outcome that adversely affected life expectancy. The procurement of synthetic fertilizers by small-holder farmers in Nigeria is usually costly, even though the government subsidizes them in most of the planting seasons. The study is therefore of the view that the reason for the none-significant negative impact of agricultural nitrous oxide emissions on life expectancy could be because most farmers in the country mainly apply none-synthetic fertilizers which pose less harmful effect on health.

Food importation was found to have a negative but none-significant impact on life expectancy in the short-run but in the long-run the outcome was positive though not significant. This result contrasted the finding that found food importation to contribute positively and significantly to life expectancy in Nigeria (Agu et al., 2020). The study is of the view that the

reason for the non-significant positive impact could be because most of the imported food items in Nigeria may produce harmful effects on health due to the chemicals used in preserving them and for the fact that some are also rich in cholesterol. In both the short-run and the long-run, GDP per capita impacted positively on life expectancy. In Nigeria, this result finds support in Arikpo et al. (2019) but contrasted the finding by Aigheyisi (2020). The positive impact of GDP per capita on life expectancy equally finds support in a study in Iran (Somayeh et al., 2016), in the U. S.A by Ketenci and Murthy (2018) and in Spain by Cervantes et al. (2019). The marginal impact of GDP per capita on life expectancy, especially in the short-run confirms our earlier stand that income is not widely spread in Nigeria. Government expenditure on education did not produce any significant positive impact on life expectancy which contrasted the findings in studies in Iran and in developing countries by Somayeh et al. (2016) and Hassan et al. (2017) that revealed a positive impact, respectively. What this implies is that the annual budgets on education and other education intervention programmes both at the primary, secondary and tertiary levels did not influence life expectancy within the study period. There is no gainsaying the fact that part of the reasons for this outcome is the usual diversion of funds meant for education to other uses. However, the positive impact of government health expenditure on life expectancy both in the short-run and the long-run is an indication that health intervention programmes in Nigeria produced positive health outcome. The result finds support in Nigeria in a study by (Aigheyisi, 2020).

The results of the post diagnostic tests in Table 9 revealed that the study passed the tests for heteroskedasticity, serial correlation, normality and model specification. However, for the test of stability of the model, while the CUMSUM test indicated that model is stable, the CUMSUM of square test revealed that the model has an outlier as the plot of the CUMSUM of square statistic falls outside the critical bands of the 5% confidence interval of parameter stability.

Table 9: Post-diagnostic Results

Test	P-value
Heteroskedasticity Test: Breusch-Pagan-Godfrey	0.97
Serial Correlation: Breusch-Godfrey LM Test	0.43
Normality Test: Jarque-Bera	0.18
Model Specification: Ramsey RESET Test	0.20

4. CONCLUSION

The low life expectancy in Nigeria despite the country being among the biggest economies in Africa motivated this study as the paper sought to investigate the factors that impact on life expectancy in the country. Precisely, the study set out to examine the effects of agricultural nitrous oxide emissions and nutritional food production on life expectancy in Nigeria. Investigating the effect of these factors is apt considering that the impact of food on life expectancy is direct and also that in the production of food, the application of fertilizers to improve crop yield leads to poisonous emission that could adversely affect life expectancy. The study used annual series that covered the period from 1980 to 2020. Findings of the study revealed that in both the short-run and the long-run, food production index had a positive and significant impact on life expectancy, while the effect of agricultural nitrous oxide emissions was negative though not significant. The study also found that while both GDP per capita and government expenditure on health improved life expectancy within the study period, the impact of food importation and government expenditure on education was not significant. These findings have some implications among which are that the production and ingestion of nutritional foods enhanced longevity in Nigeria which is in line with many empirical findings. Also, another implication is that the continuous applications of fertilizers in order to improve yields produced negative health outcome. Improved GDP per capita and government expenditure on health were also found to enhance longevity within the study period. The study has thus shown the relevance of several health interventions by the government on life expectancy. The study therefore is of the opinion that there is need for government intervention in the cultivation of local crops that are rich in nutrients through various incentives to small holder farmers. The use of fertilizers in the cultivation of crops should be reduced, especially synthetic fertilizers, while the importation and consumption of foods should be restricted to foods that are rich in nutrients. Finally, while there is need to step up health intervention programmes; even distribution of income should be given a priority.

CONFLICTS OF INTEREST

The authors declare that there is no existing or potential conflict among them in terms of finance or any other issue which could adversely influence the work reported in this paper.

AUTHOR CONTRIBUTIONS

Innocent Chile Nzeh: Conceptualization, methodology, original draft preparation & results analysis. Uzochina, Benedict I.: Conceptualization & editing. Ozoh Joan Nwamaka: Writing- review & methodology. Okoli, Uju Victoria: Editing & conceptualization.

REFERENCES

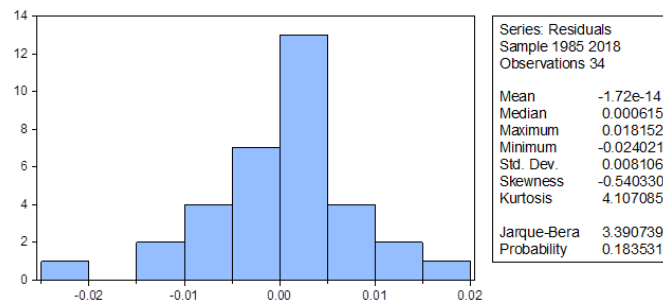
- Abe, S., Zhang, S., Tomata, Y., Tsuduki, T., Sugawara, Y., and Tsuji, I., 2020. Japanese diet and survival time: The Ohsaki cohort 1994 study. *Clin. Nutr.* 39, Pp.298-303.
- Agbatogun, K. K., Osinusi, B., K. and Opeleyeru, O. S., 2019. Socio-economic determinants of life expectancy in Nigeria. *The International Journal of Business and Management*, 7 (11), Pp.263-269.
- Agu, A. O., Agu, S. V., and Onwuteaka, I. C., 2020. Food poverty in Nigeria: Implications for life expectancy. *Journal of Economics and Sustainable Development*, 11(2), Pp.107-114. DOI: 10.7176/JESD/11-2-11
- Aigheyisi, O. S., 2020. Determinants of life expectancy in Nigeria: Does agricultural productivity matter? *KIU Interdisciplinary Journal of Humanities and Social Sciences*, 1(2), Pp.194-210.
- Arikpo, D. I., Eke, F. A., and Obafemi, F. N., 2019. Determinants of life expectancy in Nigeria: A macroeconomic analysis. *International Journal of Social Science and Economic Research*, 04(04). Pp.2722-2749.
- Cervantes, P. A. M., López, N. R., and Rambaud, S. C., 2019. A causal analysis of life expectancy at birth. Evidence from Spain. *Int. J. Environ. Res. Public Health*, 16(13), Pp.1-14. Retrieved from: <https://doi.org/10.3390/ijerph16132367>.
- Etikan, I., Babatope, O., Yuvah, M., and Ilgi, S., 2019. Effects of socioeconomic factors on Nigeria's life expectancy at birth. *Annals of Biostatistics and Biometric Applications*. 1(5).
- Galvani-Townsend S, Martinez I, and Pandey A., 2022. Is life expectancy higher in countries and territories with publicly funded healthcare? Global analysis of healthcare access and the social determinants of health. *Journal of Global Health*, 12(04091). doi: 10.7189/jogh.12.04091
- Golkhandan, A., 2019. Long-term impact of economic misery on the life expectancy in Iran. *Health Research Journal*, 4(2), Pp.104-111.
- Gulcan, C., 2020. A study on life expectancy in Turkey. *EMU Pharmaceutical; Sciences*, 3(2), Pp.86-96.
- Hassan, F. A., Minato, N., Ishida, S., and Nor, N. M., 2017. Social environment determinants of life expectancy in developing countries: A panel data analysis. *Global Journal of Health Science*, 9(5), Pp.105-117.
- Ketenci, N., and Murthy, V. N. R., 2018. Some determinants of life expectancy in the United States: Results from cointegration tests under structural breaks. *Journal of Economics and Finance*, 42, Pp.508-525.
- Miladinov, G., 2020. Socioeconomic development and life expectancy relationship: evidence from the EU accession candidate countries. *Genus*, 76(2). <https://doi.org/10.1186/s41118-019-0071-0>.
- Nzeh, I. C., 2023. Does domestic food production contribute to improved life expectancy? Evidence from low-income food-deficit countries (LIFDC) in Africa. *International Journal of food and agricultural economics*, 11(1). Pp.51-63.
- OECD (Organization for Economic Co-operation and Development), 2011. *Health at a glance 2011: OECD indicators*. Retrieved from <http://www.oecd.org/els/health-systems/49105858.pdf>
- Okada, E., Nakamura, K., Ukawa, S., Wakai, K., Date, C., Iso, H. and Tamakoshi, A., 2018. The Japanese food score and risk of all-cause,

CVD and cancer mortality: The Japan collaborative cohort study. *Br. J. Nutr.*, 120, Pp. 464-471.

- Pesaran, M. H., Shin, Y., and Smith, R. J., 2001. Bounds testing approaches to the analysis of level relationships. *Journal of Applied Econometrics*, 16(3), pp. 289-326. Available at: <https://doi.org/10.1002/jae.616>.
- Roswall, N., Sandin, S., Lof, M., Skeie, G., Olsen, A., Adami, H.O., and Weiderpass, E., 2015. Adherence to the healthy Nordic food index and total and cause-specific mortality among Swedish women. *Eur. J. Epidemiol.* 30, Pp. 509-517.
- Shahbaz, M., Loganathan, N., Mujahid, N., Ali, A. and Nawaz, A., 2015. Determinants of life expectancy and its prospects under the role of economic misery: A case of Pakistan. *Social Indicators Research*, 126(3), Pp. 1299-1316.
- Somayeh, D., Hamed, Z., Satar, R., Mehdi, M., Sajad, D., Ali, S. and Razieh, F., 2016. Life expectancy and its socio-economic determinants in Iran. *Electronic Physician*, 8(10), Pp.3062-3068. DOI: <http://dx.doi.org/10.19082/3062>
- Trpkova-Nestorovska, M., and Levkov 2019. Determinants of life expectancy: analysis of Southeastern European countries. *Knowledge -International Journal*, 31(1), Pp.193-198.

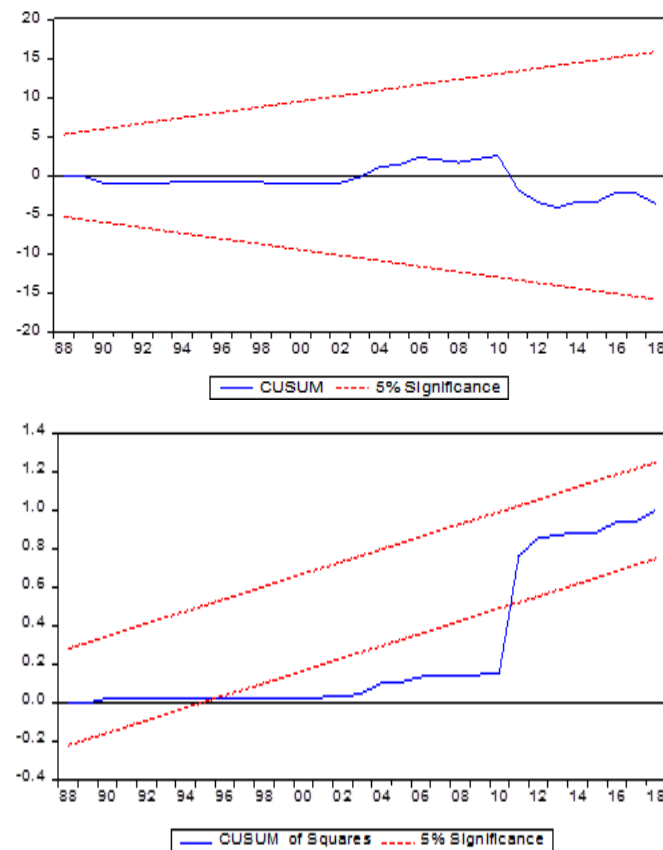
APPENDIX I

Jarque-Bera Normality Graph



APPENDIX II

Plots of Stability Test



APPENDIX III**VAR Lag Order Selection Criteria**

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-634.6	NA	5828501	37.74	38.06	37.85
1	-418.3	330.8	3301.6	27.90	30.41	28.76
2	-282.7	151.5*	29.93*	22.80*	27.52*	24.41*

*Indicates lag order selected by the criterion, FPE – final predictor error, AIC – Akaike information criterion, SC – Schwarz information criterion, HQ – Hannan –Quinn information criterion

