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RESEARCH PAPER

Is Population Growth a Requisite For National Economic Growth? A Revisit of the Debate Using Panel Data Analysis

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Abstract
This current paper reassesses the controversial discourse regarding the impact and predictability of economic growth by population growth using data from 66 countries that constitute 85 percent of the global population. The countries were drawn from the six continents and the panel data span through the periods 2001-2019. The variables include GDP per capita used to measure economic growth (Regressand), aggregate population, fertility rate, life expectancy, crude death rate as well as gross fixed capital formation. The Pedroni residual cointegration test, fixed effects estimator, and panel causality tests were utilized to estimate the data at the regional and global levels. The result of the cointegration test established that the regressand and regressors have a long-run relationship both at the regional and global levels. Findings from the fixed effects model suggest that the main variable (population growth) exerts a negative significant effect on per-capita GDP in each continent. While the result for the complete continent advances that GDP per capita is adversely and significantly predicted by population growth and fertility rate whereas, gross fixed capital formation and crude death rate exert a direct significant effect on the regressand. The panel causality result for the whole continent suggests that there is a two-way causality between the regressand and the regressors. Following the findings, it is recommended that pragmatic policy measures that will control the rising fertility and rate encourage skill acquisition programs, and raise employment generation for the rising population will be a welcome development.
Keywords: Causality Test, Economic Growth, Fixed Effects Model, Population Growth.
JEL Classification: C33, J11, O47, O50.

1. Introduction

For more than a century, there have been unending debates among policy makers, economists, demographers and other scholars regarding the nexus between the growth of national economies and human population. For some authors such as Ukpolo (2002), Li and Zhang (2007), Headey and Hodge (2009), Dao (2012), Minh (2012), Ogbuabor et al. (2018) and Adisu (2019), population growth retard economic growth. To support this view, Creshaw et al. (1997) noted that increasing population is responsible for economic unproductivity in less developed nations. Hence, rising population causes scarce capital to be channel to the dependency population (such as children), thereby supporting undercapitalization, underemployment, low wages and weak market demand. Other excellent studies such as Kuznets (1960), Kremer (1993), Mankiw (2010), Peter and Bakari (2018), Hiroyuki et al. (2021) and Maket (2021), noted that population growth is seen as promoting economic growth. To buttress these views, Kremer (1993) noted that globally, expanding economic prosperity is because of population growth. That is, the more the people, the more we have more investors, scientists, engineers etc., who contribute to invention and technological progress. Thus, enhances economic growth. However, other strands of the subject matter, views insignificant relationship between the two variables as reported by Dawson and Tiffin (1998), Kelly (1998) and Adenola and Saibu (2017). Until this day, no agreeable results have been reached on the subject matter. These mixed outcomes spurt this study.

Particularly, the genesis of the debates between economic growth and population gains greater momentum when R. T. Malthus (1798) claimed that if the growth of population is unchecked, its will outpaces food production. In other words, his notion is that food production will grow arithmetically while population will grow geometrically. Following the work of Malthus, three schools of thought (Optimistic, Pessimistic and Neutralists) emerged on the subject matter (See Akinbode et al., 2017). While the optimistic holds that population is a major determinant of growth, as its boost the economy productive capacity via rise in labor supply and declining cost of labor. They are of the views that cheaper labor create room for employers and firms to hire more labor, thereby increases productivity and aggregate output of the economy, while unemployment tends to reduced. For the pessimistic, the concept of “population bomb” came to the limelight, as this is attributed to rapid growth in population. Their premises follow Malthus doctrine of food supply been outrun by rising population. They opined that at a point, there would be scarcity of food for the rising populace, which unresolved will leads to feeding on the death. Another argument emerges from the Neutralist, which posited that population growth has no link or connection with economic development. That is, they believed that the growth of the economy is independent of population growth. Generally, there remains no consensus if population expansion is deleterious, promote or independent of economic growth.

Globally, statistics have shown that Asia is the most populous continent with estimated population of 4.67 billion people, and her annual population growth rate and fertility rate are estimated as 0.83% and 1.9% respectively. While her purchasing power parity is $14, 984 and share of global GDP is the highest (47.48% as at 2021). Next is the Africa continent with 1.3 billion people, alongside having the highest annual population growth and fertility rates of 2.45% and 4.3% respectively. However, the continent has the lowest PPP per capita GDP of $5,362 and her contribution to World GDP is as low as 4.97% (as at 2021). Whereas, Europe population is estimated to be 747 million and her annual growth rate of population is 0.01% while fertility rate stood at 1.5%. Her PPP per capita GDP is $42,279 and contribution to global GDP is second highest, i.e. 21.73% as at 2021[1]. From the above statistics, the study can infer that the growth statistics and population indicators differ among regions and there is the need for recent study of this nature, which includes countries with the largest population in each continent.

In the light of the aforementioned discussion, it is imperative to ascertain if population is a panacea for national economies growth or not. In the really sense, this present work examines if economic growth is significantly determined by total population on continental basis and global perspective. This work is structured into five sections. The introduction and literature reviews are depicted in sections one and two. The research methodology is presented in section three. The section four depicts the result presentation and discussion of findings while the concluding and policy suggestions is presented in section five.

2. Literature Review

2.1 Contributions by Each Continent to Global population and Gross Domestic Product

The information in Figure 1 depicts each continent share of population (POP) and GDP as a percentage of world aggregate for the periods of 1970, 2000, 2020 and 2021. Note that, GDP is at purchaser's prices and is obtained from World Development Indicators (WDI, 2021).

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[1]. See https://statisticstimes.com/economy/continents-by-gdp.php

Figure 1. Percentage Shares of Global POP and GDP by Regions

Source: Research finding.

Inferring from Figure 1, it can be deduce that Asia region/continent experience the largest share of global population while the lowest is in Oceania. The interesting aspect of the data is that there is mix outcomes between population and GDP relationship in each continents. For instance, as population is increasing or diminishing gradually, GDP of five continents is increasing overtime. Only, Africa is challenged with rising population and declining GDP (Figure 1).

From Figure 2, African has the highest annual growth rate of population given as 2.45%, though with moderate annual growth rate of GDP in 2021 (Figure 2).

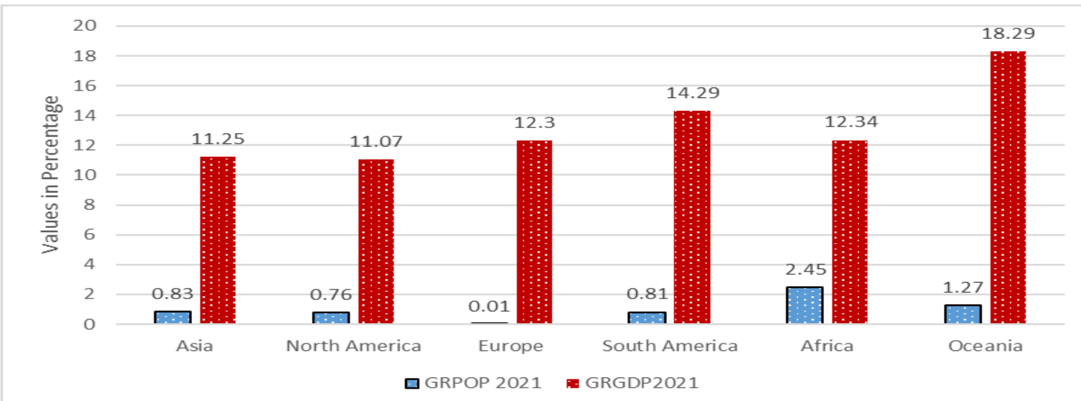

Figure 2. Trends of Annual POP and GDP Growth Rates in 2021
Source: Research finding.

In spite of the COVID pandemic, the Oceania continent has the maximum GDP of 18.29% in 2021. The post-COVID effect of the pandemic can be noticed in the GDP growth rate of Asia, North America and Europe (Figure 2).

Another vital information examined is the population share and nominal GDP per-capita of each sub-region (Table 1). Southern and Eastern Asia have the largest share of global population. This is follows by the Eastern Africa, thereafter Southern America. The Micronesia and Polynesia are the least populated sub-region in the globe. In term of annual population growth rate, available data for the period 2021 shows that Middle Africa has the highest growth rate of population and this is followed by Eastern Africa. Contrarily, Eastern and Southern Europe are confronted with negative population growth rate.

Using the nominal per capita GDP for 2021, the information in Table 1 depicts that Northern America and Oceania (Australia/ New Zealand) has the highest per capita GDP, and these continents account for 4.71% and 0.39% share of global population. Similarly, Northern Europe and Western Europe have the second highest per capita GDP with global population shares of 1.36% and 2.50% respectively. The sub-region with the lowest per capita GDP is Eastern Africa ($1,067) and Middle Africa ($1,199), as these regions account for 5.80% and 2.35% percent of world population in 2021.

Despite the COVID pandemic, record has it that some regions experienced very high GDP growth rate. A cursory look at Table 1, as arranged in alphabetical order, confirmed that Southern Africa, Australia/New Zealand and Central America are the top three regions with the highest annual growth rate of GDP globally. While other regions such as Micronesia and Polynesia are faced with negative GDP growth.

Table 1. Sub-Regional Statistics on Population and GDP Growth

Sub-region of Continents	Population (POP) in million			2021 Share of World Pop (%)	POP Growth Rate (2021)	GDP (Nominal per capita) ($)			Share of World 2021	Annual GDP Growth rate 2021
	2000	2020	2021			2000	2020	2021		
Australia/New Zealand	22.85	30.32	30.65	0.39	1.080	20,272	50,965	60,249	490	18
Caribbean	38.10	43.53	43.76	0.56	0.530	4,357	8,261	8,908	73	8
Central America	135.32	179.67	181.72	2.31	1.140	5,738	7,445	8,644	70	16
Central Asia	55.35	74.34	75.43	0.96	1.460	758	3,915	4,334	35	11
Eastern Africa	257.35	445.41	457.05	5.80	2.620	318	1,032	1,067	9	3
Eastern Asia	1519.78	1,678.09	1,682.85	21.37	0.280	4,735	13,892	15,327	125	10
Eastern Europe	303.92	293.01	292.49	3.71	-0.180	2,168	10,838	12,167	99	12
Melanesia	7.47	11.12	11.33	0.14	1.850	1,473	2,837	3,102	25	9
Micronesia	0.48	0.55	0.55	0.01	0.990	2,163	3,948	3,891	32	-1
Middle Africa	96.12	179.60	184.98	2.35	2.990	455	1,063	1,199	10	13
Northern Africa	171.32	246.23	250.64	3.18	1.790	1,480	2,944	3,188	26	8
Northern America	312.43	368.87	371.11	4.71	0.610	35,215	61,287	67,658	551	10
Northern Europe	94.45	106.26	106.71	1.36	0.430	26,715	45,520	52,266	425	15
Polynesia	0.62	0.68	0.69	0.01	0.630	7,955	4,421	4,328	35	-2
South America	348.41	430.76	434.26	5.51	0.810	3,928	6,625	7,524	61	14
South-Eastern Asia	525.01	668.62	675.12	8.57	0.970	1,191	4,650	4,980	41	7
Southern Africa	51.44	67.50	68.36	0.87	1.270	2,928	5,426	6,576	54	21
Southern Asia	1456.57	1,940.37	1,962.27	24.92	1.130	508	2,198	2,482	20	13
Southern Europe	144.85	152.22	151.95	1.93	-0.180	14,258	25,143	28,274	230	12
Western Africa	234.75	401.86	412.46	5.24	2.640	506	1,676	1,823	15	9
Western Asia	184.56	279.64	283.99	3.61	1.560	4,830	11,025	12,558	102	14
Western Europe	182.34	196.15	196.60	2.50	0.230	24,220	46,294	51,141	416	10
World	6143.49	7,794.80	7,874.97		1.03	5,476	11,108	12,284		

Source: Research finding.

In the same vein, Table 2 depicts data of three selected countries with the largest population in each continent. The variables of discussion includes; aggregate population in million (POP), population growth rate (GRPOP), life expectancy (LEX), fertility rate (FER), birth rate (BR), death rate (DR), sex ratio (male per 100 female, SR), nominal gross domestic product (NGDP) in millions of Dollar, per capita GDP (PCGDP) and annual growth rate of GDP (GRG). All information extracted are for the year 2021.

In Table 2, the most populated nations in each continent are China, United State of America, Russian Federation, Brazil, Nigeria and Australia. Interestingly, growth rate of POP and fertility rate were highest in Nigeria and Ethiopia, nonetheless, the countries life expectancy values show the lowest when compared with other countries. Similarly, these two countries are linked with the lowest NGDP, PCGDP and GrGDP. Whereas, China alone account for the highest life expectancy (84.63 years), death rate as well as a moderate annual GRGDP.

Table 2. Selected Indicators of Countries with Largest population in Each Continent

Continent	Countries with largest population	POP in Million	GR of POP	FER	LEX	Birth Rate per Year (BR)	Death Rate (DR)	Sex Ratio: Male Per 100 Female	NGDP in millions of $	PC-GDP	Gr-GDP
Asia	China	1,444.2	0.34	1.69	84.63	15,918,889	10,905,680	105.233	16,642.3	18,931	8.44
	India	1,393.4	0.97	2.24	69.27	24,016,020	10,226,555	108.147	3,049.70	7,333	12.56
	Indonesia	276.4	1.04	2.32	71.41	4,745,911	1,832,615	101.385	1,158.78	12,882	4.30
North America	United States of America	332.9	0.58	1.78	80.32	3,985,712	3,010,161	97.945	22,675.27	68,309	6.39
	Mexico	130.3	1.03	2.14	74.98	2,178,189	808,786	95.773	1,192.48	20,266	5.00
	Canada	38.1	0.86	1.53	82.22	387,294	299,681	98.581	1,883.49	51,713	5.05
Europe	Russian Federation	145.9	-0.02	1.82	72.29	1,721,868	1,876,338	86.412	1,710.73	29,485	3.76
	Germany	83.9	0.14	1.59	81.1	790,071	966,086	97.877	4,319.29	56,956	3.25
	United Kingdom	68.2	0.47	1.75	81.15	771,021	643,918	97.754	3,124.65	47,089	5.34
South America	Brazil	214.0	0.67	1.74	75.56	2,823,915	1,432,757	96.519	1,491.77	15,643	3.66
	Colombia	51.3	0.75	1.82	77.02	720,417	294,410	96.463	295.61	15,184	5.15
	Argentina	45.6	0.91	2.27	76.45	750,359	346,615	95.304	418.15	22,141	5.84
Africa	Nigeria	211.4	2.55	5.42	54.18	7,748,319	2,379,631	102.781	514.049	5,280	2.53
	Ethiopia	117.9	2.53	4.3	65.97	3,654,995	727,516	100.133	93.966	2,973	1.99
	Egypt	104.3	1.88	3.33	71.74	2,549,359	596,512	102.106	394.284	13,083	2.47
Oceania	Australia	25.8	1.13	1.83	83.2	317,933	171,823	99.183	1,617.54	54,891	4.54
	Papua New Guinea	9.1	1.92	3.59	64.15	239,622	66,232	104.352	24.536	3,956	3.47
	New Zealand	4.9	0.8	1.9	82.06	59,743	34,678	96.645	243.332	44,226	4.04

Source: Research finding.

Another interesting aspect of the information in Table 2 is that USA, Canada, United Kingdom, New Zealand and Australia have very low population growth rate and high life expectancy, which is associated with high per capita income.

2.2 Theoretical Review and Empirical Literature

The theoretical underpinnings for this work are; Malthus population theory, Cannan Edwin optimum population theory, the demographic transition and Neoclassical theories. One of the earliest and renowned population theory is the one put forward by Malthus (1798). His publication titled “theory of population”, describes how human population growth or moves at a faster paste than food production and supply. He noted that rising population if unchecked would put pressure on food supply, which will put an end to perfection and bring about misery or vice to the world. His view is that human beings has the natural sex drive to increase at a geometrical progression, that is, double itself every 25 years, in the form of 1, 2, 4, 8, 16, 32, 64 etc., if unchecked. However, due to constant supply of land, his notion is that food supply will rise slowly in arithmetical progression such as 1, 2, 3, 4, 5, 6 etc. His points is that, because food supply rises in arithmetical progression while population grows at geometrical progression, food supply will be outruns by population growth, consequently causing an imbalance that bring about over-population. Nonetheless, one of the flaws of this theory is that Malthus never foreseen the technological revolution and agricultural inventions that will tackle the problem of constant land supply.

In like manner, Canna Edwin in 1924 published his book titled; “Wealth” which explains the concept of optimum population theory. However, the work was popularized by Carr-Saunders, Dalton and Robbins. Contrasting from Malthus theory, optimum population theory studied wealth production as it relates to population size. That is, the tenets is that an ideal size of population when pooled with the available resources of a nation will produce the best returns or income per capita. Thus, any diminish or increase in population size below or beyond the optimum level will cause decrease in income per head. Akin to Malthus studied; this theory also has some drawbacks. One of such criticisms is that in reality, there is no evidence of optimum population practise in any nation. Furthermore, Thompson (1929) and Notestein (1945) propounded the demographic transition theory to explain discrepancy in birth rate and mortality rate and the consequence on population as development occur (Dudley, 1996). They structured the transition stages/process of population into three categories. The starting point of population cycles is the decline in mortality rate, which continues with another phase of rising population growth and the ending phase is the drop or decline in birth rate. All these phases occurred during the sequence of economic development. Like other discussed theories, one of the shortcomings of this theory is that the sequences of the stages of the theory are not uniform likewise; the notion of initial decline in fertility rate in urban areas of Europe is not backup by empirical analysis.

In addition, the Neoclassicals explains the concept of economic growth and population nexus using labor force growth. They believes that the growth in labor force is essential for economic growth. The common stand is that there exists a direct correlation that takes place concerning development of economies and labor force expansion, which orbits around demand and scale effects. From the perspective of the demand side (the Kuznets cycles), it is noted that population increase is associated with rise in economic production. This nexus is attributed to increases in the demand for consumable goods as family grow larger or develop (Crenshaw et al., 1997). Drawing from the scale effect, it is noted that labor force growth supports scale effects viz: more multifaceted division of labor, large domestic market, greater volume of skills, technology and information diffusion and low per capita spending which is associated with public infrastructure (such as ports, roads) because of many users (Crenshaw et al., 1997). In spite of the downsides of the theories reviewed, the strand is that the theories are the building block of many empirical studies. For instance, Akintunde et al. (2013) drawing from Malthus and demographic transition theories surveyed the issue of changing population and its nexus with growth of economies in 35 Sub-Sahara Africa nations between 1970 to 2005. The variables were estimated using dynamic panel data analysis and pooled ordinary least square (OLS) techniques. The finding suggests that life expectancy at birth positively impact on economic growth while fertility rate negatively influence economic growth. Based on the outcomes, it is suggested that SSA nations should try as much as possible to address the issue of rising population for sustainable development to be attain. Contributing to the debates, Crenshaw et al. (1997) evaluated the subject matter using 75 emerging nations with panel data obtained from 1965 to 1990. The OLS technique was employed to predict the dependent variable (per capita real gross domestic product). The finding shows that a rising dependency ratio (children population) impedes economies growth whereas rapid growth of the population of adults promotes economic advancement. From the outcomes, it is concluded that the main demographic effect on economic growth is an erstwhile offshoot of the demographic transition. Using a sample of seven Latin American nations (Brazil, Argentina, Colombia, Chile, Peru, Mexico & Venezuela), Thornton (2001) analyzed the nexus between growth in population and economic growth for the periods 1900 -

1994. Per-capita GDP was employed to measures economic growth (regressand), while population growth was used as the regressor. The findings from the ECM indicates that population growth and GDP per capita do not depicts any long run relationship. Conclusively, the Granger causality result suggests that both variables neither Granger cause each other. Also, Wong and Fumitaka (2005) utilized 10 Asian economies with data from 1950 to 2000 to determine economic growth and population relationship and the Johansen, Gregory and Hansen cointegration test shows that both variables are not cointegrated. Findings from the causality test predicted that bidirectional nexus between both variables in Korea, Japan and Thailand were observed while nations such as Philippines, Singapore and China were faced with population variable Granger causing growth only. Meanwhile, the growth variable was noted to cause population to change in Malaysia and Hong Kong without feedback effect. However, in Indonesia and Taiwan, evidence of causality between both variables were not recorded. Drawing from the outcomes, the authors noted that population might be harmful or helpful to the economy while economic growth can significantly contribute to the growth in population.

Along the same line, Tsangyao et al. (2014) explored the causal association using population as the predictor and growth variable as the outcome variable for 21 nations between the periods 1870-2013. The Granger causality result shows that there is a bi-directional causal connection within the variables in Italy, Japan and Austria only. However, the predictor is found to influence the predicted variable without response from the latter in France, Finland, Sri Lanka, whereas, a reversal response was not noticed from the predictor as growth cause population to change in Norway, Denmark, Spain, Belgium, New Zealand, Germany and Uruguay. Based on the outcomes, the study elucidated that the differences in the results of causality is due to the difference in time series period employed. Utilizing 30 nations with the highest population, Sibe et al. (2016) tested the link between GDP per capita (PCGDP) and population growth within the period of 1960-2013. The ECM outcome depicts that PCGDP is positively influence by population in the analysis. Likewise, the Granger causality results suggested bidirectional connection for the two variables. The policy implications of the findings, is that, government in less populated nations should review their policies on family planning and social security exercise to ensure that young people are gainfully employed by creating jobs/availability skill platforms and credit scheme accessibility. Contrary, Maestas et al. (2023) adopting aging population as predictor and per capita GDP as predicted variable evaluated how aging population affect the economies of selected States in USA for the periods 1980 to 2010. The data was analyzed using panel OLS technique. The result shows that aging population has negative impact on per capita output. Based on the outcome, the study recommended that there should be expansion in human capital development alongside more labor force participation especially at older ages to cushion the adverse influence of population on the economies of the States.

In like manner, Karim and Amin (2018) assessed the population and economic growth relationship using selected countries (India, Bangladesh, Nepal, Pakistan and Sri Lanka), in Asian with data spanning from 1980 to 2015. The findings of the VECM and Granger techniques illustrated that population parameter does not significantly predict per capita income; as well no causal relationship was detected in the end result. Using dynamic panel approach with 53 nations drawn from the Africa region, Peter and Bakari (2018) investigated how growing population can affect the aggregate economies of these nations using data within the periods 1980 to 2015. The variables understudied include total population, crude birth rate, fertility rate, inflation rate and gross domestic product. The findings from the GMM indicates that population growth positively predict economic growth while fertility rate adversely affected the predicted variable. The study suggests that African countries should carry out practical policy that will boost population productivity in order to tap the gain from demographic change. In a related study, Mahmoudinia et al. (2020) using 34 nations from Organization of Islamic Conference (OIC), investigated the connection that exist between the subject matters with the inclusion of real stock of capital variable in the model. The data spanned from 1980-2018. The outcome depicts a cointegrating relationship among the variables based on the Pedroni cointergration estimated technique. In addition, findings from the fully modified OLS, indicates that economic growth is considerably predicted by capital stock and the growth of population. Further result shows a bidirectional causality between the two key variables. From policy point of view, the study concluded that population growth is most likely an impetus for economic advancement not a barrier. Furthermore, Shen and Shen (2021) investigated how population change affect 31 provinces in China by employing data spanning from 2011 to 2019. The first result exhibit a cointegrating relationship among the variables employed. While the second using the fixed effect estimator shows that economic growth is positively and significantly predicted by population structure, though there are regional discrepancy on the results. Following the findings/results, the study recommended that there is the need to encourage fertility in order to increase the population of the labor force.

Undoubtedly, it must be noted that examining the link between the core variables from the above reviewed literatures is complex and the historic evidence is indistinct, primarily when its deals with impacts and causes (See, Thirlwall, 1994). Therefore, a recent study such as this, which incorporates the gaps of extant literature, is a welcome development in the field of development economics.

3. Research Methodology

The theoretical framework and model specification of this work are drawn from the simple classical growth model. In the model, output (Y_{it}) is considered to be a function of labor force (L_{it}) and capital stock (C_{it}). The '$_t$' is the period (2001-2019), and '$_i$' is the cross-sectional units of the 66 countries drawn from the 6 continents.

The model is utilized because of data availability and homogeneity of data across the selected countries in the study. The model is expressed as:

$$Y_{it} = F(L_{it}, C_{it}) \quad (1)$$

Following the works of Kelley and Schmidt (1995) and Akintunde et al (2013), where output is said to be influenced by demographic changes while the labor force is determined by some key demographic indicators. As a result, the labor variable is technically defined as:

$$L_{it} = F(POP_{it}, LEX_{it}, FER_{it}, CDR_{it}) \quad (2)$$

where;

POP; Aggregate population of a country

LEX; Life expectancy at birth

FER; Fertility rate

CDR; Crude death rate.

Drawing from the works of Hakeem, Emecheta, and Ngwudiobu (2016) and Yang et al. (2021), the capital stock variable (C) is measured using gross fixed capital formation (GFCF).

That is $C_{it} = GCF_{it}$ (3)

Incorporating equations 2.0 and 3.0 into equation 1.0, will lead to;

$$Y_{it} = F(POP_{it}, LEX_{it}, FER_{it}, CDR_{it}, GCF_{it}) \quad (4)$$

Eariler studies such as Crenshaw et al. (1997), Wong and Fumitaka (2005) and Akintunde et al (2013), utilized GDP per capita (PCGDP) to proxy the regressand (output; Y). Therefore, the model for the study is stated as;

$$PCGDP_{it} = F(POP_{it}, LEX_{it}, FER_{it}, CDR_{it}, GCF_{it}) \quad (5)$$

The equation 5.0 can be restated in the econometric form and taking the Log of each variable gives;

$$LogPCGDP_{it} = \alpha_1 + \alpha_2 LogPOP_{it} + \alpha_3 LogLEX_{it} + \alpha_4 LogFER_{it} + \alpha_5 LogCDR_{it} + \alpha_6 LogGCF_{it} + \mu_{it} \quad (6)$$

where 'α_1' is the intercept, α_2, α_3, α_4, α_5 and α_6 are the regressor parameters of the explanatary variables.

A priori expectation

The a priori expectation is stated as follows:

$$\frac{\partial LogPCGDP_{it}}{\partial LogPOP_{it}} > 0 \ , \quad \frac{\partial LogPCG_{it}DP}{\partial LogLE_{it}X} > 0 \ , \quad \frac{\partial LogPCGDP_{it}}{\partial LogFER_{it}} > 0 \ ,$$

$$\frac{\partial LogPCGD_{it}P}{\partial LogCD_{it}R} < 0 \ , \quad \frac{\partial LogPCGDP_{it}}{\partial LogGCF_{it}} > 0$$

For clarity purpose, see Table 3.

Table 3. Variables and Measurements

Variable	Definition and Measurement of Variable	Hypothesized sign	Source
Per capita Gross Domestic Product (PCGDP)	This measures the average standard of living of persons in a nation. It is obtained by dividing GDP by midyear population. It is used to measure economic growth in the model. For more details, see Crenshaw et al. (1997) and Sibe et al. (2016). Data is in current US$.	Dependent Variable	WDI 2021.
Aggregate Population (POP)	It is the aggregate number of residents living in a country. It is used to measure the population in each nation and continent. See the Neoclassical model by Solow (1956), Onuigbo (2018), Kremer (1993) and Maket (2021). Data in figure.	+	WDI 2021.
Life expectancy (LEX) at birth	An indicator shows the expected age or years an infant would live throughout its life. See Baro (2013), Hansen and Lønstrup (2015). Data in year.	+	WDI 2021.
Fertility rate (FER)	This is the estimated number of children a woman should born if she were to live to the end of her childbearing years. The increase in FER will increase population growth as well as output growth. See Baro (2013), Hansen and Lønstrup (2015). Data in %.	+	WDI 2021.
Crude death rate (CDR)	It is the number of death that occur per thousand in a population of a country usually a year. This is used to measure mortality rate in the model. Increase in CDR can reduce population and might have adverse effect on economic activities of the country. See Lorentzen et al. (2008), Rocco et al. (2021). Data in %.	-	WDI 2021.
Gross fixed capital formation (GFCF)	Equally called investment, and is the procurement of production asset (which include nearly new assets), as well as assets created by producers for personal usage while deduct disposals. It is used to capture capital stock in the study. See Mahmoudinia et al. (2020) and Sayef and Malek (2022). Data is in current US$.	+	WDI 2021

Source: Research finding.

3.1 Sampled Countries and Estimation Techniques

To analyze the population and economic growth relationship, a panel data from 2001-2019 (19 years) were obtained from 66 countries in the six continents of the globe. The six continents constitute 100 percent of the total global population[1]. From Africa, North America, Asia and Europe, 15 countries were picked from each region/continent. Due to fewer countries and data availability, nine countries were selected from South America and seven from Oceania region. These nations were selected on the ground of population size, as they constitute 85% of global population (Table 4). One merit of using panel data is that it gives analysis from the angle of cross – sectional variables and time dimensions (Prada and Cimpoeru, 2019).

[1]. https://worldpopulationreview.com/continents

Table 4. Population of Sampled Countries as a Percentage of Total in each Continents

Continents	Countries	Population as at 2021		Sample population as % of Continent population
Asia (15 Nations)	China, India, Thailand, Malaysia, Japan, Bangladesh, Indonesia, Philippines, Iran, Saudi Arabia, Iraq, Pakistan, Vietnam, Turkey and Uzbekistan	Asian	4, 679, 660, 580	90
		Sampled Nations	4, 224, 011, 212	
Africa (15 Nations)	Nigeria, Egypt, South Africa, Algeria, Morocco, Ghana, Angola, DR Congo, Tanzania, Cameroun, Ivory Coast, Uganda, Kenya, Madagascar and Mozambique	African	1,373,486,472	65
		Sampled Nations	894,182,107	
Europe (15 Nations)	United Kingdom, Russia, Germany, Ukraine, Czech Republic, Belgium, Belarus, France, Italy, Poland, Hungary, Portugal, Netherlands, Spain and Romania	European	747,747,396	86
		Sampled Nations	639,724,993	
North (15 America Nations)	United States, Mexico, Canada, Honduras, Bahamas, Belize, Cuba, Barbados, Haiti, Costa Rica, El Salvador, Dominican Republic, Guatemala, Jamaica and Panama	Northern American	596,591,192	98
		Sampled Nations	583,473,099	
Southern America (9 Nations)	Brazil, Bolivia, Argentina, Ecuador, Colombia, Chile, Peru, Paraguay and Uruguay	Southern American	434,260,138	93
		Sampled Nations	403,863,086	
Oceania (7 Nations)	Australia, Caledonia, Fuji, Vanuatu, New Zealand, Solomon Islands and Tonga	Oceanian	43, 219, 954	77
		Sampled Nations	32,965,193	
Aggregate: 6 Continents	66 Countries			85% of Global population

Source: Research finding.

The data is estimated using pooled panel OLS, random and fixed effects techniques. For simplicity sake, only the fixed and random techniques are stated. The fixed effects model for panel data analysis assumed that the regressors has a constant or fixed relationship/nexus with the regressand across all-time series observations. The fixed effects equation is stated as:

$$\delta_{it} = \beta_i + \alpha_1^{'}\varpi_{1it} + \alpha_2^{'}\varpi_{2it} + \varepsilon_{it} \quad (7)$$

Where: δ_{it} is the regressand; β_i is the unknown intercept for each country (which capture the fixed effects that the model is all about), α_1 $\alpha_2^{'}$ are coefficient of regressors, ϖ_1 ϖ_2 are regressors and ε_{it} is reported as random disturbance term. Hence, the 'i' is a series of number such as 1, 2, 3, 4, 5, 6….., N countries and the time periods 't' takes the form of 1, 2, 3, 4, …T.

Thus, it must be noted that fixed effects model does not faced heterogeneity bias issue because its estimation is within effects. Similarly, the random effects model assumed that the discrepancies between entities/individual countries or continents are random. The model for each individual continent 'i' at time 't' is given as;

$$\delta_{it} = \beta_i + \alpha_1^{'}\varpi_{1it} + \alpha_2^{'}\varpi_{2it} + \mu_i + \varepsilon_{it} \quad (8)$$

In equation 8.0, the random effects model incorporate 'μ_i', a random variable that varies across individual countries or continents. The random term is believed to possess a constant variance and a mean that is zero, which is like that of the error term. Furthermore, it is assumed to be uncorrelated with the regressors in the model/regression.

Furthermore, the Hausman and Wald tests are carried out to see which estimator is the best for the study. Particularly, the estimation is first made on the basis of continental level, before the whole data is evaluated. Prior to the aforementioned tests, the variables are subjected to difference unit root tests to see if the data in question are stationary at difference levels. These tests are Im et al. (1997), Levin, Lin and Chu (2002), PP Fisher Chi-Square and ADF- Fisher chi-square stationarity techniques. Thereafter, The Pedroni's procedure, which allows for the presence of cointegration among the selected variables, is carried out. Lastly, the causality test among the variables are tested. Thus, the Granger causality test is estimated using a bivariate regression in a panel data as stated below:

$$\infty_{i,t} = \beta_{0,i} + \beta_{1,i} + \infty_{i},_{t-1} + \ldots\ldots + \beta_{1,i}\infty_{i},_{t-1} + \omega_{1},_{i}\ \phi_{i},_{t-1} + \ldots. + \omega_{1i}\phi_{i},_{t-1} + \varepsilon_{i},_{t} \quad (9)$$

$$\phi_{i,t} = \beta_{0,i} + \beta_{1,i} + \phi_{i},_{t-1} + \ldots\ldots + \beta_{1,i}\phi_{i},_{t-1} + \omega_{1},_{i}\ \infty_{i},_{t-1} + \ldots. + \omega_{1i}\infty_{i},_{t-1} + \varepsilon_{i},_{t} \quad (10)$$

From equations 9.0 and 10.0, the Granger (1969) approach is to see whether ∞ causes ϕ, and how much of the current values of ϕ can be predicted by the previous values of ϕ likewise to see if the added lagged value of ∞ can improve the explanation. It is noted that ϕ is Granger caused by ∞, if ∞ can assist to predict ϕ, or equally when the coefficients of the lagged ∞ is statistically significant.

4. Presentation and Discussion of Results

The Table 5 shows the summary statistics of per capita income (PCGDP), total population (POP), annual growth rate of population (GRPOP), life expectancy (LEX), fertility rate (FER), crude death rate (CDR) and gross fixed capital formation (GCF) by continent. A cursory look at the result shows that Africa has the lowest PCGDP out of the six continents. More interestingly, Table 6 will be the basic for comparison among continents. Remarkably, Africa, Asia and South America have PCGDP that is below the global average of $11370.57 (Table 6). Only the Asia continent has average population that is greater that the globe figure (79,126,786). The continent with the lowest population is Oceania.

The annual population growth rate is maximum in Africa, as Asia and Oceania experiences GRPOP larger than overall estimate. In addition, Africa has the highest fertility rate and only two continents (Africa and Oceania) have FER greater than global rate. Life expectancy is highest in Oceania while Africa has LEX lesser than the whole continents average. Surprisingly, both Europe and Africa have the highest CDR, which are more than global mean (7.963369). The Asia continent has the least CDR and is among the continents (South America, North America & Oceania) with figures lower than global estimate.

Particularly, Asia has the premier gross fixed capital formation while the least is Africa. Apart from Asia, only Europe and North America have GCF greater than global estimate ($183,000,000,000). Following the skewness information in Table 6, it can be infer that all the variables are positively skewed expect life expectancy. The kurtosis estimate suggests that GRPOP distribution exhibit a platkurtic curve while the other variables exhibit leptokurtic curves as the estimated values are greater than 3, going by the probability values of the Jarque-Bera statistics in Table 6, it can be deduce that all the variables are not normally distributed.

Table 5. Descriptive Statistics for Each Continent

Continents	Statistics	PCGDP$	POP	GRPOP	FER	LEX	CDR	GCF$
ASIA	Mean	6,952	2.52E+08	1.42	2	72	6.16	3.86E+11
	Maximum	49,145	1.41E+09	3.9	5	84	11.1	6.12E+12
	Minimum	383	21202646	-0.21	1	63	3.41	1.77E+09
	Std. Dev.	10,013	4.11E+08	0.78	1	4	1.49	8.97E+11
	Observations	285	285	285	285	285	285	285
AFRICA	Mean	1,885	45460832	2.5051	5	60	9.78	2.00E+10
	Maximum	8,811	2.01E+08	3.7557	7	77	17.6	1.10E+11
	Minimum	154	15928910	1.1078	2	47	4.64	496000000
	Std. Dev.	1,740	36039535	0.6671	1	8	3.41	2.24E+10
	Observations	285	285	285	285	285	285	285
EUROPE	Mean	23,559	42028188	0.1048	1.51	77.1	11.12	2.09E+11
	Maximum	57,644	1.46E+08	1.8511	2.03	83.5	18.6	8.37E+11
	Minimum	808	9419758	-1.8537	1.078	65	8.1	2.80E+09
	Std. Dev.	15,669	36046719	0.5598	0.22	4.6	2.41	2.15E+11
	Observations	285	285	285	285	285	285	285
NORTH AMERICA	Mean	12900.1	35186461	1.2138	2	74	6.5	2.56E+11
	Maximum	65279.5	3.28E+08	3.0888	4	82	11.13	4.49E+12
	Minimum	542.334	255068	-0.1258	1	57	3.99	1.87E+08
	Std. Dev.	15244.1	78227437	0.6808	1	5	1.6	8.16E+11
	Observations	285	285	285	285	285	285	285
SOUTH AMERICA	Mean	6779.86	40266431	1.1654	2	74	6.41	5.79E+10
	Maximum	18703.9	2.11E+08	1.9577	4	80	9.47	5.39E+11
	Minimum	904.226	3321486	-0.0717	2	63	5.03	1.02E+09
	Std. Dev.	4429.73	56802590	0.4515	0	3	1.43	1.01E+11
	Observations	171	171	171	171	171	171	171
OCEANIA	Mean	15280.1	4707267	1.4572	3.183	73.1	6.43	5.17E+10
	Maximum	68156.6	25365745	2.8184	4.659	82.9	8.26	4.39E+11
	Minimum	788.613	98482	-0.9467	1.657	65.9	4.23	20744429
	Std. Dev.	19329.2	8002827	0.9624	1.048	5.87	1.04	1.10E+11
	Observations	114	114	114	114	114	114	114

Source: Research finding.

Table 6. Descriptive Statistics for the Whole Continents

	PCGDP	POP	GRPOP	FER	LEX	CDR	GCF
Mean	11370.57	79126786	1.304779	2.731561	71.51856	7.963369	1.83E+11
Maximum	68156.63	1.41E+09	3.896284	6.800000	84.35634	18.60000	6.12E+12
Minimum	153.5910	98482.00	-1.853715	1.078000	46.51000	3.407000	20744429
Std. Dev.	14403.07	2.07E+08	1.019197	1.337473	8.035103	3.000588	5.65E+11
Skewness	1.628444	5.290161	0.107389	1.190191	-1.028455	1.027767	6.133831
Kurtosis	4.601531	31.25310	2.496927	3.545199	3.578639	3.521062	46.53533
Jarque-Bera	792.5288	54762.56	18.00261	358.8013	274.7032	270.5530	123090.2
Probability	0.000000	0.000000	0.000123	0.000000	0.000000	0.000000	0.000000
Observations	1444	1444	1444	1444	1444	1444	1444

Source: Research finding.

Table 7. Panel Unit Root Test: Summary

	Test Types	LOGPCGDP	FER	LOGPOP	LEX	CDR	LOGGCF
Asia	Levin, Lin & Chu t*	-6.05393	-5.109	-4.21055	-29.16	-7.446	-6.8372
	Im, Pesaran and Shin, W-stat	-3.15438	-0.29966	-4.65332	-13.12	-6.005	-5.7662
	ADF - Fisher Chi-square	59.4765	64.4566	68.298	401.7	128.665	91.2721
	PP - Fisher Chi-square	71.1387	406.303	19.5564	85.60	50.0768	103.972
	INTEGRATED ORDER	**I(0)**	**I(0)**	**I(1)**	**I(0)**	**I(1)**	**I(0)**
Africa	Levin et al.	-7.05154	-7.0384	-23.1994	-24.29	-20.83	-7.4362
	Im et al., W-statistics	-4.09839	-7.5264	-9.89516	-24.68	-24.431	-3.2184
	ADF - Fisher Chi-square	69.9787	456.421	471.532	674.513	832.717	60.855
	PP - Fisher Chi-square	134.483	57.3163	140.564	208.655	592.527	70.9842
	INTEGRATED ORDER	I(0)	I(0)	I(0)	I(0)	I(0)	I(0)
Europe	Levin et al.	-9.36528	-3.096	-3.02348	-3.2958	-5.8906	-7.253
	Im et al., W-statistics	-7.10529	-5.1168	-2.64348	-5.46745	-8.54879	-4.7432
	ADF - Fisher Chi-square	105.959	76.3104	52.6698	83.9538	126.494	72.7422
	PP - Fisher Chi-square	198.594	103.039	71.6984	234.639	547.903	81.462
	INTEGRATED ORDER	**I(0)**	**I(1)**	**I(1)**	**I(0)**	**I(0)**	**I(0)**
North America	Levin et al.	-7.5825	-7.5220	-5.58535	-11.83	-13.03	-7.288
	Im et al., W-statistics	-5.78263	-3.4058	-2.67943	-7.416	-3.9319	-6.1252
	ADF - Fisher Chi-square	87.7511	121.573	77.3769	135.45	171.122	92.5086
	PP - Fisher Chi-square	107.719	704.769	986.099	44.302	124.94	136.131
	INTEGRATED ORDER	**I(1)**	**I(0)**	**I(1)**	**I(1)**	**I(0)**	**I(1)**
South America	Levin et al.	-3.9163	-16.131	-3.6734	-14.73	-3.3548	-7.4855
	Im et al., W-stat	-4.7678	-5.1427	-10.162	-10.261	-3.7897	-4.5731
	ADF - Fisher Chi-square	54.3368	294.214	244.463	119.568	48.427	51.565
	PP - Fisher Chi-square	109.935	389.412	42.1567	533.858	6.78296	19.670
	INTEGRATED ORDER	**I(1)**	**I(0)**	**I(1)**	**I(1)**	**I(1)**	**I(0)**
Oceania	Levin et al.	-6.78701	**-6.4362**	-21.3845	-11.507	**-7.373**	-4.9438
	Im et al., W-stat	-4.51955	-4.3945	-14.3897	-10.501	-4.0557	-4.8651
	ADF - Fisher Chi-square	46.2197	47.5475	85.3371	84.1049	80.505	47.123
	PP - Fisher Chi-square	72.204	37.3651	10.4588	57.3575	37.133	76.2606
	INTEGRATED ORDER	**I(0)**	**I(1)**	**I(1)**	**I(1)**	**I(0)**	**I(1)**

Source: Research finding.

Table 8. The Whole Continents Unit Root Results

	Test Types	LOGPCGDP	FER	LOGPOP	LEX	CDR	LOGGCF
Six Continents	Levin, Lin & Chu t*	-14.3141	-14.824	-17.1565	-29.994	-27.148	-11.5069
	Im, Pesaran & Shin, W-stat	-9.39522	-6.6396	-11.7611	-16.564	-12.101	-6.19535
	ADF - Fisher Chi-square	359.596	981.362	1126.1	1254.8	1428.6	278.507
	PP - Fisher Chi-square	550.026	1591.53	2795.76	1000.94	879.43	265.618
	INTEGRATED ORDER	I(0)	I(0)	I(0)	I(0)	I(0)	I(0)

Source: Research finding.

Table 9. Pedroni Residual Cointegration Test

Asia					**Africa**				
Alternative hypothesis: common AR coefs. (within-dimension)					Alternative hypothesis: common AR coefs. (within-dimension)				
	Statistic	Prob.	Statistic	Prob.		Statistic	Prob.	Statistic	Prob.
Panel v-Statistic	-1.3338	0.9089	-6.02549	1	Panel v-Statistic	-5.85423	1	-6.4145	1
Panel rho-Statistic	4.20761	1	4.431388	1	Panel rho-Statistic	5.798251	1	4.56087	1
Panel PP-Statistic	-1.95778	0.0251	-15.2147	0.000	Panel PP-Statistic	-2.26746	0	-11.212	0.0000
Panel ADF-Statistic	-6.20809	0	-8.25197	0.000	Panel ADF-Stat	-6.14176	0	-7.4979	0.0000
Alternative hypothesis: individual AR coefs. (between-dimension)					Alternative hypothesis: individual AR coefs. (between-dimension)				
	Statistic	Prob.				Statistic	Prob.		
Group rho-Statistic	5.601747	1			Group rho-Stat	6.335068	1		
Group PP-Statistic	-17.8679	0.0000			Group PP-Statistic	-15.6397	0.0000		
Group ADF-Statistic	-10.6856	0.0000			Group ADF-Stat	-8.06078	0.0000		
Europe					**North America**				
Alternative hypothesis: common AR coefs. (within-dimension)					Alternative hypothesis: common AR coefs. (within-dimension)				
	Statistic	Prob.	Statistic	Prob.		Statistic	Prob.	Stat	Prob.
Panel v-Statistic	-1.62445	0.9479	-2.11218	0.98	Panel v-Statistic	-4.06302	1	-5.8254	1
Panel rho-Statistic	4.278941	1	3.333493	1	Panel rho-Statistic	4.313028	1	4.08579	1
Panel PP-Statistic	-1.78308	0.0373	-5.71109	0.000	Panel PP-Statistic	-15.5988	0.0000	-17.764	0.0000
Panel ADF-Statistic	-3.47845	0.0003	-4.05138	0.000	Panel ADF-Stat	-6.44937	0.0000	-6.8403	0.0000
Alternative hypothesis: individual AR coefs. (between-dimension)					Alternative hypothesis: individual AR coefs. (between-dimension)				
	Statistic	Prob.				Statistic	Prob.		
Group rho-Statistic	5.711643	1			Group rho-Stat	5.530049	1		
Group PP-Statistic	-4.48035	0.0000			Group PP-Statistic	-22.2867	0.0000		
Group ADF-Statistic	-4.35179	0.0000			Group ADF-Stat	-5.6939	0.0000		
South America					**Oceania**				
	Statistic	Prob.	Statistic	Prob.		Statistic	Prob.	Statistic	Prob.
Panel v-Statistic	-2.74322	0.997	-4.419	1	Panel v-Statist	-1.3089	0.9047	-2.8	0.9973
Panel rho-Statistic	3.8796	0.9999	3.601	0.9998	Panel rho-Stat	2.15078	0.9843	2.6	0.9946
Panel PP-Statistic	-4.83878	0.0000	-10.24	0.0000	Panel PP-Stat	-1.9567	0.0252	-3.6	0.0002
Panel ADF-Statistic	-5.05378	0.0000	-6.724	0.0000	Panel ADF-Stat	-1.962	0.0249	-4.4	0.0000
Alternative hypothesis: individual AR coefs. (between-dimen)					Alternative hypothesis: individual AR coefs. (between-dimens)				
	Statistic	Prob.				Statistic	Prob.		
Group rho-Statistic	5.0301	1			Group rho-Statistic	3.5101	0.9998		
Group PP-Statistic	-9.61044	0.0000			Group PP-Statistic	-4.3209	0.0000		
Group ADF-Statistic	-5.02196	0.0000			Group ADF-Statistic	-2.6037	0.0046		

Source: Research finding.

Table 10. Pedroni Residual Cointegration Test (For the Whole Continents)

Included observations: 1444					Cross-sections included: 76		
Null Hypothesis: No cointegration					Trend assumption: Deterministic intercept and trend		
User-specified lag length: 1							
Newey-West automatic bandwidth selection and Bartlett kernel							
Alternative hypothesis: common AR coefs. (within-dimension)					Alternative hypothesis: individual AR coefs. (between-dimension)		
	Statistic	Prob.	Statistic	Prob.		Statistic	Prob.
Panel v - Statistics	-5.28033	1	-12.7221	1	Group rho-Statistic	13.06443	1
Panel rho-Statistic	9.761233	1	9.535301	1	Group PP-Statistic	-35.7228	0.0000
Panel PP-Statistic	-14.8646	0.0000	-33.2132	0.0000	Group ADF-Statistic	-14.2432	0.0000
Panel ADF-Statistic	-12.1969	0.0000	-17.5428	0.0000	Cross section specific results		

Source: Research finding.

Tables 7 and 8 show the unit root tests for each continent and the pooled continents. For Asia, there was a mixed stationarity among the variables. At level, only FER, LEX and LOGGCF attained stationarity while LOGPOP, CDR and LOGGCF were stationary at one differences, which is integrated of order one.

With the exception of Africa, where all the variables are integrated of order zero, all other regions have a mixed stationarity at difference order. In like manner, the pooled continents data shows that all the variables exhibit stationarity at level, by implication, integrated order of zero (Table 8).

Tables 9 and 10 are the Pedroni residual cointegration results to evaluate the possible existence of cointegration between the regressand (PCGDP) and the regressors. The decision rule is that we compare the number of estimated p-values that is greater or lesser than the 5% critical value. If we have more p-values lesser than 5% critical value, then we reject the null hypothesis that there is no long-run relationship that exist among the variables. From the results in Table 9 and 10, it can be deduce that there are more p-values lesser than 5% critical value. Therefore, we accept the alternative hypothesis that there is a long-run relationship between PCGDP and the explanatory variables. This finding is supported by the results of Mahmoudinia et al. (2020), Shen and Shen (2021), but contrary to the work of Thornton (2001), Wong and Fumitaka (2005) and Karim and Amin (2018).

Based on the above outcomes, the next task is to use the Hausman model selection technique and Wald test to determine which tests (pool, fixed or random effects) is appropriate for the study. The Hausman test is utilise to evaluate whether fixed effects or random effects is most appropriate while the Wald technique is carried out to see if the fixed effects or pooled regression analysis is the best estimator for the study. Thus, for the Hausman test, if the probability value of the estimated parameter is less than 5%, then reject null hypothesis (H_o), which states that random effects model is appropriate. This implies that, we accept the alternative hypothesis (H_a), which states that the fixed effects model is appropriate. Similarly, the Wald technique examines if the estimated parameters are equal to zero or equal to one another. Hence, if the estimated probability value is less than 5%, then the null hypothesis is rejected. As a result, the decision rule is that the fixed effect model is more appropriate for the empirical analysis.

A crucial look at Table 11, shows that the estimated Hausman and Wald tests at the regional and global levels are lesser than 5% critical level. The decision rule is that the fixed effects estimator is most appropriate when compared with the other techniques (the random effects and the pooled regression models).

In discussing the empirical outcomes (Panel regressions) in Tables 12 and 13, we need to understand the rule of thumb for spurious regression result. The rule states that when the coefficient of determination (R^2) is greater than the Durbin-Watson statistics, this implies that the regression outcome is spurious. From the fixed effects findings (Tables 12 and 13), both at the regional and whole continents levels, the R-squared is lesser than the Durbin-Watson statistics, therefore, the regression results is free from spuriousness problem.

Table 11. Estimators Selection Criteria

Asia	**Hausman Test;** Correlated Random Effects. Test cross-section random effects			
	Test Summary	Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
	Cross-section random	42.78839	6	0.0000
	Wald Test:		Df	
	F-statistic	16.66167	(6, 249)	0.0000
	Chi-square	99.97002	6	0.0000
Africa	**Hausman Test;** Correlated Random Effects. Test cross-section random effects			
	Test Summary	Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
	Cross-section random	35.94901	6	0.0000
	Wald Test:		Df	
	F-statistic	21.37694	(6, 263)	0.0000
	Chi-square	128.2616	6	0.0000
Europe	**Hausman Test;** Correlated Random Effects. Test cross-section random effects			
	Test Summary	Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
	Cross-section random	307.5614	6	0.0000
	Wald Test:	Value	Df	Prob.
	F-statistic	167.8097	(6, 249)	0.0000
	Chi-square	1006.858	6	0.0000
North America	**Hausman Test;** Correlated Random Effects. Test cross-section random effects			
	Test Summary	Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
	Cross-section random	82.71868	6	0.0000
	Wald Test:	Value	Df	Prob.
	F-statistic	28.07411	(6, 249)	0.0000
	Chi-square	168.4446	6	0.0000
South America	**Hausman Test;** Correlated Random Effects. Test cross-section random effects			
	Test Summary	Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
	Cross-section random	83.20887	6	0.0000
	Wald Test:	Value	Df	Prob.
	F-statistic	43.72314	(6, 146)	0.0000
	Chi-square	262.3388	6	0.0000
Oceania	**Hausman Test;** Correlated Random Effects. Test cross-section random effects			
	Test Summary	Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
	Cross-section random	17.96734	6	0.0063
	Wald Test:	Value	Df	Prob.
	F-statistic	9.501834	(6, 113)	0.0000
	Chi-square	57.01101	6	0.0000
Whole Continents	**Hausman Test;** Correlated Random Effects. Test cross-section random effects			
	Test Summary	Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
	Cross-section random	428.0166	6	0.0000
	Wald Test:	Value	Df	Prob.
	F-statistic	54.61147	(6, 1361)	0.0000
	Chi-square	327.6688	6	0.0000

Source: Research finding.

Drawing from the results (Tables 12 and 13), the key variable; total population (LOG(POP(-1)) is negatively related to per-capita gross domestic product (PCGDP), and statistically significant at 1%, 5% and 10% in impacting on the regressand (PCGDP). This outcome is contrary to the a priori expectation where POP is expected to have positive impact on PCGDP. This current result implies that an increase in population growth will bring about a decline in economic growth (PCGDP). From theoretical and empirical perspectives, when population growth rate surpasses economic growth rate, per capita income is adversely affected. Quite a number of factors are responsible for this outcome, but two key ones are rising dependency ratio above the economic active population and increasing unemployment rate. A rising dependency ratio and unemployment rate implies lesser economic active population contributing to productive activities, which might have adverse effect on economic performance of any nation. For instance, in Europe and other developed countries, the issue is growing aging population, which implies rising dependency population. While in most developing region such as Africa, the issues are rising unemployment level and poverty rate, growing corruptions coupled with increasing population. Thus, these might be the main reasons why population growth negatively predict PCGDP in this study. The negative relationship between the two variables corroborates the works of Maestas et al. (2023), Chowdbhury and Hossain (2018) but does not supports the findings of Sibe et al. (2016), Peter and Bakari (2018) and Shen and Shen (2021). The lag value of PCGDP is also observed to predict PCGDP significantly; this shows the significant of the predicted variable taking the form of a predictor.

Table 12. Panel Regression Results by Regions

ASIA	POOLED OLS			FIXED MODEL			RANDOM MODEL		
	Coefficient	Std. Error	Prob.	Coeff	Std. Error	Prob.	Coeff	Std. Error	Prob.
C	0.925	0.345	0.008	11.503	3.246	0.001	1.099	0.344	0.002
LOG(PCGDP(-1))	0.876	0.024	0.000*	0.832	0.035	0.000*	0.869	0.023	0.000*
LOG(POP(-1))	-0.124	0.026	0.000*	-0.682	0.184	0.000*	-0.135	0.025	0.000*
LEX	-0.004	0.004	0.380	-0.013	0.008	0.094*	-0.005	0.004	0.225
FER	0.008	0.016	0.624	-0.164	0.045	0.000*	0.004	0.015	0.784
CDR	0.011	0.006	0.072*	0.023	0.018	0.200	0.013	0.006	0.033*
LOG(GCF)	0.104	0.021	0.000*	0.148	0.025	0.000*	0.110	0.020	0.000*
R-squared	0.992			0.993			0.990		
F-statistic	5193.610			1847.310			4368.700		
DW-stat	1.383			1.648			1.398		
AFRICA	**POOLED OLS**			**FIXED**			**RANDOM MODEL**		
	Coefficient	Std. Error	Prob.	Coeff	Std. Error	Prob.	Coeff	Std. Error	Prob.
C	0.523	0.300	0.082	3.038	2.389	0.205	0.566	0.317	0.075
LOG(PCGDP(-1))	0.753	0.024	0.000*	0.694	0.032	0.000*	0.739	0.023	0.000*
LOG(POP(-1))	-0.182	0.022	0.000*	-0.346	0.148	0.020*	-0.191	0.022	0.000*
LEX	-0.001	0.003	0.813	0.000	0.008	0.985	-0.001	0.003	0.821
FER	-0.043	0.010	0.000*	-0.076	0.040	0.055*	-0.047	0.010	0.000*
CDR	0.019	0.006	0.003*	0.019	0.015	0.201	0.021	0.006	0.002*
LOG(GCF)	0.196	0.021	0.000*	0.234	0.025	0.000*	0.205	0.020	0.000*
R-squared	0.987			0.989			0.984		
F-statistic	3244.068			1135.061			2639.411		
DW-stat	1.490			1.677			1.523		
EUROPE	**POOLED OLS**			**FIXED MODEL**			**RANDOM MODEL**		
	Coefficient	Std. Error	Prob.	Coeff.	Std. Error	Prob.	Coeff	Std. Error	Prob.
C	0.058	0.301	0.846	8.528	2.662	0.002	0.058	0.206	0.777
LOG(PCGDP(-1))	0.580	0.028	0.000*	0.306	0.028	0.000*	0.580	0.019	0.000*
LOG(POP(-1))	-0.337	0.023	0.000*	-1.014	0.158	0.000*	-0.337	0.016	0.000*
LEX	0.006	0.004	0.111	0.036	0.004	0.000*	0.006	0.003	0.020*
FER	-0.065	0.029	0.026*	-0.097	0.048	0.045*	-0.065	0.020	0.001*
CDR	-0.003	0.005	0.630	0.019	0.006	0.004*	-0.003	0.004	0.483
LOG(GCF)	0.374	0.024	0.000*	0.507	0.021	0.000*	0.374	0.017	0.000*
R-squared	0.992			0.996			0.992		
F-statistic	5404.508			3469.625			5404.508		
DW-stat	1.042			1.070			1.042		

Source: Research finding.

Table 12. Panel Regression Results by Regions (Continuation)

NORTH AMERICA	POOLED OLS			FIXED EFFECTS MODEL			RANDOM EFFECTS		
	Coeffi-Cient	Std. Error	Prob.	Coeffi-Cient	Std. Error	Prob.	Coefficient	Std. Error	Prob.
C	0.004	0.145	0.977	5.709	1.627	0.001	0.189	0.171	0.271
LOG(PCGDP(-1))	0.880	0.019	0.000*	0.611	0.034	0.000*	0.803	0.021	0.000*
LOG(POP(-1))	-0.082	0.015	0.000*	-0.581	0.124	0.000*	-0.138	0.016	0.000*
LEX	0.005	0.002	0.001*	0.014	0.008	0.093*	0.006	0.002	0.003*
FER	-0.006	0.012	0.612	-0.137	0.030	0.000*	-0.022	0.014	0.107
CDR	0.009	0.003	0.008*	0.050	0.012	0.000*	0.015	0.004	0.000*
LOG(GCF)	0.084	0.015	0.000*	0.255	0.022	0.000*	0.142	0.016	0.000*
R-squared	0.997			0.998				0.994	
F-statistic	14505.050			6406.300				6701.8	
DW-stat	1.635			1.693				1.633	

SOUTH AMERICA	POOLED OLS			FIXED EFFECTS			RANDOM EFFECTS		
	Coeffi Cient	Std. Error	Prob.	Coeffi Cient	Std. Error	Prob.	Coeffi Cient	Std. Error	Prob.
C	0.774	0.517	0.136	4.250	4.368	0.332	0.774	0.419	0.067
LOG(PCGDP(-1))	0.435	0.036	0.000*	0.373	0.037	0.000*	0.435	0.030	0.000*
LOG(POP)	-0.428	0.033	0.000*	-0.674	0.280	0.017*	-0.428	0.027	0.000*
LEX	0.004	0.005	0.477	0.002	0.013	0.874	0.004	0.004	0.381
FER(-2)	-0.034	0.031	0.273	-0.040	0.076	0.596	-0.034	0.025	0.178
CDR(-1)	0.051	0.006	0.000*	0.060	0.025	0.016*	0.051	0.005	0.000*
LOG(GCF)	0.454	0.034	0.000*	0.507	0.031	0.000*	0.454	0.028	0.000*
R-squared	0.990			0.994			0.990		
F-statistic	2414.362			1576.312			2414.362		
DW- stat	0.956			1.282			0.956		

OCEANIA	POOLED OLS			FIXED EFFECTS			RANDOM EFFECTS		
	Coeff.	Std. Error	Prob.	Coeff.	Std. Error	Prob.	Coeff.	Std. Error.	Prob.
C	0.943	0.291	0.002	5.145	2.322	0.029	0.943	0.278	0.001
LOG(PCGDP(-1))	0.790	0.036	0.000*	0.766	0.051	0.000*	0.790	0.034	0.000*
LOG(POP(-1))	-0.051	0.015	0.001*	-0.505	0.268	0.062*	-0.051	0.014	0.000*
LEX(-1)	0.018	0.005	0.001*	0.050	0.033	0.130	0.018	0.005	0.000*
FER(-1)	-0.144	0.031	0.000*	-0.083	0.069	0.235	-0.144	0.030	0.000*
CDR	-0.002	0.009	0.815	-0.076	0.032	0.019*	-0.002	0.009	0.807
LOG(GCF)	0.039	0.015	0.012*	0.044	0.017	0.009*	0.039	0.014	0.008*
R-squared	0.996			0.997			0.996		
F-statistic	5227.482			2878.092			5227.482		
DW-stat	1.569			1.743			1.569		

Source: Research finding.

In addition, at the regional level, life expectancy (LEX) was observed to have the hypothetical sign as well have positive significant effect on economic growth in Asia, Europe and North America countries. This implies that a rise in life expectancy will cause PCGDP to grow in these regions. This outcome is buttress with the data in Table 2, where high life expectancy is accompanied by high per capita GDP. However, the finding of negative insignificant impact of LEX on the regressand at the overall continent level does not support the a priori expectation. From the economic point of view, this is an indication that a decline in mortality (i.e. rise in life expectancy) and increase in health care expenditure does not significantly lead to rise in PCGDP. This result does not support the works of Hakeem et al. (2016) and Akintunde et al. (2013) that found the dependent variable to be significantly predicted by LEX in their studies.

At the regional and global levels, fertility rate is negatively related to the predicted variable. The negative relationship between FER and PCGDP does not conform to the expected a priori sign. In the sense that, when there is rise in fertility rate, population growth tends to increase as well as the economic active population. The more the productive force, there is the tendency that economic activities as well as economic growth and PCGDP will rise. In term of significant impact, only in Asia, Africa, Europe, North America and the global result that FER is relevant to PCGDP. Using the global result, an increase in FER by 100 percent will cause economic growth to decline by 9.7 percent. This result support the works of Dao (2012), Akintunde et al. (2013), Peter and Bakari (2018) regarding the negative effect of FER on per capita income.

In another instance, the number of death per thousand (CDR) does not adversely affect PCGDP at the regional and global levels. Nevertheless, its significant effect is noticed in Europe, North America, South America, Oceania nations as well as global levels (Tables 12 and 13). The significant effect of CDR on PCGDP indicates that an upsurge in CDR; will have significant effect on population growth and the future labor force which might affect economic growth indifferently. On a priori ground, CDR does not have the expected hypothetical sign.

Interestingly, the coefficients' of gross fixed capital formation (GCF) positively and significantly predict PCGDP at the regional likewise the completely continent levels. So far, GCF meet up with the expected positive sign. This result explains how expansion in gross domestic investment, increases the demand for labor, in turn, boosts economic activities and raises purchasing power. The resultant effect is the rise in economic growth and per capita income. Thus, the works of Iheanacho (2017)

.and Mahmoudinia et al. (2020) support this result, but contrary to the study of Ajose and Oyedokun (2018).

A brief glance at the F-statistics at the regional and global levels (Tables 12 and 13), suggests that the results typically explain the model as well, the model is well-specified and very good-fit. That is, all the regressors jointly and significantly explain changes in the regressand (LOG(PCGDP)).

The direction of causality using the Dumitrescu Hurlin procedure was tested between LOG(POP) and PCGDP at the region levels (Table 4.10). This test was carried out due to the cointegration relationship among the selected variables, correspondingly, to see if the macroeconomic variables explain each other. Accordingly, bi-causality was found to exist between LOG(PCGDP) and LOG(POP) in four regions (Asia, Africa, North America and South America). While, a unidirectional causal effect that runs from LOG(PCGDP) to LOG(POP), without a feedback effect from LOG(POP) to LOG(PCGDP) is noticed in Europe and Oceania continents.

In the same vein, the whole data is subjected to the pairwise Dumitrescu Hurlin panel causality tests (Table 15). In sum, the result indicates that there is a bidirectional causality between the regressand (LOG(PCGDP)) and all the regressors (LOG(POP), LEX, FER, CDR & LOG(GCF)). This is because the probability values of the panel causality test indicates that all the values are lesser than 5% critical value. The bidirectional causality between the key variables; LOG(PCGDP) and LOG(POP) is supported by the works of Kremer (1993), Sibe et al. (2016), Wong and Fumitaka (2005). As noted by Kremer (1993), the bi-causal relationship between population variable and growth variable shows that population is the driving force of development. However, this current result is not in line with the results of Thornton (2001), Karim and Amin (2018) that found no causal effect between both variables.

Decisively, one possible reasons for the result in Table 15 between the core variables, is that increases in population growth might have significant effect on economic growth but the effect might be adverse, the reason is that there are many other variables that influence economic growth to expressively cause population growth to change.

Decisively, one possible reasons for the result in Table 15 between the core variables, is that increases in population growth might have significant effect on economic growth but the effect might be adverse, the reason is that there are many other variables that influence economic growth to expressively cause population growth to change.

Table 13. Panel Regression Results for the Whole Continents

	POOLED OLS			FIXED EFFECTS MODEL			RANDOM EFFECTS MODEL		
	Coeff	Std Error	Prob.	Coeff.	Std. Error	Prob.	Coeff	Std. Error	Prob.
C	0.402	0.082	0.000	4.731	1.065	0.000	0.402	0.072	0.000
LOG(PCGDP(-1))	0.859	0.009	0.000*	0.697	0.014	0.000*	0.859	0.008	0.000*
LOG(POP(-1))	-0.113	0.008	0.000*	-0.403	0.068	0.000*	-0.113	0.007	0.000*
LEX	0.001	0.001	0.174	-0.001	0.003	0.792	0.001	0.001	0.120
FER	-0.011	0.005	0.018*	-0.097	0.018	0.000*	-0.011	0.004	0.007*
CDR	0.007	0.001	0.000*	0.010	0.005	0.031*	0.007	0.001	0.000*
LOG(GCF)	0.110	0.008	0.000*	0.206	0.010	0.000*	0.110	0.007	0.000*
R-Squared	0.994			0.996			0.994		
F-statistic	37482.1			3638.6			37482.1		
DW- stat	1.375			1.501			1.375		

Source: Research finding.

Table14. Pairwise Panel Causality Test via Dumitrescu Hurlin Technique by Regions

	Sample: 2001 2019 Lags: 2 Null Hypothesis:	W-Stat.	Zbar-Stat.	Prob.	Results
Asia	LOG(POP) does not homogeneously cause LOG(PCGDP)	4.79505	3.15575	0.0016	↔
	LOG(PCGDP) does not homogeneously cause LOG(POP)	7.03888	6.11226	0.000000	
Africa	LOG(POP) does not homogeneously cause LOG(PCGDP)	5.9063	4.61995	0.0000	↔
	LOG(PCGDP) does not homogeneously cause LOG(POP)	10.5546	10.7446	0.00000	
Europe	LOG(POP) does not homogeneously cause LOG(PCGDP)	2.79187	0.51634	0.6056	X
	LOG(PCGDP) does not homogeneously cause LOG(POP)	7.18547	6.30541	0.00000	→
North America	LOG(POP) does not homogeneously cause LOG(PCGDP)	16.0501	17.9855	0.0000	↔
	LOG(PCGDP) does not homogeneously cause LOG(POP)	22.4192	26.3777	0.00000	
South America	LOG(POP) does not homogeneously cause LOG(PCGDP)	4.60186	2.24726	0.0246	↔
	LOG(PCGDP) does not homogeneously cause LOG(POP)	10.1855	7.94602	0.000000	
Oceania	LOG(POP) does not homogeneously cause LOG(PCGDP)	2.47752	0.06978	0.9444	X
	LOG(PCGDP) does not homogeneously cause LOG(POP)	33.8324	28.2924	0.0000	→

Source: Research finding.

Note: Bidirectional Causality (↔), Unidirectional Causality (→) and No Causality (X).

Table 15. Causality Tests using Dumitrescu Hurlin Methods for the Whole Continents

Sample: 2001 2019	Lags: 2			Results
The Null Hypothesis forms:	W-Stat.	Zbar-Stat.	Prob.	
LOG(POP) does not homogeneously cause LOG(PCGDP)	5.91149	10.4146	0.0000	↔
LOG(PCGDP) does not homogeneously cause LOG(POP)	15.7088	39.4719	0.0000	
LEX does not homogeneously cause LOG(PCGDP)	4.94644	7.55236	0.0000	
LOG(PCGDP) does not homogeneously cause LEX	16.2136	40.9692	0.00000	↔
FER does not homogeneously cause LOG(PCGDP)	4.01907	4.80193	0.0000	
LOG(PCGDP) does not homogeneously cause FER	19.4243	50.4916	0.0000	↔
CDR does not homogeneously cause LOG(PCGDP)	4.27249	5.55354	0.0000	
LOG(PCGDP) does not homogeneously cause CDR	11.4543	26.8538	0.0000	↔
LOG(GCF) does not homogeneously cause LOG(PCGDP)	3.34927	2.8154	0.0049	
LOG(PCGDP) does not homogeneously cause LOG(GCF)	3.61741	3.61065	0.0003	↔

Source: Research finding.

Note: Bidirectional causality (↔), unidirectional causality (→) and no causality (χ)

5. Conclusion

This search paper is a revisit on the debates on whether population influence or not influence national economies growth. The aim of this work is achievable with the aid of 66 countries that constitute 85 percent of total global population. The countries were drawn from six continents, which made up 100 percent of world population and the panel data span through 2001-2019. The variables include per capita GDP (employed to measure economic growth), total population, crude death rate, fertility rate, life expectancy and gross fixed capital formation. The data were retrieved from WDI and mainly analyzed using Pedroni residual cointegration test, Hausman and Wald tests; panel OLS, fixed and random effect estimators likewise the Dumitrescu Hurlin panel causality tests at each continent and global levels. The outcomes from the cointegration technique established that both the regressand and the explanatory variables are cointegrated at the regional and global levels. This result is supported by extant studies. As well, the findings from the Hausman and Wald tests indicate that the fixed effects estimator is favoured against the other estimating techniques. The empirical result from the fixed effects model suggests that logged of total population growth lagged at one period, life expectancy and fertility rate have negative significant effect on per capita GDP while lagged of per capita income, crude death rate and gross fixed capital formation have positive significant effect on the outcome variable in Asia. For African region, only logged of total population and fertility rate have negative significant effect on economic growth while lagged of per capita income and gross fixed capital formation have positive significant effect on growth of the region. In Europe and North America, population growth and fertility rate are observed to have negative significant effects on economic growth while lagged of per capita income, life expectancy, crude death rate and gross fixed capital formation positively and significantly predict GDP per capita. For the result of South America, both population growth and crude death rate have negative significant effects on economic growth while lagged of per capita income and gross fixed capital formation depicts positive significant impact on the predicted variable. In addition, the result for Oceania countries suggest that economic growth is negatively and significantly predicted by population growth and crude death rate whereas lagged per capita income and gross fixed capital formation have positive and significant effects on the predicted variable. For the result of the whole continent, only life expectancy does not exert significant impact on economic growth. This is a signal that increasing life span or declining mortality does not significantly affect the spending capacity of the populace. Beside, both population growth and fertility rate negatively predict per capita GDP while lagged per capita income, crude death rate and gross fixed capital formation exert positive effects on national economies.

The panel causality tests between PCGDP, LOG(POP) and other variables at the regional and global levels are depicted in Tables 4.10 and 4.11. At the regional levels, there is bi-directional causal relationship between LOG(POP) and LOG(PCGDP) in four regions (Asia, Africa, North America and South America. Whereas, unidirectional causality exist from LOG(PCGDP) to LOG(POP) without a feedback effect from LOGPOP to LOG(PCGDP) in Europe and Oceania continents. At the global level, there is bidirectional causal relationship between the regressand (LOG(PCGDP) and all the regressors (LOG(POP), LEX, FER, CDR & LOG(GCF)). This implies that a two-way causal relationship exist between the predicted variable (PCGDP) and the explanatory variables.

The important lesson to draw from the fixed effects result is that both FER and POP are connected, drawing from the negative effects on PCGDP at the regional and global levels. In essence, if, there is no moderate growth in both variables, there is a tendency that economic growth will be adversely affected. In other words, economic growth is rising slower than population growth, which has caused the variables to predict PCGDP negatively. Relating these results to policy options for developing countries such as Asia and Africa, it is suggested that workable policy measures that will control fertility rate, encourage skill acquisition program and employment generation for the rising population will be a welcome development. These strategies will not only boost the productivity of the rising labor force; but also increase GDP growth rate, per–capita income and perhaps raise the living standard of the populace. For the developed continents such as Europe, North America, Oceania etc., where aging population and dependency ratio is growing faster, there is the need to easy or apply less restrictive migration policy. This is to encourage highly skills and productive youth to migrate to the continents in order to augment the aging population, boost labor force and raise productivity. In turn, this measure will enhance the rate of economic growth. Furthermore, it is popularly said, “a healthy population is a productive population”, therefore, there is the need for more investment in infrastructural facilities such as good health system as well as sound equipped and affordable educational structure which will promote population health as well as growth in both emerging and industrialized nations. In conclusion, it must be noted that demographic variable in the form of population has adverse and significant effect on economies of the countries understudy.

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