Population Dynamics, Energy Consumption and Economic Growth in Sub-Saharan African

EZEBUNWA, Justice Ndukwu PhD and NYECHE, Ezebunwo PhD
[1]Department of Economics, Rivers State University, Port Harcourt, Nigeria
[2]Department of Economics, Rivers State University, Port Harcourt, Nigeria
Corresponding Authors: justice.ezebunwa@ust.edu.ng ; Tel: +2348035081755
Nyeche.ezebunwo1@ust.edu.ng ; Tel: +2348033097907
DOI: 10.56201/ijefm.v10.no1.2025.pg41.57

Abstract

This study examined the effect of population dynamics, energy consumption, and economic growth in Sub-Saharan Africa using panel data spanning from 2010 to 2021. Sourced from World Development Indicators and Central Bank of Nigeria Statistical Bulletin, 2022. Economic growth was proxied by Real Gross Domestic Product (RGDP), while Mortality rate (MOR), Fertility rate (FER), Net Immigration (NIM), and Energy Consumption (ENCM), Electricity consumption (ELEC), and Fossil fuel Consumption (FSFC) were the proxies for population dynamics and energy consumption respectively. The variables for the study were subjected to stationarity test and the results showed that the variables were integrated at order zero I(0) and order one 1(1). The Hausman test was conducted to determine whether either fixed or random effect model is suitable for the study. While the two-system Generalized Method of moment (GMM) approach were also employed to test the hypotheses and the presence of a long-run co-integration connection. The finding reveals that mortality rate, net migration rate, energy consumption and electricity consumption all have a joint negative and significant effect on Real Gross Domestic Product of sub-Saharan Africa. While fertility rate and fossil fuel consumption have a positive and significant effect on Real Gross Domestic Product of sub-Saharan Africa. Based on the finding, the study concludes that population dynamics and energy consumption play a significant role in enhancing economic growth of sub-Saharan Africa. The paper highlights the need for sustainable population policies and energy strategies in Sub-Saharan Africa. It emphasizes the importance of investing in renewable and efficient energy sources to promote economic growth while minimizing environmental costs. It also suggests the implementation of population management policies that balance demographic trends with resource availability and socioeconomic development goals.

Key words*: Population Dynamics, energy consumption, economic growth, Sub-Saharan Africa*

1. INTRODUCTION

The effect of population dynamics, energy consumption, and economic growth has long been acknowledged since Malthus's innovative study in 1798 (Suhana, M. D. S. (2016)). Over the centuries, it has become apparent that human capital is a fundamental element in compelling progress and growth. This is because the production needed to arouse economic growth can only be realized in the presence of human capital. In this regard, a rising populace can be observed as sanctification, particularly if the demographic arrangement comprises youths who are lively contributors in economic pursuit. Population progress also undesirably influences poverty and inequality, education, employment, health, food, migration, and the environment, all of which forage into economic growth. Other features of population away from numbers that effect economic results for persons and society as a whole comprise age, mortality, geographic, and social movement. To shed more light on population dynamics, it will be wise to define population dynamics here. According to Redmond (2016), population dynamics is the total number of human inhabitants in a specified area, such as a city, country, or continent, at a given time.

Economic growth is a basic macroeconomic strategy objective that nations all over the globe (i.e., emerging and emerging) continue to struggle to realize. In spite of the fact that there are other significant macroeconomic arrangement targets, for example, full employment, price stability, and balance of payment equilibrium, economic progress can exclusively be worked with by appropriate administration or the feasibility of balancing this multitude of other macroeconomic strategy goals. Indeed, even in the emerging nations where a substantial degree of economic progress has been accomplished, efforts are still being put in place not just to maintain the rate of progress but also to develop at the serial rate of development. The anticipated thirst for a consistent, significant, and supportable degree of economic progress and growth fed by nations from one side of the planet to the other, particularly non-industrial nations, has turned into a tremendous burden that governments and policymakers need to endure. Rutherford (2002) defined economic growth as progress in the total production of an economy over a period of time. Over the last few decades, population growth and economic growth have become heated subjects between scholars (Isaiah, J. M. 2021).

Sub-Saharan Africa, home to more than 1 billion individuals, a big part of whom will be under 25 years of age by 2050, is a different mainland offering human and normal assets that can possibly yield comprehensive development and kill destitution in the district. Sub-Saharan Africa (SSA) is made up of low, lower-centre, upper-centre, and high-salary nations, 22 of which are delicate or struggle-impacted. Economic progress in Sub-Saharan Africa (SSA) is set to decelerate from 4.1% in 2021 to 3.3% in 2024 because of a lull in worldwide development, rising expansion exacerbated by the conflict in Ukraine, unfavorable weather patterns, a fix in worldwide monetary circumstances, and the rising gamble of obligation trouble (World Bank 2023). In Sub-Saharan Africa, the high pass-through of food and fuel costs to customer costs has caused economic downturns to take off to keep highs in numerous nations, penetrating the roof of national bank focuses in many nations that have them. By far, most of the populace in Sub-Saharan Africa is touched by these high food costs, as they account for more than 40% of absolute spending on food (World Bank 2022).

Energy is extensively observed as a driving force behind any economic movement and industrial production. More than 640 million Africans have no access to energy, compared to a power access rate for African nations of a little more than 40%, the least on the planet. Per capital utilization of energy in sub-Saharan Africa (barring South Africa) is 180 kWh, contrasted with 13,000 kWh per capital in the US and 6,500 kWh in Europe (Africa Development Bank Group 2022). However, Jumbe (2004) defines energy consumption as the annual metered energy (kWh) consumption of a distributor that is generated by a PPA or other generation asset controlled by TVA and is referred to as energy consumption. Energy access for everything is one of the vital drivers of comprehensive development, as it sets out open doors for ladies, young people, and kids both in metropolitan and rural regions. Africa's energy potential, particularly sustainable power, is gigantic, yet only a small portion of it is presently utilized. Additionally, the specialized capabilities of solar-powered, biomass, wind, and geothermal energy are huge. While sustainable power will be focused on by the Bank, petroleum products will stay a significant piece of the general energy blend, just like with a few newly created economies, with the Bank supporting cutting-edge innovation to limit emanations (Africa Development Bank Group 2022). Nonetheless, the link between energy utilization and economic progress has long been an argumentative topic. At dissimilar periods and in dissimilar nations, different testing approaches frequently lead to dissimilar results.

Empirically, quite a few papers opt for the objectionable outcomes on population dynamics and economic progress, while others expose constructive results while others have no effects. Due to the distinct interpretations, similar analyses must be carried out in this vicinity in order to better explain this correlation. More lately, empirical studies have been disregarded in Africa, especially in sub-Saharan Africa. The aim of this study is therefore to investigate the connection between population dynamics and energy consumption and economic growth in Sub-Saharan Africa.

2. Review of Related Literature

Theoretical Framework

Optimistic and Neutralist Theories of Population

The population-optimistic view was put forward by the renowned Danish economist Ester Boserup in 1981. This economist noted that contrary to the negative relationship between population and economic growth acclaimed by Malthusian theorists, a rapidly growing population will impact an economy positively because a rapidly growing population will make room for economies of scale as well as the promotion of technological and institutional innovations (Kuznets, 1967). The followers of this theory strongly counter the Malthusian's position of an inevitable future food shortage (resulting from population expansion) by explaining that advancements in technology will positively influence productivity, thus neutralising any potential threat of a growing population on the food supply. These theorists recalcitrant belief in technology as a way out was also backed by Simon (1981), who noted that humans are only weights on earth without skill, science, and technology; therefore, output and productive capacity can be expanded using their own knowledge, forethought, and skills.

Population neutralist views dominated the thinking of scholars about population growth in the last half century (Kassim, F. & Isik, A. 2020).

Harrod-Domar Growth Model

Harrod-Domar opined that economic growth is achieved when more investment leads to more growth. The theory is based on a linear production function with output given by capital stock (K) as a constant. Investment, according to the theory, generates income and also augments the productive capacity of the economy by increasing the capital stock. As much as there is net investment, real income and output continue to be expended. And, for a full employment equilibrium level of income and output to be maintained, both real income and output should expand at the same rate as the productive capacity of the capital stock. The theory maintained that for the economy to maintain full employment in the long run, net investment must increase continuously as well as growth in real income at a rate sufficient to maintain full capacity use of a growing stock of capital. This implies that a net addition to the capital stock in the form of new investment will go a long way towards increasing the flow of national income. From the theory, the national savings ratio is assumed to be a fixed proportion of national output, and total investment is determined by the level of total savings, i.e., $S = SY$, which must be equal to net investment I. The net investment, which is $I = \Delta K = K\Delta Y$ because K has a direct relationship to total national income, And, therefore, $SY = K\Delta Y$, which simply means $\Delta Y/Y$ is the growth rate of GDP that is determined by the net national savings ratio, s, and the national capital output, K. In the absence of government, the growth rate of national income will be positively related to the saving ratio, i.e., the more an economy is able to save and invest out of a given GDP, the greater the growth of GDP, which will be inversely related to the capital output ratio. In order to grow, economies must save and invest a certain proportion of their GDP. The more an economy can save and invest, the faster it can grow. For any level of growth, it depends on how productive the investment is (Kuznets, S. 1967).

Growth Hypothesis Theory of Energy Consumption

This theory outlines a unidirectional interconnection from energy utilization to economic growth. The growth hypothesis model of energy utilization plays a vital role (affirmative or undesirable) in economic growth, either directly or indirectly, as a counterpart to labour and capital. On the other hand, energy consumption is either the reason for or the initiator of economic growth. The rule proposition of this theory advocates that saving energy might have an undesirable influence on economic growth. Nevertheless, it is proposed by the growth hypothesis that economic progress is touched uni-bidirectionally by energy utilization. As a result, energy is an essential element for any nation to achieve a high and steady economic progress rate. This debate states that economic progress is dependent on energy utilization. The growth hypothesis accepts a unidirectional connection from energy to economic growth, stressing the vital role energy plays and utilization plays in production growth. This affiliation signifies an energy-dependent economy where no or inadequate access to contemporary energy supplies possibly limits free enterprise and economic actions, resulting in insignificant economic implementation (Tsani, 2010).

Conceptual Framework

Population Dynamics

The concept of population dynamics has been a point of departure among scholars in the past centuries. In simple terms, population dynamics refers to how the number of people in a population changes over time. Like Nigeria, a region like Africa, and the world like the global population.

Population dynamics is concerned with the size, composition, and distribution of populations, their patterns of change over time through birth, deaths, and migration, and the determinants and consequences of such change. Population studies yield knowledge important for planning, particularly by the government in fields such as health, education, housing, social security, employment, and environmental preservation. The population of a country, which is the number of people living in that country, has come to mean different things to the demographer and the economist (Sinding, 2009). Malthus (1798) called it the human population. The demographer sees population as the scientific study of human populations, primarily with respect to their size, structure, and development, according to the Van De Walle Multilingual Demographic Dictionary in 1982. The foregoing explanations have only confined the term to inhabitation and have failed to integrate composition and distribution. Population explosion, otherwise known as rapid population growth, population outburst, or population upsurge, is a concept that has been variously interpreted. Sub-Saharan Africa's large population is likely to have economic implications as it affects a range of socioeconomic variables and displacements due to violence, insecurity, and insurgency.

Energy Consumption

Energy consumption in a precise nation or economy mostly focuses on energy use by the home, industrial, and transportation segments (Khobai, H. 2017). Nonetheless, energy utilization, energy use, or energy consumption is defined as the consumption of primary energy before alteration to other end-use fuels, which is equivalent to aboriginal output plus imports and stock changes minus exports and fuels supplied to ships and aircraft involved in global transportation (World Bank, 2019). At the domestic stage, energy use can be affected by the household range, income stage of the homes, career type, sex, education, urbanization level, population density (people per sq. km of land area), and yearly population progress at the shortcut level (Dash, 2013). In Sub-Saharan Africa (SSA), the stage of energy utilization in SSA has had proficient comparative undulations throughout the years (World Bank, 2021). The level of incorporation of energy use into other segments of the economy, like the transportation sector, the aviation sector, and shipping, among others, underlines its responsibility in assisting economic pursuit. All in all, countries with high per capital energy consumption are more advanced than those with low energy use. Nevertheless, the debate on whether and how energy consumption contributes to economic growth has been an indecisive one in the literature. Numerous studies have pronounced that energy consumption is optimistically linked to economic growth (International Energy Agency, 2020). Numerous authorities throughout the globe have obtained several measures to increase energy deliveries due to the quick increase in demand.

It's been viewed that energy has remained a broad "utilisation good" until the "production shortage," which ushered the 1970's oil downturn.

Economic Growth

Economic growth has traditionally been attributed to increases in population, the accumulation of capital, and increased productivity. Economic growth refers to the increase in the quantity of goods and services produced by an economy over time. It is conventionally measured as the percent rate of increase in real gross domestic product, or real gross domestic product. Growth is usually calculated in real terms, in inflation-adjusted terms, in order to net out the effect of inflation on the price of the goods and services produced. In economics, economic growth, or economic growth theory, typically refers to the growth of potential output production at full employment, which is caused by growth in aggregate demand or observed output. Kidane, A. (2020) defined economic growth as an increase in the ability of the economy to produce commodities and services. It is the steady process by which the productive capacity of the economy is increased over time to bring about rising levels of national income. It is also said to be either growth in national output as measured by GDP or GNP (which measures economic power) or growth in the national average standard of living as measured by the GNP per capita (which measures the well-being of citizens). In addition, a fast rise in population could hamper economic growth and lessens the standard of living (international Energy Agency IEA 2020).

Empirical Literature Review of Population Dynamics and Economic Growth

Ezebunwa et al. (2022) employed a vector error correction model approach to assess the effect of population growth, financial development, and economic growth in Nigeria spanning from the period of 1980 to 2019. The empirical analysis uncovers that there is a considerable long-term positive linkage between population growth, financial development, total fertility rate, and mortality rate, which has a significant positive effect on economic growth in Nigeria, while economic growth and population growth have a negative influence on economic growth in Nigeria.

Anthony et al. (2021) applied the Hausman test and the composite mean group (PMG) estimator between 2002 and 2017 to examine the association between population growth, life expectancy, and population growth. Economic growth in some countries is grouped into very high-income, high-income, middle-income and low-income countries to explore long-run linkages as well as the unweighted short- and long-term averages of individual countries. Furthermore, the results of the pooled mean method show that life expectancy, population growth, and total fixed capital significantly predict long-term economic growth. Also, life expectancy and population growth have a negative impact on economic growth.

Joshua (2019) adopted the autoregressive distributed leg (ARDL) framework and examined Granger causality for the period 1981–2006 to examine the effect of population structure on economic growth in Nigeria. The empirical paper shows that the ageing population has a negative effect on economic growth while the child population and labour force stimulate the growth of the Nigerian economy, thus supporting the existence of demographic dividend theory. Furthermore, there is a bidirectional relationship between the ageing population and economic growth in Nigeria and a unidirectional causality from the child population and labour force to real GDP and economic growth, leading to the formation of total fixed capital (investment) and scholarships.

Energy Consumption and Economic Growth

Bhuiyan et al. (2022) examine the utilisation relationship between renewable energy and economic growth in selected emerging and emerging nations from the period of 2010 to 2021. The empirical study used a threshold model approach to find that renewable energy does not hinder economic growth for both emerging and advanced nations, while there is little significance of consuming renewable energy (threshold level) on economic growth for advanced nations within the period of study.

Lekana, H. (2020), examine the linkage between economic growth, renewable and non-renewable energy, and electricity utilisation in 48 African nations from the period of 1980 to 2018. The study applied an ARDL approach to find The follows: (i) For the whole sample, both renewable consumption and non-renewable use have affirmative and substantial effects on growth, but non-renewable use has an enormous influence. (ii) The marginal effects of renewable consumption and non-renewable use vary across African counties. In the energy transition dilemma, there is a requirement for public-private partnership investments to bring a balanced combination between renewable consumption and non-renewables. Also, the heterogeneity suggests that a one-size-fits-all policy designed to increase growth through renewable consumption may not yield the same outcome in Africa.

Chen et al. (2020) employed a threshold model approach to assess the causal association between renewable energy use and economic growth in OECD nations spanning from 1995 to 2015. The study found that renewable energies optimistically and meaningfully touch economic growth in the OECD nations, while no substantial influence is felt in the advanced nations. Furthermore, the paper emphasised that in emerging and non-OECD nations, renewable energies meaningfully affect economic growth over a certain threshold of their utilisation within the period of study.

Maji et al. (2019) explore the link between renewable energy consumption and economic growth in 15 West African nations from 1995 to 2014. The empirical study applied the use of dynamic ordinary least squares (DOLS) to uncover that renewable energy utilisation diminishes economic growth in 15 West African nations. Also, the result is accredited to the description and basis of renewable energy used in 15 West African nations, which is mainly timber biomass.

Despite the current empirical debate over previous studies in the area of demographic dynamics that have a positive effect on economic growth, only in some cases do negative or non-negative effects appear. Significantly. To learn more about how this outcome occurs, very little analysis on the link between population dynamics and economic growth has been considered, and the analysis is ongoing but still remains to be seen.

3. Methodology

This chapter presents the research methodology underlying this study, model specification, sources and methods of data collection, variable descriptions and measurement, and finally the method of data analysis used to accomplish the purpose of this study.

Model Specification

We adopted a two-system GMM model technique used by Barro and Sala-i-Martin (2017) because is favored in the thesis due to its proficient of avoiding biased results due to relationship between the error term and the lagged endogenous variable. The equation of the GMM is given as

$$\sum (z (y1 - x1\beta) = 0 \quad (3.0)$$

Thus, the estimated model is;

$$LnRGDPt = \alpha o + \alpha 1 LFER_{it} + \alpha 2 \, \text{Ln} MOR_{it} + \alpha 3 \text{Ln} NIM_{it} + \alpha 4 \text{Ln} ELEC_{it} + \alpha 5 \text{Ln} \, ELEC_{it} + \alpha 6 \text{Ln} \, FSFC_{it} + \text{Ut} \quad (3.1)$$

Where; αo and b0 are the constant terms, α1 – α2 and b1-b2 are intercept parameters, Ln is Logarithm to base ten, RGDP is Real Gross Domestic Product, FER is fertility Rate, MOR mortality rate, NIM net migration, ENCM energy consumption, U is the error term at time, ELEC is electrical consumption and FSFC fossil fuel consumption at current form

Where:

RGDP = Real Gross domestic product of the countries

FER = Fertility rate

MOR = Mortality rate

NIM = Net Immigration

ENCM = Energy Consumption

ELEC = Electricity consumption

FSFC = Fossil fuel consumption

$\varepsilon 1$ = Stochastic or disturbance/error term.

t = Time dimension of the variables

α0 = Constant or intercept

Data Analysis and Result Interpretation

Descriptive Analysis

Table 1: Descriptive Data Analysis

	RGDP	NIM	MOR	FSFC	FER	ENCM	ELEC
Mean	5.143193	4.445454	25.99160	-0.501731	31513.68	24274.67	2 231.111
Median	4.950000	4.451000	26.40000	-0.263000	8.670000	44.00000	9.700000
Maximum	19.68000	6.194000	38.10000	4.018000	910441.0	330816.0	221500.0
Minimum	0.110000	2.261000	11.00000	-9.399000	-5.690000	1.210000	-30.71000
Std. Dev.	3.405715	1.005040	6.956092	2.863729	115128.7	73313.46	20300.49
Skewness	1.305694	-0.402620	-0.452236	-1.814291	5.229762	2.750824	10.72299
Kurtosis	5.839983	2.620325	3.069030	6.366301	35.16739	8.850704	116.3229
Jarque-Bera	73.80406	3.929806	4.079884	121.4722	5673.040	319.8070	65955.74
Probability	0.012357	0.014016	0.013036	0.01016	0.01287	0.13139	0.015421
Sum	612.0400	529.0090	3093.000	-59.70600	3750128.	2888686.	265502.2
Sum Sq. Dev.	1368.670	119.1923	5709.692	967.7115	1.56E+12	6.34E+11	4.86E+10
Observations	120	120	120	120	120	120	120

Source: *E-views Output, 2023*

Table 4.1 illustrates the characteristics of the variables studied. It is known that the number of samples is 120, which is from ten (10) sub-Saharan African nations. The description of the object of research can be seen in descriptive statistics. Which is processed using the programme E-Views 12. This analysis aimed to explain the average value (mean) and standard deviation of the comparison between the independent variables and moderate variables on the dependent variable.

Table 4.1 above presents the descriptive statistics of research variables (real gross domestic product, fertility rate, mortality rate, net migration rate, energy consumption, electricity consumption, and fossil fuel consumption) over a period of eleven years from 2010 to 2021. As shown in Table 1, real gross domestic product (RGDP) recorded over the period a mean value of 5.14 with a maximum of 19.68 and a minimum of 0.11 per annum. The standard deviation of real gross domestic product (RGDP) is 3.4, and this indicates that real gross domestic product (RGDP) has a low deviation or dispersion from the mean over the study period. The skewness value of 1.305694 indicates that the panel data has long-left tails, while the kurtosis value of 5.839983 indicates the presence of a mesokurtic series (normal distribution). This was validated by the Jarque-Bera statistic value of 73.80406 and its associated probability value of 0.01235, which is greater than 0.05.

Also, the net migration rate (NIM) recorded over the period had a mean value of 4.45, with a maximum of 6.19 and a minimum of 2.26 per annum. The standard deviation of the net migration rate (NIM) is 1.01, which indicates the net migration rate (NIM) has a low deviation or dispersion from the mean over the study period. The skewness value of -0.402620 indicates that the panel data has long-left tails, while the kurtosis value of 2.620325 indicates the presence of a mesokurtic series (normal distribution). This was validated by the Jarque-Bera statistic value of 3.929806 and its associated probability value of 0.014016, which is greater than 0.05.

In addition, the mortality rate (MOR) recorded over the period had a mean value of 25.99, with a maximum of 38.1 and a minimum of 11.0 per annum. The standard deviation of mortality rate (MOR) is 6.95, and this indicates that mortality rate (MOR) has a high deviation or dispersion from the mean over the study period. The skewness value of -0.452236 indicates that the panel data has long-left tails, while the kurtosis value of 3.069030 indicates the presence of a mesokurtic series (normal distribution). This was validated by the Jarque-Bera statistic value of 4.079884 and its associated probability value of 0.013036, which is greater than 0.05.

In furtherance, fossil fuel consumption (FSFC) recorded over the period a mean value of -0.50 with a maximum of 4.02 and a minimum of -9.40 per annum. The standard deviation of fossil fuel consumption (FSFC) is 2.86, and this indicates that fossil fuel consumption (FSFC) has a high deviation or dispersion from the mean over the study period. The skewness value of -1.814291 indicates that the panel data has long-left tails, while the kurtosis value of 6.366301 indicates the presence of a mesokurtic series (normal distribution). This was validated by the Jarque-Bera statistic value of 121.4722 and its associated probability value of 0.01016, which is greater than 0.05.

Moreover, fertility rate (FER) recorded over the period a mean value of 31513.68 with a maximum of 910441.0 and a minimum of -5.69 per annum. The standard deviation of fertility rate (FER) is 115128.7, and this indicates that fertility rate (FER) has a high deviation or dispersion from the mean over the study period. The skewness value of 5.229762 indicates that the panel data has long-left tails, while the kurtosis value of 35.16739 indicates the presence of a mesokurtic series (normal distribution). This was validated by the Jarque-Bera statistic value of 5673.040 and its associated probability value of 0.01287, which is greater than 0.05.

Furthermore, energy consumption (ENCM) recorded over the period a mean value of 24274.67, with a maximum of 330816.0 and a minimum of 1.21 per annum. The standard deviation of energy consumption (ENCM) is 73313.46, and this indicates that energy consumption (ENCM) has a high deviation or dispersion from the mean over the study period. The skewness value of 2.750824 indicates that the panel data has long-left tails, while the kurtosis value of 8.850704 indicates the presence of a mesokurtic series (normal distribution). This was validated by the Jarque-Bera statistic value of 319.8070 and its associated probability value of 0.13139, which is greater than 0.05.

Lastly, electricity consumption (ELEC) recorded over the period a mean value of 2231.11 with a maximum of 221500.0 and a minimum of -30.71 per annum. The standard deviation of electricity consumption (ELEC) is 20300.49, and this indicates that electricity consumption (ELEC) has a high deviation or dispersion from the mean over the study period. The skewness value of 10.72299 indicates that the panel data has long-left tails, while the kurtosis value of 116.3229 indicates the presence of a mesokurtic series (normal distribution). This was validated by the Jarque-Bera statistic value of 65955.74 and its associated probability value of 0.015421, which is greater than 0.05. The values of skewness and kurtosis were also computed for the 120 observations. Using the probability of the explanatory variables computed in Table 1 at the 5% level of significance, we conclude that all the variables used in this study are statistically significant.

Table 2: Summary of Im, Pesaran & Shin Test and Levin, Lin & Chu Test Panel Unit Roots Test Results

	IM, PESARAN AND SHIN W-STAT			LEVIN, LIN & CHU (LLC)TEST		
Variables	**Statistic**	**Prob.****	**Order of Integration**	**Statistic**	**Prob.****	**Order of Integration**
RGDP	-3.88262	0.0001	I(0)	-2.78945	0.0026	I(0)
MOR	-3.91774	0.0000	I(0)	2.86675	0.0003	I(0)
FER	-3.83498	0.0001	I(0)	-4.09486	0.0000	I(0)
NIM	-2.65473	0.0040	I(0)	-4.84760	0.0000	I(0)
ELEC	-4.86331	0.0000	I(0)	-5.07476	0.0000	I(0)
ENEC	-2.73330	0.0031	I(0)	-3.67476	0.0001	I(0)
FSFC	-6.52805	0.0000	I(0)	-10.4512	0.0000	I(0)

Source: *E-views Output, 2023.*

The results of panel unit root in Table 4.2 above show that all variables were stationary at level forms since the probability values of LLC are less than 0.05; thereby indicating that all variables were integrated of order zero, that is [I(0)]. In other words, after comparing the probability value of Levin, Lin and Chu t-statistics against the alpha value at 0.05 level of significance, it was ascertained that Real Gross Domestic Product (RGDP), fertility rate (FER), mortality rate (MOR), net migration rate (NIM), energy consumption (ENCM), electricity consumption (ELEC) and fossil fuel consumption (FSFC) were integrated at order I(0) and were as a result stationary at levels. However, since the variables were integrated of the same order I(0), we cannot test for co-integration but estimate the panel regression based on the order of integration of the model variables.

Table 3: Correlation Matrix

VARIABLES|	RGDP	MOR	FER	NIM	ELEC	ENCM	FSFC
RGDP|	1.0000						
MOR|	0.4537	1.0000					
FER |	0.6371	0.6554	1.0000				
NIM|	0.4648	0.4963	0.6065	1.0000			
ELEC|	0.4345	0.5543	0.6814	0.6917	1.0000		
ENCM|	0.2415	0.4897	0.1685	0.5524	0.4651	1.0000	
FSFC |	0.7135	0.5740	0.7043	0.5393	0.6299	0.4499	1.0000

Source: Source: *E-views Output, 2023.*

Table 4.2.2 directly above displays the correlation statistics on both constructs simultaneously. It is the avenue of knowing if the data analyzed labelled any form of multicollinearity and to ascertain any possible association amongst the variables. Though, the summary of this Table 4.2.2 demonstrates that the correlation between construct does not exceed the 80% threshold. Therefore, the absence of multicollinearity.

Table 4: Presentation of Fixed Effect (Within) Regression Results

Dependent Variable: RGDP

Variables	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
MOR	-.0164418	.0041239	-3.99	0.000	-.0246197	-.008264
FER	.2500245	.0667756	3.74	0.000	.1176059	.3824431
NIM	-.0170685	.0027831	-6.13	0.000	-.0225875	-.0115494
ELEC	-.0055339	.0017274	-3.20	0.002	-.0089594	-.0021084
ENCM	-.0060544	.0046545	-1.30	0.196	-.0152845	.0031757
FSFC	-.018767	.0029789	-6.30	0.000	-.0246742	-.0128598
_CONS	9.61305	.7258755	13.24	0.000	8.173611	11.05249

Source: Source: *E-views Output, 2023*
R-squared = 0.7288; Adjusted R-squared = 0.0929; F-statistic = 46.59;
Prob(F-statistic) = 0.0000;

The result of the fixed effect model analysis in Table 4.4 shows that fertility rate (FER) has a positive (.2500245) and significant (0.000) effect on real gross domestic product (RGDP). This means that real gross domestic product (RGDP) will increase by 123.3% given a unit increase in fertility rate (FER), while real gross domestic product (RGDP) will decrease by 123.3% given a unit decrease in fertility rate (FER).

Also, mortality rate (MOR) has a negative (-.0164418) and significant (0.000) effect on real gross domestic product (RGDP). This means that real gross domestic product (RGDP) will decrease by 131.9% given a percentage increase in mortality rate (MOR), while real gross domestic product (RGDP) will increase by 0.0122 given a percentage decrease in mortality rate (MOR).

In addition, the net migration rate (NIM) has a negative (-.0170685) and significant (0.000) effect on the real gross domestic product (RGDP). This means that real gross domestic product (RGDP) will decrease by 17% given a percentage increase in the net migration rate (NIM), while real gross domestic product (RGDP) will increase by 17% given a percentage decrease in the net migration rate (NIM).

Moreover, energy consumption (ENCM) has a negative (-.0060544) and insignificant (0.196) effect on real gross domestic product (RGDP). This means that real gross domestic product (RGDP) will decrease by 6% given a unit increase in energy consumption (ENCM), while real gross domestic product (RGDP) will increase by 6% given a unit decrease in energy consumption (ENCM).

Furthermore, electricity consumption (ELEC) has a positive (-.0055339) and significant (0.0231) effect on real gross domestic product (RGDP). This means that real gross domestic product (RGDP) will increase by 5.5% given a percentage increase in electricity consumption (ELEC), while real gross domestic product (RGDP) will decrease by 5.5% given a percentage decrease in electricity consumption (ELEC).

Also, fossil energy electricity consumption (FSFC) has a negative (-.018767) and significant (0.000) effect on real gross domestic product (RGDP). This means that real gross domestic product (RGDP) will decrease by 18.7% given a unit increase in fossil energy electricity consumption (FSFC), while real gross domestic product (RGDP) will decrease by 18.7% given a unit decrease in fossil energy electricity consumption (FSFC).

From the empirical result of the fixed effect model analysis presented in Table 4.2.3, the adjusted R-squared obtained is 0.7288. This shows that if the coefficient of determination is adjusted, approximately seventy-two percent (72%) of the changes in real gross domestic product are attributable to changes in fertility rate, mortality rate, net migration rate, energy consumption, electricity consumption, and fossil energy consumption, while the remaining twenty-eight percent (28%) of the variation in the model is equally captured by the error term (unknown factors outside the fixed effect model).

Lastly, the prob (F-statistic) value of 0.0000, which is less than 0.05, shows that the fixed effect model estimated is statistically significant. This also means that fertility rate, mortality rate, net migration rate, energy consumption, electricity consumption, and fossil energy consumption have a joint significant effect on real gross domestic product.

Table 5: Result of Hausman's Test

Test Summary	Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
Period random	3.76	6	0.7089

Source: Source: *E-views Output, 2023.*

The result of the Hausman test is shown in Table 4.6, From the Table, the chi-square statistic value (3.76) with a probability value of 0.7089 suggests that the fixed effect model is appropriate and should be preferred over random effect model. Specifically, since the p-value of 0.7089 is less than 0.05, we therefore retain the null hypothesis and conclude that random effect model is appropriate for this study. Specifically, it is well known that both the "random effects" and the "fixed effects" panel estimators are consistent under the assumption that the model is correctly specified and that (among other things) the repressors are independent of the "individual-specific effects" (the "random effects" assumption).

Table 5: Presentation of Dynamic Panel Data Two-Step System Generalized Method of Moment (GMM) Results

| Variables |	Corrected Coef.	Std. Err.	z	P>|z|	[95% Conf	. Interva
LNRGDP |						
L1. |	1.005355	.0218198	46.08	0.000	.9625886	1.048121
MOR|	-.0391875	.0030491	-12.85	0.000	-.0451637	-.0332114
FER|	.4156479	.001985	-209.39	0.000	-.4195385	-.4117573
NIM|	-.009889	.0013137	-7.53	0.000	-.0124637	-.0073143
ELEC|	-.0060048	.0010525	-5.71	0.000	-.0080676	-.0039419
ENCM|	-.0466035	.0007211	-64.63	0.000	-.0480168	-.0451901
FSFC|	.0018047	.0026217	0.69	0.491	-.0033338	.0069431
_cons |	-.0466035	.0007211	-64.63	0.000	-.0480168	-.0451901

R-squared = 0.846527; Prob (F-statistic) = 0.000;

Note: *** p < 0.01, ** p < 0.05, * p < 0.1 show statistical significance at 1%, 5%, and 10% level, respectively. Robust Standard errors are in parentheses. P-value reported for A-Bond AR (2), Sargan, and Hansen test statistics. Yitayaw et al., Cogent Economics & Finance (2023).

Arellano-Bond test for AR(1) in first differences: z = 0.13 Pr > z = 0.000
Arellano-Bond test for AR(2) in first differences: z = -0.47 Pr > z = 0.637

Sargan test of overid. restrictions: chi2(5) = 64.42 Prob > chi2 = 0.135, (Not robust, but not weakened by many instruments.)

Hansen test of overid. restrictions: chi2(5) = 1.11 Prob > chi2 = 0.253, (Robust, but weakened by many instruments.)

Source: Source: E-views Output, 2023.

The result of the Dynamic Panel Data Two-Step System Generalised Method of Moment Analysis in Table 4.7 shows that mortality rate (MOR) has a negative (-.0391875) and significant (0.000) effect on real gross domestic product (RGDP). This means that real gross domestic product (RGDP) will decrease by 39.1% given a unit increase in mortality rate (MOR), while real gross domestic product (RGDP) will increase by 39.1% given a unit decrease in mortality rate (MOR).

Also, fertility rate (FER) has a positive (.4156479) and significant (0.000) effect on real gross domestic product (RGDP). This means that real gross domestic product (RGDP) will increase by 41.5% given a unit increase in fertility rate (FER), while real gross domestic product (RGDP) will increase by 41.5% given a unit increase in fertility rate (FER).

In addition, the net migration rate (NIM) has a negative (-.009889) and significant (0.000) effect on the real gross domestic product (RGDP). This means that real gross domestic product (RGDP) will decrease by 9.8% given a unit increase in the net migration rate (NIM), while real gross domestic product (RGDP) will increase by 9.8% given a unit decrease in the net migration rate (NIM).

Moreover, energy consumption (ENCM) has a negative (-.04 66035) and significant (0.000) effect on real gross domestic product (RGDP). This means that real gross domestic product (RGDP) will decrease by 4.6% given a unit increase in energy consumption (ENCM), while real gross domestic product (RGDP) will increase by 4.6% given a unit decrease in energy consumption (ENCM).

Furthermore, electricity consumption (ELEC) has a negative (-.0060048) and significant (0.000) effect on the real gross domestic product (RGDP). This means that real gross domestic product (RGDP) will decrease by 6% given a unit increase in electricity consumption (ELEC), while real gross domestic product (RGDP) will increase by 6% given a unit decrease in electricity consumption (ELEC).

Also, fossil fuel consumption (FSFC) has a positive (.0018047) and insignificant (0.491) effect on the real gross domestic product (RGDP). This means that real gross domestic product (RGDP) will increase by 18% given a unit increase in fossil fuel consumption (FSFC), while real gross domestic product (RGDP) will decrease by 18% given a unit decrease in fossil fuel consumption (FSFC).

Conclusion

This study examined the effect of population dynamics and energy consumption on the economic growth of sub-Saharan Africa from 2010 to 2021. The data used in the study were generated from World Bank indicators, while the data analysis was facilitated by econometric views (E-views) statistical software 12. The variables for the study were subjected to stationary test using Im, Pesaran & Shin Test and Levin, Lin & Chu shows that all variables were integrated at order zero I(0) and order one 1(1). The paper was subjected to a colleration matrix in order to check for multicollinearity among the variables Therefore, the result finds absence of multicollinearity. The Hausman test were conducted to determine whether either fixed or random effect model is suitable for the study. While the two-system Generalized Method of moment (GMM) approach were also employed to test the hypotheses and the presence of a long-run co-integration connection was indicated. The finding reveals that mortality rate, net migration rate, energy consumption and electricity consumption all have a joint negative and significant effect on Real Gross Domestic Product of sub-Saharan Africa. While fertility rate and fossil fuel consumption have a positive and significant effect on Real Gross Domestic Product of sub-Saharan Africa. The finding is related to the finding of Isaiah, J. M. (2021), who established that fertility had a long-term co-integrating relationship with economic growth. Also, the finding is in agreement with the finding of Ezebunwa, et al (2022), who found that there is a substantial and positive association between economic growth and energy consumption.

References

Anthony, O. O, Wilson F. O, & Olorunwa J. O, (2021). Population growth, life expectancy and economic growth: a panel data analysis. *Journal of Economics and Policy Analysis, 6*(1), 1-12.

Bhuiyan, A. M., Qiannan, Z., Qiannan, Z., Vikas, K., Alexey, M., Gabor, P., & Xiaowen, H. (2022). Renewable energy consumption and economic growth nexus, systematic review. *Front. Environ. Sci., 6*(3), 78-86. https://doi.org/10.3389/fenvs.2022.878394

Chen, C., Pinar, M., & Stengos, T. (2020). Renewable energy consumption and economic growth nexus: Evidence from a threshold model. *Energy policy 139,* 111-295. doi:10.1016/j.enpol.2020.111295.

Chen, P., Chen, S., Hsu, C., & Chen, C. (2016). Modeling the global relationships among economic growth, energy consumption and Co_2 emissions. *Renewable and Sustainable Energy Reviews, 65*, 420-431.

Ezebunwa, J. N. Amini, M-A., & Amadi, R. (2022). The influence of population growth and financial development its impact on economic growth in Nigeria. *Journal of Economics and Social Science Review, 1*(1), 60-70.

IEA (2020). *World energy outlook 2020*. International Energy Agency.

International Energy Agency (IEA) (2020). *World energy outlook 2004.* International Energy Agency

Isaiah, J. M. (2021). Population dynamics and economic growth in Kenya. *Hungarian Statistical Review, 4*(2), 18–33.

Kassim, F. & Isik, A. (2020). Impact of energy consumption on industrial growth in a transition economy: Evidence from Nigeria. *MPRA Paper No. 101757.*

Khobai, H. (2017). Does renewable energy consumption drive economic growth: Evidence from Granger causality technique. *Journal of Business Economics, 1*(1), 1-8.

Kidane, A. (2020). The impact of population growth on economic growth: Evidence from Ethiopia using ARDL approach. *Journal of Economics and Sustainable Development, 11*(3), 20-32.

Kuznets, S. (1967), Population and economic growth. *Proceedings of the American Philosophical Society, 111*, 170-193,

Lekana, H. (2020). Energy consumption and economic development in sub-Saharan African countries: Role of governance quality. *Modern Economy, 11*, 1901-1918. doi:10.4236/me.2020.1111127.

Sinding S. W. (2009). *Population, poverty and economic development; A review*, Phil's and Sons Publishers.

Suhana, M. D. S. (2016). *Population dynamics and the nexus between human capital and economic growth in Malaysia.* Victoria Institute of Strategic Economic Studies (vises), Victoria University Melbourne, Australia.

Tang, C. F. & Tan, E. C. (2013). Exploring the nexus of electricity consumption, economic growth. *Applied Energy, 104*, 297-305, https://doi.org/10.1016/j.apenergy.2012.10.061.

Tsani, S. Z. (2010), Energy consumption and economic growth: A causality analysis for Greece. *Energy Economics, 32*(3), 582-590..

World Bank (2023). *World development indicators,* World Bank.

World Bank (2022). *World development indicators 2021,* World Bank,