# Population Growth, Life Expectancy and Economic Growth: A Panel Data Analysis

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**Abstract**
*Over the years, quite a number of studies have investigated the apparent relationship between demographic factors and nations' economic performance. However, these investigations have turned out diverse outcomes. This study therefore, contributes to the debate by examining the effect of population growth and life expectancy on economic growth using one hundred selected countries sub-grouped into very high income, high income, middle income and low income. The data set range from 2002 to 2017, and are sourced from World Bank database. The variables engage include growth rate of real gross domestic product, gross fixed capital formation, life expectancy and population growth. The data are analysed using Imp, saran-Shin unit root technique, Kao cointegration test, Hausman test and pooled mean group (PMG) estimator to ascertain the stationarity of the variables, long run relationship, as well as the short run and long run unweight average of the individual nations. In sum, the PMG result reveals that, life expectancy, population growth and gross fixed capital formation, significantly predict economic growth in the long-run. Even so, both life expectancy and population growth rate negatively influenced economic growth. The implication of this is that, the two demographic factors are inversely associated with growth rate of gross domestic product in the sampled countries. The study therefore, recommends the need for sound policies initiation that will address these demographic variables changes to support economic advancement in the studied nations.*

***Keywords:*** *Economic Growth, Life Expectancy, Population, Pooled Mean Estimator, Panel Data*

***JEL Classifications:*** *C33, J11, O40, Q56*

## Introduction

Demographic changes and their impact on nations' economies all over the world have gained considerable attention in recent time. For instance, studies such as Lasen and Lawson (2007), Atanda, Aminu and Alimi (2012), Ahmen and Ahmad (2016), Ogunleye, Owola and Mubarak (2018), Amade and Ibrahim (2019) examined the impact of population growth on economic growth (EG). However, there have been mixed results from these studies. While Lasen and Lawson (2007), Ahmen and Ahmad (2016) observed that population growth adversely affect EG. Atanda, Aminu and Alimi (2012), Ogunleye, Owola and Mubarak (2018), Amade and Ibrahim (2019) found population growth to have significant and positive effect on EG. On another hand, other studies investigated the relationship between life expectancy (LE) and EG. While Barro (1996), Bloom, Canning and Sevilla (2001), Castello-Climent and Domenech (2008), Ecevit (2013) saw a positive LE-EG impact, the works of Hansen and Lønstrup (2015), Ogungbenle, Olawumi and Obasuyi (2013) established a negative and no causality between both variables. Therefore, mixed outcomes of the effect of population growth on EG on one hand, and LE on EG on the other hand by different studies have be confirmed.

Meanwhile, country-based studies on the effect of population growth and LE on EG are rare in the literature. Based on this, it must be pointed out that quite a number of complex factors determine population growth rate of nations, and it must also be noted that rise in population growth rate is not necessarily driven by variations in LE of a country, but increase in birth rate. Population growth rate however, drives economic variables like labour force, age structure, per capita income and inequality aside EG (Oladayo, 2018).

In scientific debate of demographic issues, population growth rate has become the focus with the view of predicting trends and creating policies that will address issues affecting well-being of the populace. Prior to industrial revolution, growth rate of population was close to zero. But during, and after industrial revolution, growth in population increased geometrically. That was contingent on improved living conditions due largely to enhanced healthcare system, diversification of economic structure and technological expansion (Maddison, 2006; Skare & Blazevic, 2015). A growing population aids developing economies as it makes labour force and consumers readily available thereby leading to an expanded market. Though, where population growth surpasses national productivity level, it leads to abysmal economic performance (such as food insecurity). This was the rationale for Thomas Malthus advocacy on population control.

Life expectancy (LE) is another evolving area of demographic indicators. LE at birth is the average number of years a new born is expected to live on earth or in life in any given society. Life expectancy contribution to or influence on EG is still a paradox. Countries with high LE will have improved economic performance (Boucekkine, Diene & Azomahou, 2007; Cervellati & Sunde, 2011), on the contrary, LE greatly affect population growth, and has negative impact on aggregate gross domestic product [GDP] (Acemoglu & Johnson, 2007). This is indeed a conundrum, which calls for concern, and requires further clarification.

It is vital to remark that, rising population growth accompanied by improved EG will influence demographic factors to bring about variation in LE, declining death rate and improving birth rate (Mateo, 2016). Prehistoric humans average LE was between 20 – 35 years, and was 36 years in Sweden in the 1750s, 78 years in 1990 and 83 years in 2017. In the United States, it was 39 years in 1820, 77 years in 1999 and 82 years as at 2017 (United Nations Development Programme [UNDP], 2018). Western Europe had 36 years in 1820, 78 years in 1999 and was 80.9 years in 2017 (Skare & Blazevic, 2015; UNDP 2018). However, high population growth rate is the bane of low GDP per capita in some countries, and why many nations could no longer attain their pre-recession per capita income level even after the recovery.

Regrettably, the inability of some countries to attain pre-recession income per capita or achieve an appreciable one due to increasing population growth has impacted poorly on their standard of living. Thus, directly or indirectly, LE is negatively affected thereby influencing labour force; reduce productivity and eventual insignificant economic output. On the contrary, it has been claimed that EG improves as mortality rate falls, because as people live longer, they tend to invest in the future with willingness to take risk and ultimate better living standard (Dao, 2012; Craig & Bauman, 2014). Given these varied conclusions on demographic variables link with economic performance, and the paucity of studies in this regard, this study contributes to knowledge by examining the connections between these two demographic variables and EG, engaging data from many countries. This study therefore builds on existing literatures, though extant studies have not considered grouping these sampled countries according to income distribution. To achieve this, following the introductory part is the summary of the existing literature in section 2. Section 3 describes the research design and technique of analysis. In section 4, the research findings are displaced; section 5 discusses the finding as shown in 4. Finally, section 6 concludes the study summarizing the research findings and discusses some policy implications.

## Literature Review

The broad-spectrum of empirical studies in this section examine the relationship between LE and EG on one hand, and growth in population and EG on the other hand. Gaps in the reviewed studies are therefore identified.

### Studies on Life Expectancy and Economic Growth

Quite a number of studies have explained the dependency of EG on LE and other macroeconomic variables globally. For instance, Barro (1996) works on three models of health and economic growth in 84 countries, using a panel data analysis. The result shows that an increase in life expectancy by 10% will bring about five to six per cent growth in GDP. Using a convergence method, Bloom, Canning and Sevilla (2001) examine the effect of health on economic growth by employing a panel data approach of 104 nations and the result indicate that a one-year increase in LE will cause GDP to grow from 2.6 to 4%. In like manner, Castello-Climent and Domenech (2008) investigate human capital inequality, LE and EG using 92 countries with data spanning from 1960 to1985. The study employed ordinary least squares (OLS) technique for the empirical analysis and the outcome suggested that there was a positive relationship between LE and EG in the selected countries. Thus, the study concluded that high per capita income brings about longer LE which invariably affects the number of year of people's education.

Another empirical analysis on the nexus between LE and EG was carried out by Ecevit (2013), and the study utilizes panel data of 21 Organization for Economic Corporation and Development (OECD) countries from 1970-2010. The outcome reveals that LE is an essential determinant of EG in the studied nations. In what is considered as related study, Ogungbenle, Olawumi and Obasuyi (2013) extract data that spans from 1977 to 2008 to evaluate the link between LE, public health spending and EG in Nigeria. Using vector autoregressive (VAR) model, the result indicates that there was no bi-directional causal association between LE and EG in Nigeria. Based on the result, the study recommended that the country should increase public health expenditure and put in place measures that will enable LE impacts EG positively.

Hansen and Lønstrup (2015) in their study examine effect of LE at birth on EG of 35 nations using data set spanning from 1940 to 2000. The investigation findings show that in the past 20th century, increase in LE causes decline in per capita GDP, and a rise in population growth. However, in what looks like a reversal, Marhyar (2016) examines the effect of EG on LE in Iran using time series data from 1966 - 2013. Engaging vector error correction model (VECM) to evaluate data collected, the findings reveal EG positively and significantly influenced LE during the studied periods. Furthermore, Ogunjimi and Adebayo (2018) investigate the relationship between health spending, health outcomes and EG in Nigeria using time series data which ranges from 1981-2017. Utilizing the Toda - Yamamoto causality test, the study found a uni-directional causal relationship that run from GDP to LE without feedback effect. Consequent upon these outcomes, the study concludes that, the Nigeria government should increase budgetary allocation to health to align with WHO recommendation (13% of total budget annually).

**Studies on Population Growth and Economic Growth**

In extant studies, quite a number of theoretical and empirical studies have examined the association between growth in population and EG. Malthus (1798) was first to explain the concept of population theory and food supply nexus. He opines that, unchecked population growth rate will surpass food supply, and could lead to misery and vice. He further submits that, while population grows geometrically (1, 2, 4, 8, 16, 32, 64. . .), food supply grows arithmetically (1, 2, 3, 4, 5, 6, 7…). All of this he hinged on the law of diminishing returns, assuming that land is a fixed factor. The theory however was criticised on the grounds that, the proponent was influenced by happenings around England then, the theory was built on the law of diminishing returns, the proponent failed to see the growth in scientific knowledge and technologically known-how in farm produce to stayed the law of diminishing returns and developed nations like India with green revolution equally made nonsense of the theory.

Another germane theory which possibly underpins this study is the Demographic Transition Theory (DTT) by Warren Thompson in 1929. According to the originator of the theory, nations undergo different phases of population growth (four stages). At stage one, is the pre-industrial society with fluctuating death and high birth rates. Stage two is the industrialization period with improved healthcare facilities, enhanced sanitation system and good dietary leading to reduce death rate. The third stage is late transition period. At this time, both death and birth rates experienced a fall, which culminates in reduced population growth rate. The last phase is stationary state where birth and death rates remain low leading to slim population growth rate. The DTT is still widely accepted because it is not pessimistic like Malthus theory. It was only condemned for sequence of occurrences which is not often as explained.

Furthermore, the concept of population was discussed as an exogenous variable in the Solow (1956) neoclassical growth model. In line with this growth model notion, population does not grow geometrically, instead, it grows arithmetically. Solow thus, assumes that a natural and constant population growth rate is independent of economic dynamics. Therefore, a rise in growth rate of population will bring about rise in the number of labour and consequently both absolute output level and growth rate of output in the steady state. On the other hand, an increase in population will cause physical stock of each worker to decline, thereby reducing productivity and output per worker in the steady state. In sum, Solow idea is that a rising population growth would be unfavourable for economic progress.

Following Solow's theoretical idea, Lasen and Lawson (2007) examine the nexus between population growth, economic growth per capita and poverty reduction in Uganda using data spanning 1960-2000. Combining both micro and macro econometric approach, and also utilizing panel analysis, the study observed that rising population has negative impact on per capita growth. Likewise, rising population significantly contribute to low achievement in poverty reduction in the considered nation. Therefore, the study concluded that, it will be difficult to achieve poverty reduction and growth in income per capita due to rising population. In a related but slightly different to Lasen and Lawson's study, Atanda, Aminu and Alimi (2012) investigate the determinants of population growth, and nexus between population growth and economic performance amongst developed countries (United States and Germany) and developing nations (Ethiopia, Nigeria, Mexico, Bangladesh and Indonesia). The secondary data set range from 1980-2010. The outcomes from the trend analysis showed that life expectancy (LE), fertility rate, crude death rate, birth rate and mortality rate are the major determinants of rising population growth rate in the sampled nations. Further findings reveal that rising population leads to higher real GNI per capita in developed nations when compared to developing economies. Following this result, the study called for a framework for population control and provision of crucial infrastructural facilities that will match population size and enhance the welfare of the people in developing nations.

In a similar study, Ahmen and Ahmad (2016) investigate the causal relationship between population growth and economic growth (EG) in Pakistan using secondary data which spans from 1981-2010. Using autoregressive distributive lag (ARDL) approach, the result show a negative impact of population on EG and that, an increase in population growth increases the pool of unemployed population. Thus, the study called for policies that will tackle overpopulation. But in what seems a contradictory outcome to Ahmen and Ahmad (2016), using data from 1981 to 2015, Ogunleye, Owola and Mubarak (2018) study the effect of growing population on EG in Nigeria using (OLS) technique. The outcomes indicate that population growth has significant and positive effect on EG; however fertility rate has a negative and significant effect. Further analysis show that both crude birth rate and exchange rate do not significantly predict EG in Nigeria. Based on the findings, it is suggested that the government of Nigeria should ensure that rising population should be channel to those sectors that will tap the growth potential for rapid EG in the country.

In a recent study by Amade and Ibrahim (2019), panel data of 53 African nations were engaged to explore the impact of growth in population on EG using time series data ranging from 1980-2015. Utilizing generalized method of moment (GMM) methodology, the findings indicate that increase in population exerts positive significant effect on EG, whereas fertility rate inversely impacted EG in the selected countries. Based on the findings, the study concluded that African nations should carry out policy that will utilize the capacity of the growing population in order to reap the dividends of demographic change.

In a broader term, it is evident that there is still paucity of works on the subject matter of population growth, life expectancy and economic growth connection. Therefore, this work makes attempt to bridge the gap in extant studies by examining the impact of LE and POP on economic growth, engaging data from 100 countries (See Table 2), that are further classified into 4 income distribution groups. These countries are selected based on their Human Development Index (HDI) rank as provided by the United Nations Development Programme (UNDP, 2019).

**Methodology**

This study is built on the traditional classical growth model, where output (Q) is express as a function of physical capital (K) and labour (L). Thus, the model is depicted as:

$$Q = (K, L) \quad (1)$$

Where Q is output, L is labour force and K is as hitherto explained. However, since a society's labour force is influence among others by its population (POP) and life expectancy (LEX), the labour force variable (L) can be defined as;

$$L = (POP, LEX) \quad (2)$$

Substituting therefore, equation (2) into (1), the classical model in (1) shall be redefined. Thus, we have:

$$Q = (K, POP, LEX) \quad (3)$$

Therefore, apriori (that is, expected) there should be a positive relationship between the output variable (Q) and all the explanatory variables (K, POP and LEX).

**Model Specification**

Following the model in 3.3, the empirical equation to be estimated in this study is simply specified as:

$$GDP = f(K, POP, LEX) \quad (4)$$

The equation (4) is modified to include GDP (gross domestic product) which is a proxy variable for (Q) output in equation (3), and is thus a deterministic equation. The econometric form for easy analysis is as stated below:

$$\text{GDP} = \alpha_0 + \alpha_1 K_t + \alpha_2 POP_t + \alpha_3 LEX_t + \varepsilon_t \quad (5)$$

Where;

*GDP* = Real Gross Domestic Product growth
*POP* = Population growth rate

*LEX* = Life expectancy
*K* = Gross Fixed Capital formation
$\alpha_0$ = Intercept
$\alpha_1$, $\alpha_2$ *and* $\alpha_3$ = Parameters
$\varepsilon_t$ = Error term
$t$ = Time

In line with economic theory, the a priori expectation is given as:
$\alpha_1 > 0$, $\alpha_2 > 0$ and $\alpha_3 > 0$.

**Table 1: Variable Description and Data Sources**

| Variables | Symbol | Definition | Source |
|---|---|---|---|
| Gross Domestic Product growth | *GDP* | Without making deduction for depreciation and degradation, the annual percentage growth rate of GDP at market prices based on constant local currency. Aggregates are based on constant 2010 U.S. dollars. GDP is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. | World Bank WDI (2018) |
| Capital | *K* | Capital in this investigation is captured using gross fixed capital formation (formerly gross domestic fixed investment) which is made of investment in land improvements; plant, machinery and equipment purchases; and construction. | |
| Life expectancy | *LEX* | Life expectancy at birth indicates the number of years a new born infant would live if prevailing patterns of mortality at the time of its birth were to stay the same throughout its life. | |
| Population growth | *POP* | Annual population growth rate for year t is the exponential rate of growth of midyear population from year t-1 to t, expressed as a percentage. Population is based on the de facto definition of population, which counts all residents regardless of legal status or citizenship. | |

***Sources:** Authors' Compilation*

The sample used for this study is a panel of 100 countries, and the periods cover 2002 - 2017. These periods mark the era of the financial meltdown that affected most countries globally. The 100 countries are further group into four income groups based on World Bank classification as shown below.

**Sampled Countries According to Income Groups**

The 100 nations considered are drawn from five continents (Africa, America, Asia, Australia/Oceania and Europe) in the world. The grouping is based on HDI classification (very high-income, high- income, middle-income and low-income nations), of these nations in each continent in line with World Bank categorisation.

**Table 2: Countries group according to income distribution**

| Ranking | Countries | Source |
|---|---|---|
| Very High Income Countries | Australia, Austria, Belgium, Canada, Denmark, Estonia, Finland, France, Germany, Iceland, Ireland, Israel, Italy, Netherlands, Norway, Poland., Portugal, Russian Federation, Saudi Arabia, Singapore, Spain, Sweden, Switzerland, United Kingdom and United States. | WDI (2018) |
| High Income Countries | Armenia, Azerbaijan, Bosnia and Herzegovina, Botswana, Brazil, China Colombia, Costa Rica, Dominican Republic, Ecuador, Gabon, Georgia, Iran, Islamic Rep., Peru, Jamaica, Lebanon, Mexico, Panama, Paraguay, Sri Lanka, Thailand, Tunisia Turkey, Ukraine &Uzbekistan | WDI (2018) |
| Middle Income Countries | Angola, Bangladesh Bhutan, Bolivia, Cambodia, Cameroon, Congo Rep., Egypt, Arab Rep., El Salvador, Ghana, Guatemala, Honduras, India, Indonesia, Iraq, Kenya, Kyrgyz Republic, Lao PDR, Morocco, Namibia, Nepal, Pakistan, Philippines, South Africa & Vietnam. | WDI (2018) |
| Low Income Countries | Benin, Burkina Faso, Central African Republic, Chad, Comoros, Congo Dem. Rep., Cote d'Ivoire, Guinea, Guinea-Bissau, Liberia, Madagascar, Mali, Malawi, Mauritania, Mozambique, Niger, Nigeria, Rwanda, Senegal, Sierra Leone, Sudan, Tanzania, Togo, Uganda & Zimbabwe | WDI (2018) |

***Sources:*** *Authors' Compilation*

**Analytical Framework**

The methodological approach adopted covers both descriptive and econometric techniques. The descriptive statistics involves the use of mean, minimum, maximum, standard deviation and correlation analysis. For econometric approach, it includes panel unit root test, Kao co-integration test, Hausman test and the pool mean group (PMG) estimator.

**Panel Unit Root Test**

This study employs Im, Pesaran and Shin (1997) unit root test methodology to carry out stationarity of these data. Thus, it must be noted that for test that involve regression of lagged difference terms, Im, Pesaran and Shin test is most suitable. Im *et al* methodology allows for individual unit root processes so that it may vary across the different income groups. The test is characterized by combination of individual unit root tests to derive a panel-specific result. Therefore, study begins by classifying the unit root tests on the basis of whether it is restricted on the autoregressive process across countries or series. Let say, the autoregressive process, that is, AR (1) process for panel data is stated as:

$$y_{it} = \rho_i y_{it-1} + X_{it}\delta_i + \varepsilon_{it} \qquad \textbf{(7)}$$

From equation (7), the study specifies a similar ADF regression for each income groups, following the work of Im, Pesaran, and Shin. Thus:

$$\Delta y_{it} = \alpha y_{it-1} + \sum_{j=1} \beta_{ij}\Delta y_{it-j} + X'_{it}\delta + \varepsilon_{it} \qquad (8)$$

Where i=1,2,3,…., N, are cross section income groups of nations or series, that are observed over periods; 't'=1, 2, ...$T_i$. The '$X_{it}$'represents the exogenous variables in the model, which includes any fixed effects or individual trends, '$\rho_1$ and $\alpha$ 'are autoregressive coefficients, '$\varepsilon_i$' are error terms and they are assumed to be mutually independent idiosyncratic disturbance.

After the unit root test was performed, the Kao cointegration test, which only allows for individual intercept was carried out. The Kao test follows the same basic approach as the Engle-Granger (1987) and Pedroni (1999, 2004) tests (See equations 3.9 - 3.10), but emphasized on specific cross-section, specific intercepts and homogeneous coefficients on the first-stage regressors. The Pedroni equation is stated as:

$$y_{it} = \alpha_i + \delta_i t + \beta_{1i} x_{1t,t} + \beta_{2i} x_{21,t} + \ldots + \beta_{Mi} x_{Mi,t} + \varepsilon_{i,t} \qquad (9)$$

For t=1, …, T,; í=1,…, N; m=1…., M; where 'y' and 'x' are assumed to be integrated of order one, e.g. I(1). More generally, the study may consider running the first stage regression from equation (9), requiring the '$\alpha_i$' to be heterogeneous, '$\beta_1$' to be homogeneous across all income groups, and setting all of the trend coefficients '$\Upsilon_i$' to zero.

Following the general model specification of the ARDL (p, q) model, the long-run growth regression equation is used and the error correction form is specified as:

$$\Delta(y_i)_t = \sum_{j=1}^{p-1}\gamma_j^i \Delta(y_i)_{t-j} + \sum_{j=0}^{q-1}\vartheta_j^i \Delta(X_i)_{t-j} + \varphi^i\left[(y_i)_{t-1} - \left\{\beta_0^i + \beta_1^i (X_1)_{t-1}\right\}\right] + \varepsilon_{it} \qquad (10)$$

Where, y is the real GDP growth rate, X represents a set of growth determinants including life expectancy, population growth rate and control variables. The symbols '$\gamma$' and '$\partial$' are the short-run coefficients related to growth and its determinants, $\beta$ are the long-run coefficients, $\varphi$ is the speed of adjustment to long-run relationship and $\epsilon$ is a time-varying disturbance. The subscripts represent country and time specifications (Pesaran, 2001; Loaza & Ranciere, 2006).

In line with equation (10), is the panel pool mean group estimated equation (11). The pool mean group (PMG) estimator in this study offers a balance between efficiency and consistency. One of the main assumption of the pooled mean group is that the long run coefficient are the same across all the group that makes up the panel while the short-run coefficients and long-run speed of adjustment differs across each country in the panel. However, in this study, we will only explore the coefficients across the income group and not country specific. The first section of the PMG table shows the long-run coefficient while the second section of the table shows the short-run coefficients. The study adopts the short-run and long-run coefficient model in which real GDP is used to capture economic growth as a function of population growth, life expectancy, education expenditure, investment rate and governance. The specific form of our model is:

$$\Delta(GDP_i)_t = \theta_i\left[GDP_{i,t-1} - \lambda^i X_{i,t}\right] + \sum_{j=1}^{p-1}\iota_{ij}\Delta GDP_{i,t-j} + \sum_{j=0}^{q-1}\beta_{ij}^i \Delta X_{i,t-j} + \phi_i + \varepsilon_{it} \qquad (12)$$

The parameter $\varepsilon$ represents error term which is identically and independently distributed, and the letters $i$ and $t$ represents countries index and time index respectively. Thus, $\theta_i = -(1 - \delta_i)$ represents the group-specific speed of adjustment coefficient which is expected to be less than zero. The vector $\lambda'$ is long-run relationship, while $\xi_{ij}$ and $\beta'_{ij}$ are the short-run dynamic coefficients. Besides, $[GDP_{i,t-1} - \lambda' X_{i,t}]$ in the model signifies the error correction term.

**Discussion of Result**

This section presents the descriptive statistics and other dynamic tests. The dynamic tests include the Im-Pesaran-Shin unit root, Kao co-integration, Hausman and pooled mean group (PMG) estimators. These tests results are explained below.

## Descriptive Analysis

The descriptive statistics is done to have a clearer understanding of the characteristics of each variable and to do a comparative analysis of the outcomes. Decomposing the sampled nations into income groups as in table 4, shows that low-income countries record the highest growth in population while the least population growth is in very high-income nations. This is an indication of effect of the population control measures in place in high-income countries. The highest growth in GDP is in the middle-income groups while the least which is surprising, is in very high-income countries. This confirms the catching-up effect theory in line with growth. The life expectancy indicator shows that the minimum life expectancy is around 40 years and is in low-income countries, while the high-income group has the highest with 83 years. This is a reflection of the difference in the living standards and other social desirable changes needed for longevity of human lives in high-income countries.

**Table 3: Descriptive Statistics according to Income Groups**

| Variable | Obs | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|
| | | *Low Income* | | | |
| GDP | 400 | 4.721318 | 5.336405 | -36.69995 | 33.62937 |
| K | 400 | 20.66205 | 9.515804 | 2.000441 | 74.60823 |
| LEX | 400 | 56.28013 | 5.636485 | 40.66 | 67.5 |
| POP | 400 | 2.723325 | .6124566 | .2054935 | 4.77276 |
| | | *Middle Income* | | | |
| GDP | 400 | 5.100745 | 4.253026 | -33.10084 | 54.15778 |
| K | 400 | 23.98851 | 8.926843 | 5.360604 | 68.02272 |
| LEX | 400 | 65.90617 | 6.027597 | 49.341 | 76.5 |
| POP | 400 | 1.841722 | .7239642 | .4399957 | 3.5759 |
| | | *High Income* | | | |
| GDP | 400 | 4.644592 | 4.44725 | -14.75854 | 34.5 |
| K | 400 | 24.58152 | 6.391358 | 13.54871 | 57.71025 |
| LEX | 400 | 72.88629 | 4.577146 | 49.108 | 80 |
| POP | 400 | 1.086089 | 1.102677 | -1.315808 | 7.06102 |
| | | *Very High Income* | | | |
| GDP | 400 | 2.255372 | 3.158307 | -14.7244 | 25.55727 |
| K | 399 | 22.04984 | 3.573624 | 13.9361 | 36.73959 |
| LEX | 400 | 79.45265 | 3.313434 | 65.04781 | 83.5 |
| POP | 400 | .7819435 | .835729 | -1.853715 | 5.321517 |

**Source:** *Author's computation using STATA 15*

Table 4 shows the descriptive statistics for the whole income groups. Thus, life expectancy tends to have the highest standard deviation and mean value while population growth (POP) has the least outcome.

**Table 4: Descriptive Statistics of the 100 Countries**

| Variable | Obs | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|
| GDP | 1,600 | 4.180507 | 4.50664 | -36.69995 | 54.15778 |
| K | 1,599 | 22.82096 | 7.636689 | 2.000441 | 74.60823 |
| LEX | 1,600 | 68.63131 | 9.939972 | 40.66 | 83.5 |
| POP | 1,600 | 1.60827 | 1.125059 | -1.853715 | 7.06102 |

***Source:*** *Author's computation using STATA 15*

Generally, minimum negative growth rate was observed in real GDP and POP in the total sample.

## Correlation Analysis

To confirm that there is no linear relationship or exact dependence among the regressors, correlation analysis is required. A correlation statistic of 0.70 and above among independent variables depicts evidence of a linear relationship between the variables, and possibility of the model suffering from multicollinearity. Table 5 presents the correlation matrix for the different groups. Both middle income and very high-income countries exhibit the same pattern between the dependent and independent variables with life expectancy showing a negative relationship with growth in GDP.

**Table 5: Correlation Matrix for each Income Group**

| | GDP | K | LEX | POP |
|---|---|---|---|---|
| *Low Income* | | | | |
| GDP | 1.0000 | | | |
| K | 0.2292 | 1.0000 | | |
| LEX | 0.0357 | 0.3594 | 1.0000 | |
| POP | 0.3806 | 0.3630 | 0.1549 | 1.0000 |
| *Middle Income* | | | | |
| GDP | 1.0000 | | | |
| K | 0.1439 | 1.0000 | | |
| LEX | -0.0482 | 0.0777 | 1.0000 | |
| POP | 0.0496 | -0.0439 | -0.4798 | 1.0000 |
| *High Income* | | | | |
| GDP | 1.0000 | | | |
| K | 0.3481 | 1.0000 | | |
| LEX | -0.0573 | -0.1214 | 1.0000 | |
| POP | -0.0405 | 0.0315 | -0.0938 | 1.0000 |
| *Very High Income* | | | | |
| GDP | 1.0000 | | | |
| K | 0.2416 | 1.0000 | | |
| LEX | -0.1809 | -0.0385 | 1.0000 | |
| POP | 0.1917 | 0.2910 | 0.1632 | 1.0000 |

***Source:*** *Author's computation using STATA 15*

From the result (Table 5), all the explanatory variables have a positive relationship with GDP growth in the low-income countries while the high-income regions have two of the explanatory variables negatively related to growth in GDP. There is no evidence of perfect or exact linear representations of the explanatory variables in each of the income group.

In line with these, Table 6 presents the correlation matrix for all the countries. The outcome predicted a negative relationship which runs between life expectancy and GDP growth rate while capital and population growth exerts a positive relationship with GDP growth rate. Also, none of the explanatory variables is linearly dependent on each other from the values shown in the table.

**Table 6: Correlation Matrix for all the Countries**

| | GDP | K | LEX | POP |
|---|---|---|---|---|
| GDP | 1.0000 | | | |
| K | 0.2316 | 1.0000 | | |
| LEX | -0.1743 | 0.1387 | 1.0000 | |
| POP | 0.1906 | 0.0144 | -0.6071 | 1.0000 |

***Source:*** *Author's computation using STATA 15*

In sum, the correlation results in Tables 5 and 6 depict that two variables (GDP & POP) in the outcomes of low income, middle income and very high-income countries have a positive relationship with GDP growth and this is similar to the result of the whole sample (Table 6). From these findings, it shows that, these indicators in the low-income, middle-income and high-income countries typically influence the outcome in the whole sample result. Following the descriptive statistics is the stationary test.

**Unit Root**

To ascertain the stationarity of the data, unit root test is performed using the Im-Pesaran-Shin methodology, which has the assumption of heterogeneous slopes. The result as depicted in table 7 is for each income group and the whole sample. Of keen interest, are the stationarity levels in the low-income group, which have the same order of integration with the whole countries data (See table 7). The outcomes of high income and very high-income countries, exhibit same pattern of stationarity in which growth in GDP, population growth (POP) and capital (K) are stationary at level, while life expectancy (LEX) is stationary at first difference. The middle-income group has K stationary at first difference while the remaining variables are stationary at level.

**Table 7: Unit Root Test for each Income Group**

| Variables | Level | | 1st Difference | | Conclusion |
|---|---|---|---|---|---|
| | Statistic | p-value | Statistic | P-value | |
| *Low Income* | | | | | |
| GDP | -4.1340 | 0.0000 | NA | NA | I(0) |
| K | -1.8628 | 0.0000 | NA | NA | I(0) |
| LEX | -21.4488 | 0.0000 | NA | NA | I(0) |
| POP | -17.9102 | 0.0000 | NA | NA | I(0) |
| *Middle Income* | | | | | |
| GDP | -6.3767 | 0.0000 | NA | NA | I(0) |
| K | -1.1154 | 0.1323 | -6.4200 | 0.0000 | I(1) |
| LEX | -11.0498 | 0.0000 | NA | NA | I(0) |
| POP | -8.4964 | 0.0000 | NA | NA | I(0) |
| *High Income* | | | | | |
| GDP | -5.5160 | 0.0000 | NA | NA | I(0) |
| K | -1.9187 | 0.0275 | NA | NA | I(0) |
| LEX | 0.9550 | 0.8302 | -7.6628 | 0.0000 | I(1) |
| POP | -8.5754 | 0.0000 | NA | NA | I(0) |
| *Very High Income* | | | | | |
| GDP | -6.4989 | 0.0000 | NA | NA | I(0) |
| K | -2.9393 | 0.0016 | NA | NA | I(0) |
| LEX | 0.5951 | 0.7241 | -8.3715 | 0.0000 | I(1) |
| POP | -42336 | 0.0000 | NA | NA | I(0) |
| Unit Root Test for the Whole Sample | | | | | |
| GDP | -11.2628 | 0.0000 | NA | NA | I(0) |
| K | -3.9183 | 0.0000 | NA | NA | I(0) |
| LEX | -15.4742 | 0.0000 | NA | NA | I(0) |
| POP | -19.6074 | 0.0000 | NA | NA | I(0) |

***Source:*** *Author's computation using STATA 15*

In addition, the unit root test for the whole sample shows that all the variables are stationary at level.

## Co-integration Test

The concept of cointegration implies that the variables have long-run relationship, which can be in the form of joint significance of the level equation. The Kao test for co-integration is used, with the null hypothesis of no cointegration and the alternative hypothesis that, the variables are cointegrated. From the result presented in table 8, the p-value of the Kao test is significant at five percent, and the study therefore rejects the null hypothesis of no co- integration.

**Table 8: Kao Co-integration Test**

| | Statistic | P-value |
|---|---|---|
| Modified Dickey-Fuller t | -6.1386 | 0.0000 |
| Dickey-Fuller t | -15.9400 | 0.0000 |
| Augmented Dickey-Fuller t | -6.0926 | 0.0000 |
| Unadjusted modified Dickey-Fuller t | -29.1175 | 0.0000 |
| Unadjusted Dickey-Fuller t | -26.0778 | 0.0000 |

***Source:*** *Author's computation using STATA 15*

## Hausman Test

Similarly, the Hausman test is employed to determining which estimator, that is, mean group (MG) or pooled mean group (PMG) is most appropriate for estimating the panel data. While the mean group (MG) uses the unweighted average of the individual country's coefficient to derive the long-run and short-run outcomes, the PMG employs the same long-run coefficient across the sample. The Hausman result is depicted in table 9 and the null hypothesis of homogeneity insinuates that the PMG is the most appropriate estimator. Given the p-value (0.8528) of the Hausman test, the null hypothesis cannot be rejected; therefore, the PMG is the most efficient estimator for the model (See Table 9).

**Table 9: Hausman Test**

| | mg | Pmg | Difference | S.E. |
|---|---|---|---|---|
| InK | -4.267078 | 2.883157 | -7.150235 | 7.51137 |
| GDP | 1.083664 | .2227044 | .8609597 | 20.52935 |
| InLEX | -17.44331 | -6.075422 | -11.36788 | 129.5191 |
| POP | 3.246052 | -.5887306 | 3.834782 | 14.76851 |
| | chi2(4) = 1.35 | | Prob>chi2 = 0.8528 | |

***Source:*** *Author's computation using STATA 15*

## PMG Estimates (For Individual and Aggregate Income Groups)

## Low Income Countries Outcome

The low-income countries group PMG result is presented in Table 10. The upper section of Table 10 shows the long-run coefficient of the PMG outcome, and this outcome reveals that capital has a positive relationship with GDP, and has statistical and significant impact on the predicted variable. Life expectancy is also statistically and significant, but has a negative relationship with growth in GDP. Population growth is positively related to economic growth but not statistically and significantly predicting GDP in low-income countries.

**Table 10: PMG for the Low-Income Countries**

| | D.GDP | Coef. | Std. Err. | Z | P> (z) | (95% Conf. Interval) | |
|---|---|---|---|---|---|---|---|
| ECT | lnK | 3.4026 | 0.45488 | 7.48 | 0.000 | 2.5110 | 4.2941 |
| | lnLEX | -8.1040 | 3.4027 | -2.38 | 0.017 | -14.773 | -1.4348 |
| | POP | 0.2427 | 0.6939 | 0.35 | 0.727 | -1.1173 | 1.6027 |
| SR | ECT | -1.0743 | 0.0539 | -19.90 | 0.000 | -1.1801 | -0.9685 |
| | lnK (D1) | 6.8970 | 6.5138 | 1.06 | 0.290 | -5.8698 | 19.6640 |
| | lnLEX (D1) | -304.4153 | 340.1365 | -0.89 | 0.371 | -971.0707 | 362.24 |
| | POP (D1) | 6.8430 | 10.8364 | 0.63 | 0.528 | -14.3959 | 28.0819 |
| | C | 32.0987 | 1.9102 | 16.80 | 0.000 | 28.3547 | 35.8426 |

***Source:*** *Author's computation using STATA 15*

The other section of the table starts with the ECT which is negative and statistically significant which affirms that there is long-run relationship between the variables of the low income countries. The speed of adjustment with which equilibrium will be attained for every deviation is 107%. The short-run coefficient still maintains same direction as the long-run coefficient but none of the coefficient is statistically significant.

**Middle Income Countries Outcome**

Table 11 presents the pooled mean group of middle income countries with only two of the explanatory variables significant in the long-run. Capital as proxy by gross fixed capital shows a positively relationship with growth in GDP and it is statistically significant at the five percent. Thus, LE and population growth, which are the key variables in this study, have an inverse relationship with growth in GDP and the impact of the former is statistically significant while the latter is not. Inferring from the outcome of low-income countries and this current one, it can be stated that both lnK and InLEX have the same signs and significant impact on growth rate of GDP in the long-run.

**Table 11: PMG for Middle Income Countries**

| | D.GDP | Coef. | Std. Err. | Z | P> (z) | (95% Conf. Interval) | |
|---|---|---|---|---|---|---|---|
| ECT | lnK | 1.8319 | 0.6568 | 2.79 | 0.005 | 0.5445 | 3.1193 |
| | lnLEX | -8.1128 | 4.0171 | -2.02 | 0.043 | -5.9863 | -0.2393 |
| | POP | -0.1038 | 0.5945 | -0.17 | 0.861 | -1.2692 | 1.0614 |
| SR | ECT | -0.9545 | 0.0677 | -14.10 | 0.000 | -1.0873 | -0.8218 |
| | lnK(D1) | 4.8196 | 2.0675 | 2.33 | 0.020 | 0.7674 | 8.8719 |
| | lnLEX (D1) | 165.0704 | 258.4236 | 0.64 | 0.523 | -341.430 | 671.571 |
| | POP (D1) | -7.8380 | 6.6268 | -1.18 | 0.237 | -20.8264 | 5.1503 |
| | C | 30.4988 | 2.1852 | 13.96 | 0.000 | 26.2158 | 34.7818 |

***Source:*** *Author's computation using STATA 15*

The section below in table 11 shows the error correction term and the short-run coefficient of the estimation of the middle-income countries. There is evidence of long-run relationship as shown in the coefficient of the ECT which is negative and statistically significant. In the short-run estimate, only lnK is statistically significant, and is positively related to growth in GDP. Both life expectancy and population growth are not statistically significant in the short-run. In sum, life expectancy is positive in the short-run but inversely related to GDP in the long-run.

### High Income Countries Outcome

The PMG result for high-income countries for both long-run and short-run estimate is presented in table 12. From the long-run estimate, it is observed that the three regressors are statistically significant. However, only InK has positive relationship with GDP. Both InLEX and POP are in the broad view of high-income countries and inversely related with GDP and the impact of these variables are noted to be statistically significant.

**Table 12: PMG for the High Income Countries**

| | D.GDP | Coef. | Std. Err. | Z | P> (z) | (95% Conf. Interval) | |
|---|---|---|---|---|---|---|---|
| ECT | lnK | 4.7849 | 1.2323 | 3.88 | 0.000 | 2.3696 | 7.2002 |
| | lnLEX | -40.8643 | 12.3999 | -3.30 | 0.001 | -65.1677 | -16.5609 |
| | POP | -0.7802 | 0.1774 | -4.40 | 0.000 | -1.1280 | -0.4323 |
| SR | ECT | -1.0087 | 0.0547 | -18.43 | 0.000 | -1.1160 | -0.9014 |
| | lnK (D1) | 14.2127 | 4.6356 | 3.07 | 0.002 | 5.1270 | 23.2983 |
| | lnLEX (D1) | 94.4504 | 563.8657 | 0.17 | 0.867 | -1010.70 | 1199.60 |
| | POP (D1) | -35.6738 | 43.5495 | -0.82 | 0.413 | -121.0293 | 49.6816 |
| | C | 165.6217 | 9.5362 | 17.37 | 0.000 | 146.931 | 184.3124 |

***Source:*** *Author's computation using STATA 15*

The ECT coefficient (Table 12) is negative and statistically significant and this confirms the evidence of long-run relationship among the variables. The speed of adjustment is 100% for every deviation that occurs from equilibrium. Like the other outcome, InK is positively related to GDP and statistically significant. The impact of life expectancy and population growth is not statistically significant with life expectancy positively related and population growth inversely related to GDP.

## Very High-Income Countries Outcome

From the PMG estimate of very high income countries (Table 13), the long-run coefficients shows that InK is positively related to GDP, but not statistically significant. This is an indication of diminishing returns that is already at play in very high-income countries. InLEX has an inverse and statistically significant impact on GDP. However, population growth is positively related to GDP but the impact is not statistically significant.

**Table 13: PMG for the Very High Income Countries**

| | D.GDP | Coef. | Std. Err. | Z | P> (z) | (95% Conf. Interval) | |
|---|---|---|---|---|---|---|---|
| ECT | lnK | 0.0027 | 0.9121 | 0.00 | 0.998 | -1.7849 | 1.7905 |
| | lnLEX | -17.3322 | 4.8722 | -3.56 | 0.000 | -26.8816 | -7.7827 |
| | POP | 0.1162 | 0.2045 | 0.57 | 0.570 | -0.2846 | 0.5171 |
| SR | ECT | -1.0696 | 0.0589 | -18.14 | 0.000 | -1.1852 | -0.9541 |
| | lnK (D1) | 33.1900 | 6.2118 | 5.34 | 0.000 | 21.0150 | 45.3651 |
| | lnLEX (D1) | 29.3902 | 48.1322 | 0.61 | 0.541 | -64.9473 | 123.7279 |
| | POP (D1) | 3.5261 | 1.4362 | 2.46 | 0.014 | 0.7112 | 6.3410 |
| | C | 86.9893 | 4.7673 | 18.25 | 0.000 | 77.6454 | 96.3332 |

***Source:*** *Author's computation using STATA 15*

In the second section of the Table of short-run, the ECT coefficient is negative and statistically significant, confirming the evidence of long-run relationship in the estimate. The short-run coefficient shows that capital is positively related to GDP and significant. InLEX has a positive relationship with GDP but not significant and lastly, POP is positively related to GDP and statistical significant in predicting GDP in very high-income countries.

## The Aggregate/Whole Sample Outcome

The result of the PMG as shown in Table 14 gives the long-run and short-run estimates. Thus, all the explanatory variables have significant impact on GDP in the long-run whereas only one variable (InK) was significant in the short run. A cursory look at the long-run and short-run estimates shows that InK has a positive and significant impact on GDP. The result confirms earlier growth theories such as endogenous growth theory and studies like Sayef (2017), Oyedokun and Ajose (2018) that reveal the role of capital formation in accelerating growth and development of every economy as it provides domestic resources that can be used to fund the investment effort of the economy. However, this contrary to Ozoh, Nwaka, Igberi and Uma (2016); Ewubare and Worlu (2020); Muhammad, Aldeehani and Saleh (2020) results, that investment effect on GDP is insignificant. In the result shown in Table 14, life expectancy is negatively related to GDP and it is statistically significant in the long-run, and is supported by Hansen and Lønstrup (2015) findings, that, InLEX exerts adverse impact on GDP growth. However, it is not in line with Ecevit (2013), Mahumud (2013), Ebenstein *et al* (2015), Ngangue and Manfred (2015), He and Li (2020) outcomes that found a positive and significant impact of InLEX on economic growth.

**Table 14: PMG for the Whole Sample**

| | D.GDP | Coef. | Std. Err. | Z | P> (z) | (95% Conf. Interval) | |
|---|---|---|---|---|---|---|---|
| ECT | lnK | 2.8831 | 0.3286 | 8.77 | 0.000 | 2.2389 | 3.5273 |
| | lnLEX | -6.0754 | 2.0715 | -2.93 | 0.003 | -10.1356 | -2.0152 |
| | POP | -0.5887 | 0.1398 | -4.21 | 0.000 | -0.8628 | -0.3145 |
| SR | ECT | -1.0236 | 0.0293 | -34.84 | 0.000 | -1.0812 | -0.9660 |
| | lnK (D1) | 15.0776 | 2.8641 | 5.26 | 0.000 | 9.4640 | 20.6911 |
| | lnLEX (D1) | 58.0576 | 184.6794 | 0.31 | 0.753 | -303.9072 | 420.0226 |
| | POP (D1) | -9.3396 | 10.2748 | -0.91 | 0.363 | -39.4779 | 10.7986 |
| | C | 21.2610 | 0.91633 | 23.20 | 0.000 | 19.4650 | 23.0570 |

***Source:*** *Author's computation using STATA 15*

In addition, the long-run estimate suggests that, POP negatively and significantly related to GDP given the p-value less than 5%, however in the short-run, POP is not significant. This outcome could necessarily mean that increase in population does not amount to increase labour force or their productive capacity. Furthermore, the error correction term (ECT) in the short-run estimate (Table 14) has the expected negative sign and is statistically significant which confirms the evidence of long-run relation between growth in GDP and all the explanatory variables. The ECT coefficient value shows that any deviation will be corrected with the speed of adjustment of 102% in the long-run. Particularly, the short-run coefficients have only one variable that is statistically significant and that is InK. It shows a positive relationship with growth in GDP in long-run. InLEX shows a positive nexus while POP depicts negative relationship with GDP; however, they do not have significant impact on the outcome variable. The implications of this is that, increase in POP and InLEX may not bring about improved economic growth (in the long-run), but the direct effect on productivities and indirect effect on harnessing capital formation will cause these variables to have significant impact on GDP growth.

**Conclusion and Recommendations**

This study examines the relationship between population, life expectancy and economic growth using a panel data of 100 countries. These countries are classified based on their HDI status and World Bank income group classification. The data utilized for the study span through the periods 2002-2017. The estimation techniques include descriptive statistics, correlation technique, unit root test, Kao- cointegration test, Hausman test and the PMG estimator. Inferring from the unit root test (for the whole sample), it is observed that all the variables are stationary at level. From the cointegration outcome, it is noticed that, there exists a long-run relationship among all variables. Thereafter, the Hausman test was employed to determine the appropriate estimator. Thus, the PMG estimator was chosen. The findings from PMG estimation show that there is the existence of long-run relationship among all the variables in low income, middle income, high income, and very high-income countries. For the low-income and middle-income countries, in the long-run, the variables, lnK and InLEX are significant in predicting GDP, which implies that a policy that is futuristic will work well to achieve desirable economic growth. Also, the outcome suggested that low income countries should focus on lnK and LEX, while middle income countries should pay attention on InLEX in the short-run while both regions should focus on POP in both periods.

For high income countries, all three variables (lnK, InLEX & POP) significantly predict GDP, with the exception of lnK that positively relate with GDP in the long-run. In the short-run, only lnK significantly predict GDP. The implication of these findings is that in HIC more attention should be on InLEX and POP in the short-run so as to continue to have a robust labour force and sustain economic growth and development. In much same way, in VHIC, the long-run estimate indicated that only InLEX has significant impact on GDP while LnK and POP significantly predict economic growth in the short-run. In sum, this implies that very high income countries policy emphasis should be on POP and lnK in the long-run, and LEX in the short-run.

Furthermore, when the whole sample was considered, the evidence of long-run relationship was confirmed among the variables. Similarly, capital, life expectancy and population growth is counted to be crucial to economic growth. The results show that rising life expectancy invariably affects the conception of people about investment in both fixed capital and human capital and later improve the economic growth of the society. The whole sample result is in agreement with the after-transition result of Cervellati and Sunde (2011), but at variance with Schnabel and Eilers (2009).

Consequent on these findings, it is therefore recommended that both short-run and long run analyses should be a factor in the studied countries planning strategies. In addition, there is the urgent need for sound policies that will address rising population growth and declining life expectancy (in low-income nations), and declining population growth in high-income counties in other to gauge their impact on economic performance in the sampled countries. This implies that, there is the need for sound policies initiative that will address demographic variables changes in order for these variables to support economic advancement in the studied nations. In much same way, long-term investment in both human and infrastructure development is emphatically encouraged especially in low and middle-income countries. Like many other studies, this study is however not without limitations; one of such limitation precludes the possibility of any deep analysis to ascertain these demographic variables thresholds that can aid economic growth. Notwithstanding the study's limitation, the study contributes to knowledge by decomposing the investigation's outcomes in line with the composition of the sampled countries along income distribution structures. Lastly, this study can be said to be first among several studies in recent years, to analyse the associations of population growth and life expectancy impact on economic growth using one hundred countries in a panel pooled mean group (PMG) model.

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