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Crude death and crude birth rates, and economic development in sub-Saharan Africa Countries

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Abstract--Upon the collapsed of African economy and lost decades of development opportunities, crude death and crude birth rates were prominent among identified as determining components capable of worsen the developing economies as evidence in sub-Saharan Africa (SSA) region. On this premises, this paper examined the relationship among crude death rate, crude birth rate and economic development in SSA countries using regional pooled annual time series data spanning between 1970 and 2019. The data were sourced from World Bank, World Development Indicator (2019) edition of SSA database. The underpinning theory for the study is demographic transition theory. The study employed Auto-regressive Distributed Lag (ARDL) approach and VAR Granger causality model as estimation techniques. Findings from the study showed that there is existence of long-run relationship among the variables in the model. Result of the study revealed that domestic general government health expenditure (DGGHE) having insignificant level and fertility rate (FERR) significantly exerts positive influence while infant mortality rate (INMR) exhibits negative impact on the performance of gross domestic product per capita (GDPPC) in SSA. Further, crude birth rate (CBR) and crude death rate (CDR) also showed indirect relationship contrary to theoretical expectations in the mode. Besides, VAR Granger causality result indicates that bi-directional causal relationship exists between GDPPC and CBR, INMR and FERR in the region. While a uni-directional relationship running from GDPPC to other variables without a feedback and statistically insignificant. Given the above, it is therefore recommends that government and policymakers should devise another measure while making health and economic policies to further improve gross domestic product per capita for better enhancement of crude birth rate and possible reduction of crude

death rate through increase in domestic general government health expenditure so as to achieve more economic development in SSA region.

Keywords---ARDL, crude death, birth rates, economic development, VAR granger causality.

Introduction

Upon the collapsed of African economy and lost decades of development opportunities, crude death and crude birth rates were identified as determining components capable of worsen the developing economies as evidence in sub-Saharan Africa (SSA) region (UN, 2019). There is no doubt that increased in life span of an individual or birth rate in a country possess a benefit to both person immensely and economic development but however, recent study shown the most significant component of mortality decline through reduction in infant and child deaths which can enhance economic decisions in developing countries (Kalemli, 2000).

Declining child and youth mortality occasioned by crude death and as well crude birth provides important incentives to improve economic development through qualitative of child educational attainment and increased in life expectancy at birth which has doubled in many of developed nations and African countries but the reverse is the case in sub-Saharan region. That is, rising of crude death (child mortality) in the region leads to ebb of economic growth due to poor nutrition and healthcare attentions for the children (Li & Zhang, 2007). Thus, adequate public health measures and among others from the government of this region can reduce crude death rate. Therefore, understanding the role played by crude death and crude birth rates are crucial in terms of past, present and future of growth of the economy of any country. This is because high crude birth rate is associated with high income per capita in the country (Cervellatti & Sunde, 2009). Available theory indicates that increasing life expectancy at birth through crude birth rate may have both positive and negative effects on the development of an economy. On one hand, reduction of crude death may increase income per capita thereby increasing the productivity of available resources which in turn improve economic development through human capital mechanism. On the other side, lower crude death (mortality) may lead to an increase in population size as evidence in most of African regions today (Acemoglu & Johnson, 2007).

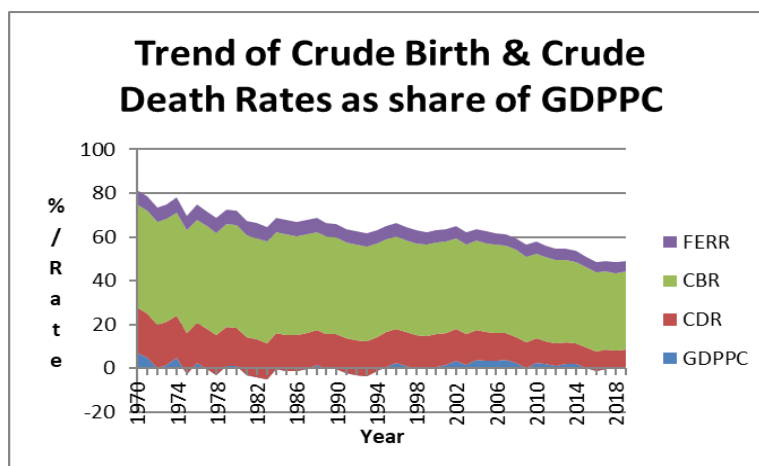


Figure 1: Trend of Demographic Transition Components
Source: Author's View

Figure 1 above shown the trending patterns occasioned by demographic transition components among fertility rate, crude birth rate, crude death rate and gross domestic product per capita. The figure indicates that the level of fertility (8%); crude birth rate (50%) and death rate (20%) move along the same time with each other but having different proportions. As the crude birth and fertility rates decline preceding the crude death rate but however, gross domestic product per capita proxied economic development fairly and really pronounced except at the inception of 1970 and resurface between 2000 and 2012. This implies the worsen of an economy in sub-Saharan African region as a result of trending and fluctuating of higher crude death which further aided uncontrolled fertility level that determine growth rate of population according to demographers' view (Kalemli, 2000). Further, taken 1996 as a base year, the fig. 1 indicates the downward trending. The downward trend shown is connected to the failure of region's government and their health sectors to effect adequate health measures for the people. In the same vein, declining crude death along side with unchanged birth rate caused population growth to raise due to poor nutrition and inadequate public health measures. However, government should take a more proactive measure when the needs arise.

Further, recent studies (e.g. Li and Zhang, 2007; O'Hare *et al.*, 2012) adjudged that children from African countries most especially in sub-Saharan Africa grossly died from childhood ailments, infirmities, and among others despite holistic solutions and modern technology identified to combat these diseases causing crude death in the region (Ude & Ekesiobi, 2014). Adduced reasons for this are not farfetched from poor health service delivery system in SSA due to mishandling and mismanagement of public health fund allocated to health sector (WHO, 2009).

O'Hare, Bar-Zeev and Chiwaula (2012) gesticulates that crude death (child mortality) decreases while crude birth (natality) shown a significant improvement and as well healthy life expectancy at birth which brought out increase in growth rate of population prior to after independence in most of African countries as

evidence sub-Saharan region. Therefore, growth and gains are witnessed in their economies as evidence from slowed drastically in crude death and higher natality between 1980s and 1990s (O'Hare *et al.*, 2012). This further implies that the average child mortality in sub-Saharan Africa countries reached a noble level of attainment during the claimed 1980s and early 1990s and thus; only started to show contrary (increase and decrease respectively) again after 1995. This coincides with stagnant/sluggish average incomes that further led to ebb of economic development in SSA countries during this time period. Perhaps, many scholars have concurred and established that as the level of income increases, crude death and crude birth significantly decrease and increase simultaneously during investigating the effect of country's income level on both average crude death and natality.

Extant literature on the relationship among crude death rate, crude birth rate and economic development are less pronounced in African countries (sub-Saharan Africa region inclusive). However, some related studies (e.g. O'Hare, Bar-Zeev & Chiwaula (2012); Li and Zhang, 2007; Kalemli-Ozcan, 2000; Ermisch, 1987; Yifang, 2013; and Adjuik, Smith, & Clark, 2006) on the theme are conducted on either an association between income, economic growth and child mortality/health or the impact of birth rate on economic growth. Most of these studies did not address the reasons why some of the African economies collapsed and the lost decades of development opportunities brought about by demographic transition components such as crude death rate, crude birth rate, fertility rate, and amongst others, capable of worsen the African economies as evidence in sub-Saharan Africa countries.

Alluding to the foregoing scenarios, this study is out to investigate the interrelationship among crude death rate, crude birth rate and economic development in SSA countries using regional pooled annual time series data spanning between 1970 and 2019 while demographic transition theory was employed that shed lighter to historical shift from high birth and infant death rates given birth by women in the societies to low birth and death rates as a result of better education, technological advancement infrastructure and economic development. The study employed Auto-regressive Distributed Lag (ARDL) approach and VAR Granger causality model as estimation techniques to achieve the objectives of the study, in contrast to other related studies (e.g. Li & Zhang, 2007; Yifang, 2013; Guest, 1974; Adjuik, Smith, & Clark, 2006; and Kutty, Thankappan, Kannan & Aravindan, 1993) that employed estimation techniques such as panel data, multiple Markov Chain Monte Carlo (MCMC) simulation, regression analysis, survey analysis and as well Verbal Autopsy (VA) surveillance analysis.

The study provides health sector authorities with a better understanding of interrelationship among crude death rate, crude birth rate and economic development to further aids better policy decision that can be used to typify African countries economy generally and how these demographic transition components plays major roles in influencing the changing of economy in SSA countries. The rest of the paper is structured as follows; section two focuses on theoretical framework and empirical evidences. Section three covers methodology

while section four deals with analysis and results of the study. Section five presents the concluding remarks and policy recommendations.

Literature Review

Theoretical Framework

This study used demographic transition theory developed by American demographer-Warren Thompson in 1929 coupled with a great depression (Warren, 2003). The use of the theory became imperative to assess the relationship among crude birth rate, crude death rate and economic development in a particular population of a country/region. Further, the theory analyzed the historical shift from both high birth and infant death rates given birth by women in the societies to low birth and death rates, as a result of better education, technological advancement infrastructure and economic development in virtually many developed and developing countries. However, the demographic transition theory in some countries may be imprecise due to social, political and economic factors affecting specific population, most especially in less-developed country. This demographic transition theory as reviewed by this present study would however, provide a conceptual framework for sub-Saharan Africa (SSA) region has been projected for United Nation (UN) demographic components for possible justification for family planning programs which in turn yielded massive agricultural populations of any country. However, as the theory developed, the relationship between development and demographic transition was inverted. Thus, further argument submitted that rapid growth constituted an insurmountable obstacle to industrialization or any kind of modernization. By implications, the rate of fertility had to be reduced in poor countries or regions by any means possible to permit their economic advancement. Because, too much population occasioned by high birth rate in any country/region may worsen their economic growth. Again, from the literature reviewed perspectives, between 1928 and 1931, Robert Kuckzinsky simultaneously analyzed the historical evolution of mortality and fertility in Europe and later come out to introduce the term "transition" in reference to Eastern Europe. To finally actualize the demographer's mission, Frank Notestein and Kingsley Davis from 1944 to 1945 presented the demographic transition's theory in a formalized form which later became and universally accepted findings in social science till today (Woods, 2000). Above all, the demographic transition theory as put forth by Thompson in 1929 and other demographer's can be summed into five stages as given thus:

-Pre-industrial society: that is, death and birth rates are high and roughly in balance. But, majority of the human populations are believed to have accedes this balance level in the 18th century and ended up in Western Europe. Specifically, in this stage, growth rates were less than 0.05% at least, since the day of Agricultural Revolution over 10,000 years ago (Kohler, Billari & Francesco, 2009). However, population growth is typically very slow under this stage, simply because the society is constrained by the available food supply; therefore, unless the society develops new technologies to increase food production (such as discovers new sources of food or achieve higher crop yields) while any fluctuations in birth rates are soon matched by death rates. This stage leads to a decline in death rates and an increase in population as a result of two major factors; (a)

improvements in the food supply brought about by higher yields in agricultural practices and better transportation reduce death due to starvation and lack of water; and (b) significant improvements in public health leads to reduce in mortalities most especially in childhood.

-In stage two of the demographic transition theory, evidence shown that death rates drop quickly due to improvement in food supply and sanitation, which increase life expectancies and possible reduction of infirmities and ailments. The improvement specific to food supply typically include selective breeding and crop rotation and farming techniques. Numerous improvements in public health reduce mortality, especially childhood mortality. Prior to the mid-20th century, these improvements in public health were primarily in the areas of food handling, water supply, sewage, and personal hygiene. One of the variables often cited is the increase in female literacy as a result of public health education programs which came into being between the late 19th and early 20th centuries.

-In the third stage, death rates are low and birth rates diminish, as a result of various fertility factors (e.g. access to contraception, increases in wages, urbanization, a reduction in subsistence agriculture, an increase in status and education of women, and among others. The decrease in birth rate fluctuates from nation to nation, as does in the time span in which it is experienced. This stage moves the population towards stability using a decline in the birth rate. It is also important to note that birth rate decline is caused by a transition in values rather than availability of contraceptives.

-Stage four comprises both low birth and death rates. Birth rate may drop to well below replacement level like other countries such as Japan and Italy which further result to a shrinking population that caused threat to many industries looking for population growth to excel. Just like the large group were born during stage two ages, it creates an economic burden on the shrinking working population. Death rate may remain consistently low or increase slightly due to increase in lifestyle infirmities due to low exercise levels and high obesity rates and an aging population in developed countries. By the late 20th century, birth and death rates in developed countries leveled off at lower rates

-The final stage happens to focus on both more-fertile and less-fertile a future which is stage five of demographic transition theory. That is, an increase in fertility and below-replacement fertility levels occur. Some countries (e.g. China, Brazil and Thailand) have sub-replacement fertility (e.g. below 2.0–2.1 children per woman). Replacement fertility seems to be marginally higher than 2 (the level which replaces the two parents, for equilibrium to be achieved). This is because boys are born more often than girls (about 1.05–1.1 to 1), and to compensate for deaths prior to full reproduction. Many European and East Asian countries now have higher death rates than birth rates. Population aging and population decline may eventually occur, assuming that the fertility rate does not change and sustained mass immigration does not occur.

Empirical Evidences

Extant literature on the relationship among crude death rate, crude birth rate and economic development are less pronounced in African countries most especially in sub-Saharan Africa region. However, some related studies on the theme are conducted on either an association between income, economic growth and child mortality/health or the impact of birth rate on economic growth. Thus, some of these studies (e.g. O'Hare, Bar-Zeev & Chiwaula (2012); Li and Zhang, 2007; Kalemli-Ozcan, 2000; Ermisch, 1987; Yifang, 2013; and Adjuik, Smith, & Clark, 2006) are hereby presented to guide and provide the underpinning foundation for study model. They are:

O'Hare *et al.*, (2012) analyzed whether there is an association between income, economic growth and child mortality in Sub Saharan Africa?. Result showed that majority of the intervened variables used such as maternal education and health care exhibits significant association between average child mortality rate and the country's level income in the region.

Li and Zhang (2007) examined the impact of birth rate on economic growth using a panel data set of 28 provinces in China for over 20 years. The study used Malthus's theory and also the proportion of minority in a province. Result showed that birth rate exhibits a negative influence on economic growth. The study recommends that China's birth control policy is indispensable to further enhance growth of the economy.

Kalemli (2000) investigated the effects of declining mortality on economic growth. The study used general equilibrium model as a result of exogenous decline in infant and child mortality. A Malthusian model steady state was also used and as well calibrated using historical and contemporary data on income and on survival probabilities from 26 countries. Findings indicates that the developed economy steady state showed higher levels of income per capita, human capital investment and a lower level of fertility as against Malthusian steady state. Further, the model was consistent with the stylized facts of the development process.

Ermisch (1987) analysed the economic influence on birth rate in Britain. The study used a group of equilibrium relationship between level of conditional birth rates and economic variables like ratio of women's hourly wage after taxes. Result indicates that decrease in birth was as a result of higher women's wages that led to reduction in the chance of another birth, as compare to men's net wages, thus, resulted to more children for couples at a young age in Britain.

Yifang (2013) analysed the child mortality in a developing country as evidence in Nigeria. The study used survey data of Nigeria demographic and health survey between 2003 and 2008. Estimation techniques of multiple Markov Chain Monte Carlo (MCMC) simulation from Bayesian prediction distribution for normal data and stratified sampling are used for the study. Findings indicates that if the age of mothers having kids for the first time is less than 20 years of age, this will greatly increase the probability of child's death. In addition, the production of child at higher age by mothers will relatively reduce child mortality in the country. The study recommends programme of action of the Cairo international conference

on population and development to further reduce child mortality through strengthening primary health care system such as provision of prenatal and neonatal care, promoting baby breastfeed amongst others.

Guest (1974) assessed the relationship of crude birth rate and its components to social and economic development across countries of the World using regression analysis to decompose the crude birth rate in six analytical components indicating illegitimacy, the marriage rate, legitimate fertility, as well as sex and age composition. Model was deduced for the study that indicates how economic development affects crude birth rate through its basic demographic components. Results showed that all the components except sex structure are important in determining differences in crude birth rates across countries of the World.

Kutty, Thankappan, Kannan and Aravindan (1993) analyzed socioeconomic status, birth and death rates in Rural Kerala, India: a health survey analysis. Data relating to birth and death were collected throughout the State of Kerala using the sample size of 9940 household (57665 persons) with respect to other variables such as region, religion and socioeconomic status. Results showed that socioeconomic status exhibits a definite influence on birth and death rates, thus resulting in lower birth and death rates due to higher socioeconomic status. Results further showed higher risk of mortality and birth rates among the poorer households could be as a result of material deprivation and poor educational attainments.

Adjuik, Smith, and Clark (2006) analysed the specific causes of mortality rates in sub-Saharan Africa and Bangladesh using Verbal Autopsy (VA) from 12 demographic surveillance sites during the period between 1999 and 2002. Findings from the study showed that causes of death in African sites strongly differ from those in Bangladesh. The study concludes that different patterns of mortality identified may be as a result of recent changes occasioned by availability and effectiveness of health interventions against childhood cluster diseases.

However, this study is limited in scope as it only focused on sub-Saharan Africa region but neglected other African regions such as; the Sahel, the Ethiopian Highlands, the Savannah, the Swahili Coast, the rain forest, the African Great Lakes and Southern Africa as a result of inability to have access to these regions database during the study period.

Methodology

Data Sources and Variables

The study relied on sub-Saharan Africa (SSA) regional pooled annual time series data spanning between 1970 and 2019. The data were sourced from World Bank, World Development Indicator (2019) edition of SSA database.

Model Specification

This study hinges on the work of Kutty *et al.*,(1993) and Guest (1974) on the basis of Warren's demographer ideology of 1929 for the assessment of relationship

among crude birth rate, crude death rate and economic development in a particular population. Based on the foregoing extant literature, the study therefore, adopted the models of Kutty *et al.*, (1993) and Guest (1974) as also reported by Warren (2003) with a little modification of intervening variables. However, the original model of Kutty *et al.*, (1993) is presented thus:

BirthRate, DeathRate = f(SocialeconomicStatus)

$$BR_{t1} = \omega_0 + \omega_1 INL_t + \omega_2 EDU_t + \omega_3 HOUS_t + \omega_4 LOW_t + \omega_5 RELG_t + \omega_6 ASPO + \rho_{t1} \dots (3.1a)$$

$$DR_{t2} = \omega_0 + \omega_1 INL_t + \omega_2 EDU_t + \omega_3 HOUS_t + \omega_4 LOW_t + \omega_5 RELG_t + \omega_6 ASPO + \rho_{t2} \dots (3.1b)$$

Where; BR_{t1} & DR_{t2} = Birth and Death rates, INL= income level, EDU = education, HOUS = housing, LOW = land ownership, RELG = religion and, ASPO = age structure of the population

However, the model was implicitly modified as presented in (3.2) and (3.3):

$$Econ.Dev. = f(CrudeDeathRate; CrudeBirthRate; InterveningVariables) \quad (3.2)$$

$$Econ.Dev.(GDDPC); CrudeDeathRate(CDR); CrudeBirthRate(CBR)$$

$$InterveningVariables(DGGHE; INMR; FERR)$$

$$GDDPC = f(CDR, CBR, DGGHE, INMR, FERR) \quad (3.3)$$

Based on equation (3.3), the operational form of the study model can be expressed as:

$$GDPPC_t = \vartheta_0 + \vartheta_1 CDR_t + \vartheta_2 CBR_t + \vartheta_3 DGGHE_t + \vartheta_4 INMR_t + \vartheta_5 FERR_t + v_t \quad (3.4)$$

Where; $GDPPC_t$ means Gross domestic product per capita in the country at time t ; CDR = Crude death rate; CBR = Crude birth rate. DGGHE = Domestic general government health expenditure; INMR = Infant mortality rate; FERR = Fertility rate

However, there is need to take the natural log of equation (3.4) owing to the fact that all the variables are already in the same rate or percentage including the dependent variable collected from Sub-Saharan Africa pooled database, 2020. After the log of (3.4), the model becomes;

$$LGDPPC_t = \vartheta_0 + \vartheta_1 CDR_t + \vartheta_2 CBR_t + \vartheta_3 LDGGHE_t + \vartheta_4 INMR_t + \vartheta_5 FERR_t + v_t \quad (3.5)$$

a-priori, it is expected that: $\vartheta_1 < 0$; $\vartheta_2 \dots \vartheta_3 > 0$; $\vartheta_4 < 0$; $\vartheta_5 > 0$

Where: $t = 1 \dots n$; $\vartheta_1 \dots \vartheta_5$ are vectors coefficient of independent variables influencing crude death and crude birth rates towards enhancement of economic development in SSA, and ϑ_0 represents constant intercept, while v_t is the

stochastic error term which is assumed to be normally distributed with zero mean and constant variance.

Estimation Techniques

Unit Root and Co-integration Tests

The use of unit root and cointegration tests became imperative in a bid to circumvent any inherent limitations from traditional modelling used in empirical analysis (Amin & Audu, 2007). Premised on this, the study employs Augmented Dickey- Fuller (ADF) model to test the stationary property of the data set employed. Here are the tests model equations:

$$\Delta\Pi_t = \varrho_0 + \varrho_1 \Pi_{t-1} + \sum_{i=t}^m \lambda_i \Delta\Pi_{t-1} + \hat{\varrho}_t \quad (3.6)$$

$$\Delta\Pi_t = \varrho_0 + \varrho_1 \Pi_{t-1} + \varrho_1 t + \sum_{i=t}^m \lambda_i \Delta\Pi_{t-1} + \hat{\varrho}_t \quad (3.7)$$

Where: time series variable is represented by Π_t and $\hat{\varrho}_t$ as time and residual respectively. If a series is stationary without any differencing it is designated as I (0), or integrated of order zero (0). On the other hand, a series that has stationary first difference is also designated I(1), or integrated of order one. Further, the ARDL bound test approach to co-integration test was employed to ascertain whether there exist long run relationships among the variables. It offers several desirable statistical features that overcome the limitations of other co-integration techniques (Pesaran *et al.*, 2001).

Auto-Regressive Distributed Lag (ARDL) Testing Procedure

To empirically investigate the dynamic relationship among crude death rate, crude birth rate and economic development for this study, we employed the Autoregressive Distributed Lag (ARDL) co-integration method introduced by Pesaran, Shin and Smith (1996, 1999 & 2001). Empirical studies further reveals that the use of ARDL bounds test approach to co-integration has been applied for the estimation of F-statistic that determines whether a long run relationship exists among the data series (Pesaran *et al.*, 2001), as also apply to this study. The condition for the existence of co-integration is that the ARDL bounds test F-statistic value must be greater than the upper critical bound value at 5% significance level. If the calculated F-statistics is less than the lower bound, then there is no co-integration among the variables but if the calculated F-statistic remains between the lower and upper critical bounds then the decision is inconclusive. Further, the coefficient of the co-integration equation CointEq(-1) of the short-run result conventionally known as the error correction term (ECT) which is expected to be positive and significant measures the speed of adjustment of the model back to long run equilibrium after disequilibrium which occurs in response to shocks (Ahmad, 2011). Hence, greater the coefficient of the ECT, the higher the speed of adjustment of the model from short run to long run and vice-versa.

Lastly, the study conducted post estimation analysis which includes Breusch-Godfrey serial correlation LM test, Breusch-Pagan-Godfrey heteroskedasticity test, Jarque-Bera histogram normality test, and as well the cusum and cusum of squares tests of stability.

In line with Pesaran *et al.*, (2001) and Bahmani and Nasir (2004) modeling approach, the ARDL dynamic (ECM-ARDL) model for the study is given as:

$$\begin{aligned} \Delta GDPPC_t = & \vartheta_0 + \sum_{j=1}^k \vartheta_1 \Delta GDPPC_{t-j} + \sum_{j=1}^k \vartheta_2 \Delta CDR_{t-j} + \sum_{j=1}^k \vartheta_3 \Delta CBR_{t-j} + \sum_{j=1}^k \vartheta_4 \Delta DGGHE_{t-j} + \\ & \sum_{j=1}^k \vartheta_5 \Delta INMR_{t-j} + \sum_{j=1}^k \vartheta_6 \Delta FERR_{t-j} + \gamma_1 GDPPC_{t-1} + \gamma_2 CDR_{t-1} + \gamma_3 CBR_{t-1} + \gamma_4 DGGHE_{t-1} + \\ & \gamma_4 DGGHE_{t-1} + \gamma_5 INMR_{t-1} + \gamma_6 FERR_{t-1} + v_t \dots \dots \dots (3.8a) \end{aligned}$$

Where: Δ = First differencing operator, L = natural logarithm, t = time, $t-1$ = lag one (previous year), ϑ_0 = constant and v_t = error term. The term summation signs (Σ) represent the short run dynamics with assumed mixed orders of integration of variables. However, the second part of the equation represents the long run dynamics, where the integration property is assumed to be $I(1)$; ϑ_0 to ϑ_6 ; and also γ_1 to γ_6 are the coefficients to respective variables estimated.

Specifically, the long run ARDL model for this study is:

$$\begin{aligned} \Delta GDPPC_t = & \gamma_0 + \gamma_1 GDPPC_{t-1} + \gamma_2 CDR_{t-1} + \gamma_3 CBR_{t-1} + \gamma_4 DGGHE_{t-1} + \\ & \gamma_4 DGGHE_{t-1} + \gamma_5 INMR_{t-1} + \gamma_6 FERR_{t-1} + v_t \dots \dots \dots (3.8b) \end{aligned}$$

After ascertaining the long run relationship, we used the following equation to estimate the short run coefficients:

$$\begin{aligned} \Delta GDPPC_t = & \vartheta_0 + \sum_{j=1}^k \vartheta_1 \Delta GDPPC_{t-j} + \sum_{j=1}^k \vartheta_2 \Delta CDR_{t-j} + \sum_{j=1}^k \vartheta_3 \Delta CBR_{t-j} + \sum_{j=1}^k \vartheta_4 \Delta DGGHE_{t-j} + \\ & \sum_{j=1}^k \vartheta_5 \Delta INMR_{t-j} + \sum_{j=1}^k \vartheta_6 \Delta FERR_{t-j} + \varpi EC_{t-j} \dots \dots \dots (3.8c) \end{aligned}$$

Where: ϖEC_{t-j} is the error correction term, indicating the speed of adjustment reverse to long run in the model. EC is the residual generated from estimated ARDL co-integration model.

VAR Granger Causality Procedure

In a bid to keep the variable constant, we used the Granger causality test in this study to examine the short run causality relationship among these variables

(Granger, 1969). Further, Granger causality test will determine if the historical value of one variable can forecast or predicts the relationship among other variables. For example, if variable CDR Granger cause another variable such as GDPPC, then the past value of CDR should contain information that are useful in predicting GDPPC, over and above the information contain in the past value of GDPPC alone. The mathematics approach to test for VAR Granger causality relationship among the variables is shown in (3.9):

$$\begin{bmatrix} GDPPC_t \\ CDR_t \\ CBR_t \\ DGGHE_t \\ INMR_t \\ FERR_t \end{bmatrix} = \begin{bmatrix} \eta_1 \\ \eta_2 \\ \eta_3 \\ \eta_4 \\ \eta_5 \\ \eta_6 \end{bmatrix} + \begin{bmatrix} \alpha_{11} & \alpha_{12} & \alpha_{13} & \alpha_{14} & \alpha_{15} & \alpha_{16} \\ \alpha_{21} & \alpha_{22} & \alpha_{23} & \alpha_{24} & \alpha_{25} & \alpha_{26} \\ \alpha_{31} & \alpha_{32} & \alpha_{33} & \alpha_{34} & \alpha_{35} & \alpha_{36} \\ \alpha_{41} & \alpha_{42} & \alpha_{43} & \alpha_{44} & \alpha_{45} & \alpha_{46} \\ \alpha_{51} & \alpha_{52} & \alpha_{53} & \alpha_{54} & \alpha_{55} & \alpha_{56} \\ \alpha_{61} & \alpha_{62} & \alpha_{63} & \alpha_{64} & \alpha_{65} & \alpha_{66} \end{bmatrix} \begin{bmatrix} GDPPC_{t-1} \\ CDR_{t-1} \\ CBR_{t-1} \\ DGGHE_{t-1} \\ INMR_{t-1} \\ FERR_{t-1} \end{bmatrix} + \dots + \begin{bmatrix} \alpha_{11} & \alpha_{12} & \alpha_{13} & \alpha_{14} & \alpha_{15} & \alpha_{16} \\ \alpha_{21} & \alpha_{22} & \alpha_{23} & \alpha_{24} & \alpha_{25} & \alpha_{26} \\ \alpha_{31} & \alpha_{32} & \alpha_{33} & \alpha_{34} & \alpha_{35} & \alpha_{36} \\ \alpha_{41} & \alpha_{42} & \alpha_{43} & \alpha_{44} & \alpha_{45} & \alpha_{46} \\ \alpha_{51} & \alpha_{52} & \alpha_{53} & \alpha_{54} & \alpha_{55} & \alpha_{56} \\ \alpha_{61} & \alpha_{62} & \alpha_{63} & \alpha_{64} & \alpha_{65} & \alpha_{66} \end{bmatrix} \begin{bmatrix} GDPPC_{t-k} \\ CDR_{t-k} \\ CBR_{t-k} \\ DGGHE_{t-k} \\ INMR_{t-k} \\ FERR_{t-k} \end{bmatrix} + \begin{bmatrix} \lambda_{1t} \\ \lambda_{2t} \\ \lambda_{3t} \\ \lambda_{4t} \\ \lambda_{5t} \\ \lambda_{6t} \end{bmatrix}$$

Where $\eta_1 \dots \eta_6$ are vectors of constant; $\lambda_{1t} \dots \lambda_{6t}$ are the vectors of error terms of VAR model while $\alpha_{11i} \dots \alpha_{66}$ are coefficients of VAR Granger causality for the model. Also, $i = 1, \dots, k$

Analysis and Discussion of Results

The unit root test results are presented in table 4.1. Thus, Augmented Dickey-Fuller (ADF) test was used in the study to ascertain the stationarity of the variables at different levels. The test result showed that variables of interest were integrated of different orders, I(0) and I(1).

Table 4.1: Unit Root Test

Variables	ADF Test Ho: Variables is not stationary	Order of Integration	Prob.
GDPPC	-4.562858	I(0)	0.0000*
CDR	-5.000919	I(0)	0.0009*
CBR	-2.172771	I(1)	0.0300**
DGGHE	-3.301688	I(0)	0.0294**
INMR	-3.266292	I(0)	0.0269**
FERR	-3.408356	I(1)	0.0155*
Asymptotic Critical Values			
1%	-2.613010		
5%	-1.947665		
10%	-1.612573		

*, (**), *** implies significant @ 1%, 5% and 10% levels respectively, Δ represents first difference
 Source: Extracted from Regression Output

From the unit root test result on Table 4.1, it showed that all the variables of interest were integrated of different orders I(0) / and I(1). However, GDPPC, CDR,

DGGHE and INMR were stationary at level while other variables including CBR and FERR became stationary at first difference. On this note, none of these variables are stationary at I(2). Therefore, Auto-regressive Distributed Lag (ARDL) approach is imperative for the study to confirm the long run relationship among the variables of interest (Pesaran, Shin & Smith, 2001).

Table 4.2: Lag Length Selection Test

Before the analysis of ARDL procedure, we carried out a conventional lag order selection process. By iteratively reducing the cited maximum lag length to where there seems to be no improvement in the choice of lag length selection, the result in Table 4.2 was generated.

Table 4.2: Lag Length Selection Criteria

Lag	LogL	FPE	AIC	SC	HQ
0	-34.2428	NA	2.79e-06	4.2361	4.5343
1	241.0751	347.7701*	3.97e-17*	-20.955*	-18.867*
* indicates lag order selected by the criterion(each test at 5% level) FPE: Final prediction error; AIC: Akaike information criterion SC: Schwarz information criterion HQ: Hannan-Quinn information criterion					

Source: Extracted from Regression Output

The result from table 4.2 showed that all the lags length selection criteria suggests maximum of two-lag for the ARDL model. That is, the majority of the criterion stood at lag 1, so that the errors in the equation can be serially independent and as well to avoid multicollarity in the model before carrying out ARDL Wald bounds test as shown in table 4.3.

Wald Test

Decision Rules: The decision rule for accepting or rejecting the null hypothesis of the calculated F-statistic value is based on the tabulated critical lower and upper bounds values specified by Narayan (2005). Thus, the table is presented below:

Table 4.3: ARDL Wald Bounds Test
Null Hypothesis: No Long-run Relationship Exist

Test Statistic	Value	K
F-statistic	4.097858	5
Critical Value Bounds (@)		
Significance	I(0) Bound	I(1) Bound
10%	2.26	3.35***
5%	2.62	3.79**

2.5%	2.96	4.18
1%	3.41	4.68*

Source: Extracted from Regression Output

Note: (i) k is the number of regressors in the ARDL model. (ii) *, **, *** indicates significance at 1%, 5% and 10% levels respectively, based on Pesaran (2001).

Table 4.3 indicates that the calculated Wald test (F-statistic) of 4.0978 is higher than the upper bound critical value of 3.79 at 5% significance level. We therefore, conclude that there is an evidence of long-run relationships among variables in the model. Hence, the null hypothesis of no co-integration is therefore rejected at 5% level of significance.

Table 4.4: Long Run Coefficients from ARDL Estimates

Dependent Variable: D(GDPPC)			
Regressor	Coefficient	t-Value	Prob.
C	135.796734	1.843713	0.0950***
CDR	17.914053	2.483468	0.0324**
CBR	-37.881811	-2.132145	0.0588***
DGGHE	0.128700	0.051748	0.9597
INMR	-3.513632	-2.482422	0.0324**
FERR	25.7823903	2.167492	0.0554***

Notes: *, (**), *** indicates statistically significant level at 1%, 5% and 10%

Source: Extracted from Regression Output

Result from long run estimates in table 4.4 indicates that coefficients of DGGHE, INMR and FERR conform to theoretical hypothesized signs of the model. While the coefficients of other variables such as CDR and CBR bears a contrary hypothesized signs to a-priori expectations. From the result, it can be observed that domestic general government health expenditure (DGGHE) having insignificant level and fertility rate (FERR) significantly exerts positive impact on the performance of gross domestic product per capita (GDPPC) in sub-Saharan Africa countries. To be factual, a unit increase in the GDPPC will increase DGGHE and FERR by 0.13 and 25.78 respectively. The pronounced variables in the model which is crude birth rate (CBR) and crude death rate (CDR) exhibited indirect values of t-ratio but statistically significant at their levels. This implies that a unit increase in CBR will reduce GDPPC by -37.88. This can be accounted for as a result of family planning by instituted various governments of this region while a unit increase in CDR will increase GDPPC by 17.91. CDR leads to population reduction in the region which in turn reduces the financial burden of the government and afterwards improves the growth of the economy of the region. This result was not in conformity with the work of Guest (1974) that shown that economic development affects crude birth rate through its basic demographic components. The infant mortality rate (INMR) indicates a negative and statistically significant impact on the GDPPC. This implies that a unit increase in INMR will lead to reduction in GDPPC by -3.15. This further showed that the higher the level of infant mortality, the worsen the development economy in the region contrary to the work of Yifang (2013)

Table 4.5: Error Correction Representation for Estimated ARDL Model

Dependent Variable: D(GDPPC)			
Regressor	Coefficient	t-Value	P-Value
C	135.796734	1.843713	0.0950***
D(CDR)	25.020578	2.050273	0.0675***
D(CBR)	-52.909567	-1.840086	0.0956***
D(DGGHE)	-3.265597	-1.418029	0.1866
D(INMR)	-4.907493	-2.034909	0.0692***
D(FERR)	8.216088	0.808141	0.4378
ECM(-1)	-1.396701	-4.695556	0.0008*
R-squared = 0.85			
Adj. R-squared = 0.73			
Durbin-Watson stat. = 2.5559			
Prob. (F-statistic) = 0.003057			
ARDL(1,0,0,1,0,1) selected on the basis of AIC			

Note: *, **, *** indicates significance at 1%, 5% and 10% levels, respectively.

Source: Author's Computation

The coefficient of most important in table 4.7 is the ECM(-1) which is well behaved as its coefficient is negative and statistically significant at 1% level, though it exceeds 1. The value (ECM -1.39%) indicates that the speed in respect of GDPPC adjusts the regressors is about 139% in the short run. This implies that errors are being corrected within the same period to ensure convergence to restore long run equilibrium in the current year. Other results are quite insightful and also in concordance with long run result of CDR and CBR that possesses an indirect/contrary hypothesized signs and statistically significant at 10% level. These results imply that crude death and crude birth rates were among of the major factors influencing GDPPC proxied by economic development in SSA. Adduced reasons for these indirect results pointed to the family planning, birth control, occurrence of natural decrease occasioned by death rate greater than birth rate, and other health measures instituted by various governments of the region. This was in agreement with the empirical study of O'Hare *et al.*, (2012). Further, the result of negative CBR and population growth reduction brought about by CDR (positively and statistically significant) signifies possible reduction in (DGGHE) financial burden of the government to further improve the growth and development of the economy of SSA region. However, this result contradict the work of Ermisch (1987) who submitted that higher women's wages leads to reduction in birth rate compared to men's net wages. More importantly, fertility rate (FERR) in the result exerts insignificant positive impact on economic development in the region. This in effect means that FERR plays a major role in economic development in SSA. The R-squared value of 0.85 showed that about 85% variations in GDPPC are jointly explained by set of explanatory variables in the model. The probability F-statistic value of 0.003057 showed that the overall model is significant in explaining economic development in SSA. The Dubin-Watson statistic value of 2.55 that fall within acceptance region. This implies that the model is free of serial autocorrelation problem in the model.

Post Estimation Analysis

This study examined various diagnostic tests to ascertain the reliability and robustness of the estimated model. The results are presented in table 4.6, Figures 4.1 and 4.2.

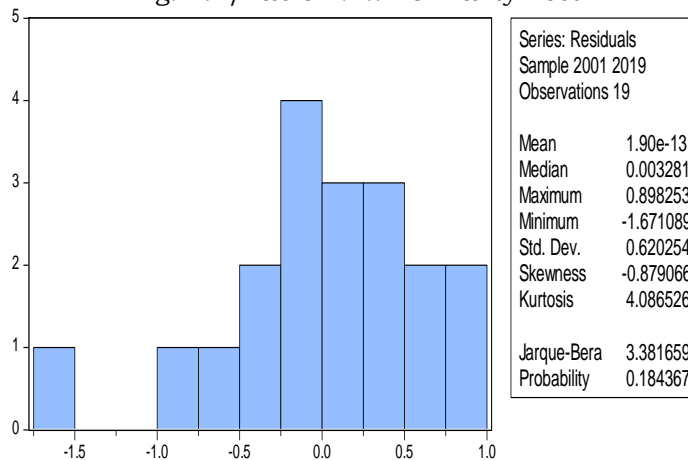
Table 4.6: Diagnostic Tests of the ARDL model

Diagnostic Test	MODEL	
	F-statistic	P-Value
B-G Serial Correlation LM Test	4.200869	0.0566
Heteroskedasticity Test: ARCH	0.073175	0.7902
Heteroskedasticity Test: Harvey	2.492584	0.0886
Heteroskedasticity Test: B-P-G	0.448930	0.8655
Ramsey-RESET Test	0.336680	0.5760

Source: Author's Regression Output

Table 4.6 of ARDL diagnostic tests showed that, the model's residuals are serially uncorrelated and has a correct functional form, normally distributed, homoskedastic and as well, the linear model is appropriate and statistically significant. This purports that the null hypothesis of model misspecification can be rejected as shown thus; Breusch-Godfrey serial correlation LM test ($0.0566 > 5\%$ to accept null hypothesis), Heteroskedasticity Harvey ($0.0886 > 5\%$ level), Ramesy-RESET test (p -value of $0.5760 >$ critical value of 0.05) and ARCH LM test ($0.7902 > 5\%$) respectively. It can therefore be deduced that the model has a satisfactory econometric properties, valid for reliable interpretation and can also be used for policy making without re-specification.

Fig. 4.1/Table 4.7.: Normality Test

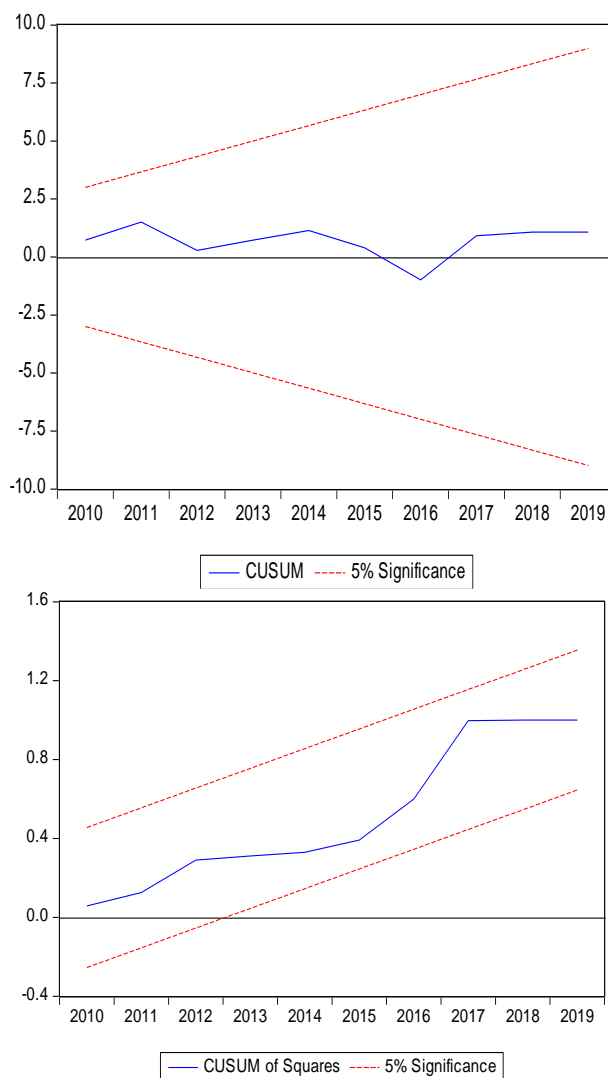


Source: Author's Regression Output

The Jarque-Bera test result of normality statistic value stood at 3.38165 with p -value of 0.18438 indicates that the null hypothesis of not normally distributed error term can be rejected for the model. Because, Jarque-Bera statistic of

338.16% confidence level > 0.05 . We there by accepts the null hypothesis of normal distribution for the model. This implies that Jarque-Bera test result of normality statistic

Fig.4.2: Plots of CUSUM Residual and CUSUMsq Tests



Source: Author's Regression Output

Figure 4.2 showed that neither CUSUM nor CUSUMsq tests provided any evidence of instability in the estimates at 5% significance level for conventional specification nor the results of which do not reject the null hypothesis of stability. This implies that all the coefficients in the short run model are stable and as well did not deviate from equilibrium in most of the periods. We therefore, conclude that all the coefficients in the short run model are stable and robust for prediction.

Table 4.8: VAR Granger Causality / Block Exogeneity Wald Tests

GDPPC				
Excluded	Df	Chi-sq.	Prob.	Decision
GDPPC → CDR	2	2.996349	0.2235	Accept
GDPPC → CBR	2	7.712406	0.0211**	Reject
GDPPC → DGGHE	2	0.169492	0.9187	Accept
GDPPC → INMR	2	9.519605	0.0086*	Reject
GDPPC → FERR	2	9.788746	0.0075*	Reject
CDR → GDPPC	2	1.893234	0.3881	Accept
CBR → GDPPC	2	3.684537	0.1585	Accept
DGGHE → GDPPC	2	0.618150	0.7341	Accept
INMR → GDPPC	2	0.160032	0.9231	Accept
FERR → GDPPC	2	3.533298	0.1709	Accept

Source: Extracted from regression output

Notes: * (**) indicates significant level @ 1% and 5% respectively

The short run equation as shown by VAR Granger causality test in table 4.8 indicates that the result of null hypothesis of gross domestic product per capita (GDPPC) do not granger-cause crude birth rate (CBR), infant mortality rate (INMR) and fertility rate (FERR) were rejected at their conventional levels. However, the null hypothesis of crude death rate (CDR) and domestic general government health expenditure (DGGHE) not granger-cause GDPPC were rejected at 5% significance level. Further, some of the variables showed non-granger-cause GDPPC exhibited having independent relationship. Conclusively, the study showed that bi-directional causal relationship exists between GDPPC and CBR; GDPPC and INMR as well between GDPPC and FERR in the region. This implies that increase in gross domestic product per capita is necessary for enhancing crude birth rate and fertility rate just as enhanced crude birth rate and prevalence of fertility are needed to improve economic development proxied as gross domestic product per capita in sub-Saharan Africa. While a uni-directional relationship running from GDPPC to other variables without a feedback and statistically insignificant. That is, they exhibited zero predictive content or power for GDPPC within the study period.

Policy Implications of the Results

Results from both long and short runs estimates indicates that crude birth rate (CBR) and crude death rate (CDR) showed indirect relationship contrary to theoretical expectations to economic development in SSA region. This further justified the probing of the recent research as the variables in question behave towards economic progress of a country/region. To be factual, these results implies that policymakers should devise another measure while making health and economic policies to improve gross domestic product per capita for better enhancement of crude birth rate and also aimed at reducing crude death rate through increase in domestic general government health expenditure so as to achieve more economic development in SSA region.

Further, from the long run estimates, fertility rate exerts insignificant positive impact on economic development in the region. This implies that fertility rate plays a major role in economic progress of SSA region. Hence, policymakers should take the level of fertility from the women to be serious so as to further marginally increase the rate of economic development in the sub-Saharan Africa region through re-appraising of instituted health policy.

VAR Granger causality result suggests that bi-directional causal relationship exists between GDPPC and CBR; GDPPC and INMR as well between GDPPC and FERR in the region. This implies that increase in gross domestic product per capita is necessary for enhancing crude birth rate and fertility rate just as enhanced crude birth rate and prevalence of fertility are needed to improve economic development in sub-Saharan Africa. Policymakers should not leave any stone unturned by using these variables in question during social and health policies formulation for better enhancement and performance of economic development in SSA region.

Conclusion and Policy Recommendations

The contributions of social-health outcomes to economic development of any economies had been well-established in the development literature. The study examined the relationship among crude death rate, crude birth rate and economic development in SSA countries using regional pooled annual time series data spanning between 1970 and 2019. The study employed Auto-regressive Distributed Lag (ARDL) approach and VAR Granger causality model as estimation techniques. The study concludes that there is an evidence of long-run relationship among the variables in the model from ARDL Wald bounds test conducted. The value of ECM stood at -1.65%, which indicates that the speed of adjustment GDPPC regressors is about 165% in the short run. This implies that errors are being corrected within the same period to ensure convergence to restore long run equilibrium in the current year. Result of long run estimates revealed that domestic general government health expenditure (DGGHE) having insignificant level and fertility rate (FERR) significantly exerts positive influence while infant mortality rate (INMR) exhibits negative impact on the performance of gross domestic product per capita (GDPPC) in SSA. Further, crude birth rate (CBR) and crude death rate (CDR) also showed indirect relationship contrary to theoretical expectations in the mode. The result of ECM further accentuated the connection among crude death rate, crude birth rate and economic development through the establishment of a stable long run relationship among the variables of interest. Besides, the result of VAR granger causality indicates that bi-directional causal relationship exists between GDPPC and CBR; GDPPC and INMR as well between GDPPC and FERR in the region. This implies that increase in gross domestic product per capita is necessary for enhancing crude birth rate and fertility rate just as enhanced crude birth rate and prevalence of fertility are needed to improve economic development in sub-Saharan Africa countries. While a uni-directional relationship running from GDPPC to other variables without a feedback and statistically insignificant. Given the above, it is therefore recommends that government and policymakers should take a proactive measure to improve gross domestic product per capita for better enhancement of crude

birth rate but aimed at reducing crude death rate at the instance of DGGHE increased in SSA afterwards economic development can be achieved.

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