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EMPIRICAL EVALUATION OF THE LONG-RUN EFFECTS OF CLIMATE CHANGE ON HUMAN HEALTH

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ABSTRACT

The importance of this study lies in the pressing need to provide emphatic insight into the relationship that exist among climate change, human health and economic growth in Nigeria, in order to achieve the Millennium Development Goals (MDG). It was established that Nigeria's macroeconomic environment has not been able to adequately mobilise growth. Given the precarious effect of climate change on human health (Ahern et al., 2006), Nigeria may not stand any good chance of growth and development considering the consequences earlier stated, coupled with the poor macroeconomic environment. Owing to these adverse consequences of global climate change, induced by increase in temperature, resulting in shortage of water supply, crop failure and displacement of people, Nigeria has been classified among the most vulnerable to climate change because of her dependence on the environment for livelihood. It was reported that 40 per cent of the world's agricultural land is seriously degraded by poor farming practices, deforestation, and the effects of climate which results in about 300 000 deaths and 5 million illnesses each year. It was also projected that by 2030 the number of deaths would be 500 000, with 310 million people suffering health consequences related to temperature rise, 20 million falling into poverty and 75 million being displaced (GHF, 2009). Ipso facto, it becomes expedient to create awareness in order to reduce the vulnerability of the Nigerian economy to climate change and its consequences, so as to engender faster and significant growth and development. Therefore, this empirical study is postulated upon the need for redirection and repositioning of the country in order to reduce the impact of climate change on human health in Nigeria and consequently on economic growth via improved economic policies. Thus, this study examined the extent to which carbon dioxide emissions explained variation in climate change in Nigeria. It also evaluated the long-run effect of climate change on human health, as well determined the relationship among climate change, human health and growth in Nigeria. All these empirical analyses would help in the formulation of health and environmental policies that would put the nation on the path of sustained growth and also increase the frontier of knowledge in this field, as econometrically analysed studies give high precision results, resulting in excellent policy. this study explicitly brought to light the peculiarities of the Nigerian economy with respect to climate change, since the study is country specific. The study examined the trend of climate change, human health and economic growth in Nigeria and analysed the extent to which carbon dioxide emissions explained variation in climate change in Nigeria. It also evaluated the long-run effect of climate change on human health. These are with a view to determining the dynamic relationship among climate change, human health and economic growth in Nigeria. The study made use of secondary data that were sourced from different

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publications and data centres. Data on real Gross Domestic Product, life expectancy, local carbon dioxide emissions, urbanization and food were sourced from the Work Development Indicators of the world bank while data on temperature were sourced from Nigeria Meteorological Agency and Earth Policy Institute. Data on carbon dioxide were sourced from carbon dioxide information analysis centre. Data on human capital spending and local rainfall were sourced from the statistical bulletin of Central Bank of Nigeria and abstract of statistics of National Bureau of statistics, Nigeria. Data were analysed using descriptive and Vector Autoregressive (VAR) model. Research results showed that there is a long-run relationship between human health and global climate change and its short-run adjustment coefficient—the error correction coefficient of 0.5 percent is negative and significant, suggesting that the speed of adjustment of human health to its long-run equilibrium is abysmally slow, as only 0.5 percent disequilibrium is corrected every year by human health. This means it will take a whole lot of 200 years before convergence to equilibrium can be achieved

Keywords: Climate Change, Human Health, Long-Run Effects, Empirical Evaluation

INTRODUCTION

Climate change is diversely understood in different quarters and this variation is innate, as climate is never constant (Mitchell *et al.*, 1996; Barring, 1993; Pielke, 2004; Von Storch, 2008). The Intergovernmental Panel on Climate Change (IPCC) defines climate change as 'change in the condition of climate that can be identified by changes in the mean and or/variability of its properties and that persists for an extended period, typically decades or longer' (IPCC, 2011) while the United Nation's Framework Convention on Climate Change (UNFCCC) defines climate change as a 'change of climate that is directly or indirectly caused by human activities that alter the composition of the global atmosphere, and that is in addition to natural climate variability over comparable time periods'. UNFCCC distinguished between climate change which is attributable to human activities and climate variability attributable to natural causes. Hence, for this study, climate change is defined as a long-term change in weather patterns which is reflected as a sustained increase in the average temperature of the earth's atmosphere over decades or longer.

Climate change is as a result of the concentration of the greenhouse gases (GHG) in the atmosphere and the emission of these gases could be human (anthropogenic) or natural (bio-geographical). In particular, the human contribution to climate change phenomenon is the main driving force of climate change (IPCC, 2007; Eboli *et al.*, 2009 and Ajayi, 2009). According to Odjugo (2010a) the anthropogenic factor in climate change involves the emission of large amount of GHG into the atmosphere or the reduction of the amount of carbons absorbed from it by human activities. Industrialization, burning of fossil fuel, gas flaring, urbanization and agriculture are some of the human factors that produce large amount of these gases. Conversely, human activities that reduce the amount of carbon sinks are deforestation, alterations in land use, water pollution and agricultural practices. Among others, the major GHG are carbon dioxide (CO_2) which is mostly from fossil fuel and land-use change; fluorinated gases from electrical power transmission and industrial processes; methane (CH_4) and nitrous oxide (N_20) from agricultural activities and waste (WHO, 1996; Nakicenovic *et al.*, 2000; Nwoke *et al.*, 2009 and McMichael, 2009). Carbon dioxide is the most dominant of the GHG because of its predominance in the atmosphere. Also, other gases decompose to become CO_2, making it account for about three-quarters of the global warming

impact. Methane and N_2O have greater warming effects per unit volume and this raises the CO_2 equivalent concentration. However, they decompose more rapidly from the atmosphere. The greatest warming effect comes from fluorinated gases; although, their global warming impact is negligible because its emission is as little as 3%. In essence, CO_2 is a major compound that influences climate change as it predominates and prevails over other GHG in the atmosphere (McMichael, 2009 and Odjugo, 2010a). Fig 1.1 shows the abundance of CO_2 in the atmosphere at 82 percent, while for methane, nitrous oxide and fluorinated gases are 9 percent, 6 percent and 3 percent, respectively.

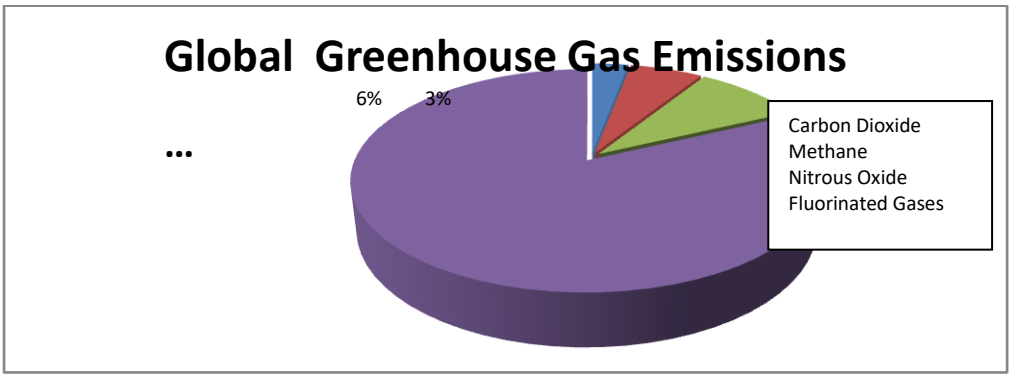

FIG. 1.1 Inventory of Global Anthropogenic Greenhouse Gas Emissions, 2012
Source: United States Environmental Protection Agency

On the other hand, Ikefuji *et al*. (2012) posited that the greenhouse effect is not only the pollution effect, as producers and consumers generate dirt that enter into the atmosphere as sulphur dioxide (aerosols) which absorb sunlight from the earth, resulting in a cooling effect.

Climate change is both a developmental and an environmental challenge, as it causes very serious risk to lives and livelihoods (McMichael *et al.*,2006; EHP, 2010), especially in the less developed countries (LDCs), which are the poorest and most vulnerable populations (Woodward *et al.*, 1998; Postnote, 2006; Jagtap, 2007; Bryant *et al.*, 2009; Hardee and Mutunga, 2009 and Odjugo, 2010a). In fact, the impact of climate change is very likely to reverse progress towards achieving any reasonable developmental goals in any nation (Factsheet, 2009; McMichael, 2009 and Mawle, 2010). Obviously, climate change is the leading global health threat of this millennium of which countries in the less developed world which are least responsible for the growing emissions are likely to experience its heaviest impact, because of their dependence on the environment for a significant part of their daily livelihoods; also, their weak resilience and limited adaptive capability.

The consequences of climate change could either be direct or indirect, the direct consequences include deaths and illnesses due to thermal extremes; injuries resulting from floods and storms while the indirect ones are more widespread vector-borne infections, increase in other infectious diseases, respiratory challenges as a result of worsened air pollution, poor nutrition due to agricultural disruptions and ill-health associated with social dislocation and migration (Woodward *et al.*, 1998 and Mc,Michael, 2009). Consequently, climate change presents a critical, multifaceted development challenge in the global world, as labour productivity moves in tandem with human health (King, 2004; Van Lieshout *et al.*, 2004; USAID, 2008; AUC, 2010). This logically infers that, if climate change negatively impacts on human health, leading to low productivity of labour which is consequential on economic growth, then, there might exist a strong link among climate change human health and economic growth. Although, WHO (2003); Luber and Hess (2007); Dell *et al*.(2008) and

McMichael *et al.* (2009) asserted that the consequences of climate change cannot be investigated with precision because the dynamics of climate change and climate variability is not totally understood. Nevertheless, there is increasing consensus that the world is experiencing major changes in climatic conditions resulting in increase in temperature as a result of high emission of GHG (McMichael *et al.*, 2006; McMichael *et al.*, 2009; Mendelsohn, 2009 and Rosenberg et al., 2010).

The Intergovernmental Panel on Climate Change (IPCC) produced assessment reports showed the evidences of climate change induced by human activities. Although, the 1990 First Assessment Report (FAR) revealed that there is insufficient observational evidence on climate change; but the second assessment which came up in 1995 suggested an evident human influence on the global climate. Subsequently, the third assessment report in 2001 concluded that most of the observed warming over the last 50 years was as a result of GHG concentrations; thereafter, the 2007 fourth assessment report ascertained that the warming of the climate system is indisputable (Dube and Chimbari, 2009). Haines *et al.* (2006) and Watson (2010) explained that average world temperature would rise between 1.4^0C and 5.8^0C over the next 100 years, against the 1^0C of the previous century. In fact, there is high probability that the earth's average surface temperature will rise by 2^0C during this 21st century because of the combined concentration of GHG, and this will without doubt lead to drought, flooding, increases in extreme weather events, coupled with all its consequences which are likely destruction of natural environmental assets and also impairment of human health (Schellnhuber *et al.*, 2006; IPCC, 2007; Hansen *et al*, 2008 and McMichael, 2009). Dube and Chimbari, (2009) put forward that the major emitters of GHG are the developed countries (DCs) and more recently are China and India. The statistics are highlighted in the table below.

Table 1
World Emissions Ranking in Million Tonnes of CO_2 in 2009

Continent	**Total Emissions**	**Highest Emitter**	**Portion Emitted**
North America	6411	United States	5425
Central & South America	1220	Brazil	420
Europe	4310	Germany	766
Eurasia	2358	Russia	1572
Middle East	1714	Iran	527
Asia & Oceania	13264	China	7711
Africa	1122	South Africa Egypt Algeria Nigeria	450 192 114 77.7

Source: United States Energy Information Administration

In the whole world, Africa emitted the least tonnes of CO2 with South Africa ranking highest with 450 million tonnes; while Nigeria was placed in the 4th position in Africa, but graded 45th position in the world for emitting 77.7 million tonnes. Accordingly, this made Nigeria one of the least emitters in the world. On the other hand, China that was earlier rated second in 2006 emitted 7711 million tonnes in 2009 and forthwith became the highest emitter of CO_2 in the whole world with 170.6 percent rise in emissions from the year 2000, as it pursued and gained 9-10 percent growth rate in 2008-2009 (EIA, 2009). Thus, the probability of higher global warming is evidently not an overstatement as the developing countries will also contribute to it in the near future in their quest for growth and development. Climate change projections based on global circulation models (GCM) point to persistent warming in the future with more negative consequences that have a bearing on water supply, food

security and human health among others. In the meantime, Africa accounted for 13.8 percent of the world population in 2005 and contributed about 2.5 percent of the global cumulative CO_2 emissions from fossil fuel (Canadell *et al.*, 2007 and Dube and Chimbari, 2009)

According to Haines et al. (2006), climate change is very likely to be associated with increases in the frequency of extreme weather events, owing to the several excess deaths which were recorded in Europe in 2003. Table 1.2 reveals the statistics of these deaths.

Table 2
Excess Mortality of the 2003 Heat Wave Period in Europe

Countries	Excess Deaths	Period
England and Wales	2091 deaths	4th_13th August
Italy	3134 deaths	1st June-15th August
France	14,802 deaths	1st-20th August
Portugal	1854 deaths	August
Spain	4151 deaths	July and August
Switzerland	975 deaths	June-September
Netherlands	1400-2200 deaths	June-September
Germany	1410 deaths	1st-24th August

Source: Haines *et al*. (2006)

Statement of the problem

Literature has established the atmospheric dominance and persistence of CO2 among the anthropogenic GHG emissions, as the major cause of global warming effect which is couched climate change (McMichael, 2009; Odjugo, 2010 and EPA, 2013). It has also been published that climate change has negative impacts in human health both directly and indirectly (Haines, 2006; Rettner, 2011) and those impacts range from ill health to deaths, which in effect lower labour productivity and ultimately, economic growth of a nation. This simply implies that increase in CO2 emissions influences climate change and climate change in turn deteriorates human health, resulting in decline in the productivity of labour and hence, economic growth (King, 2004; van Lieshout *et al.*, 2004; USAID, 2008. Bloom and Canning, 2008; AUC, 2010; Aghion *et al.*, 2010; Peykarjou *et al.*, 2011). Therefore, based on these infallible proofs, this study will empirically determine the extent to which CO_2 emissions explain variation in climate change in Nigeria.

There is no doubt that Nigeria is a reflection of the sub-optimal economy with poor portable water, poor health care delivery and unhygienic environment (Okonjo-Iweala, 2004) is susceptible to the consequences of climate change which impede meaningful growth. Moreover, studies have shown that no meaningful developmental goals can be achieved as long as anthropogenic climate change is not controlled (McMichael, 2009 and Mawle, 2010). For instance, a country with high incidence and prevalence of disease has a Gross Domestic Product (GDP) that is five times lower than that of a country that does not have these negative incidences (Gallop and Sachs, 2001). According to Ajayi (2009), agriculture employs 70 per cent of Nigerian population, besides contributing about 41 per cent to Gross Domestic Product, in addition to accounting for 5 percent total export and 88 percent of non oil earnings. In spite of this huge contribution of agriculture to the economy, sustainability of and improvement on agricultural sector productivity have been difficult, as unpredictable weather patterns induce farm abandonment for non-farm activities, causing monumental reduction in food production which is vital for human health sustainability (Apata *et al.*, 2009). This suggests that unpredictable weather condition can also be inimical to vocational engagements and cause unproductive resource allocation across sectors in the economy. Consequently, all these upshots and resultant health challenges might even lead to deaths;

thereby reducing the labour force and untimely lowering the general productivity of an economy. Therefore, to achieve any meaningful development goals in Nigeria, reducing the impact of climate change on human health is a crucial issue that the economy cannot afford to overlook.

This research was undertaken to evaluate the long run effect of climate change on human health; and as well as analysing the dynamic relationship among climate change, human health and economic growth in Nigeria.

LITERATURE REVIEW

That economic modelling deals with the interaction of economic theory and empirical analysis is indubitable, and that is why it becomes germane and paramountcy to discuss some economic theories relevant to the formulation of the model in this study. Rosenberg *et al.*,(2000) recognized the fact that studies on climate change can be grouped into meteorological models which predict changes in climate and empirical estimates of climate impacts on economic variables. The latter type can also be grouped into studies that rely on wage and income to deduce climate values and studies that directly estimate the relationship between economic outcomes and changes in climate. This research followed the second sub-type in which we attempted to identify climate effects on human health and economic growth. This work, nevertheless does not aim at predicting climate change or its values; but to evince the incontestable influence and determinant effects of temperature on climate. Correspondingly, the yardstick of measurement for climate variable in this study is temperature; for human health, it is life expectancy and the variable for economic growth is assessed through the lens of real gross domestic product.

This empirical study reviewed the neoclassical growth theory which models growth of GDP per worker via capital accumulation with the production function revealing GDP to depend on technology, labour, physical and human capital. This is because the studious research specifically focuses more on supply-side economics, coupled with the basic fact that neoclassical growth theory has been posited to be able to allocate and mobilise resources efficiently for optimal productivity and profitability (Obadan, 2003).

The Solow-Swan Growth Model

This model is credited to Robert Solow (1956) and Trevor Swan (1956) who published independently these analogous papers eventually referred to as Solow-Swan model. The Solow-Swan model is an exogenous long-run economic growth model that attempt to explain growth through capital accumulation, labour or population growth and increases in productivity (technological progress). It derives from a Cobb-Douglas type of production function, which facilitates the relation of the model with microeconomics. The Solow-Swan model is of a continuous-time model without government or international trade in which a single good (output) is produced by making use of two factors of production, labour (L) and capital (k) in an aggregate production function that satisfies the Inada conditions.

The Solow-Swan model has both short-run and long-run implications. In the short run, fiscal policy measures like tax cuts or investment subsidies can affect the steady state level of output but not the steady state rate of output growth. Also changes in savings rates can only affect growth rates in the short-run; however, the convergence of the economy to the steady state is determined by the rate of capital accumulation which is also determined by the saving rate. In the long run the Solow-swan long-run rate of growth is exogenously determined. This implies that any constant saving rate, would make the economy to always converge to a steady state rate of growth and this depends only on the rates of technological

progress and the labour force growth. In essence, a country that records a steady state of high saving rate and one with a low saving rate would experience the same rate of growth in output per worker and an economy with higher saving rate in relation to GDP will experience faster growth temporarily. In summation, the model predicts that poor countries would grow rapidly if the share of GDP invested in capital is raised according to the maximum share of GDP that can be invested. This would lead to eventual stabilisation of saving rates and the convergence of economic growth per worker to the lower steady-state rate which is determined by technological progress.

Below are the Solow-Swan equations which comprises of a production function and a capital accumulation equation.

$Y(t) = K(t)^{a} (A(t) L(t))^{1-a}$ (Production function)

Where Y = GDP
A = Technology (Labour augmenting)
K = Capital
L = Labour
t = time
a = elasticity of output ($0 < a < 1$)

Thus AL represents effective labour. Labour and the level of technology grow exogenously at rates of n and g, respectively. Therefore, effective units of labour $A(t)L(t)$ grows at rate (n+g).

$\frac{dK(t)}{dt} = sY(t) - \delta K(t)$ (Capital accumulation equation)

where s = Proportion of GDP saved ($0 < s < 1$)

δ = Depreciation rate ($0< \delta <1$)

Y and K are endogenous, δ, growth rate of L and A are expressions. Any positive change in K and L will increase Y and generate economic growth.

Assumptions of Solow-Swan model

(i) Diminishing returns to capital or labour (the law of diminishing returns)
Constant returns to scale; that is, doubling K and L, doubles Y

The capital accumulation equation can be re-written as
$K(t) = sY(t) - \delta K(t)$

Where K is shorthand for $\frac{dK(t)}{dt}$, the derivative with respect to time

Incorporating the effective labour term we have:

$$k(t)=\frac{Y(t)}{A(t)L(t)} - \delta \frac{K(t)}{A(t)L(t)} - n \frac{K(t)}{A(t)L(t)} - g \frac{K(t)}{A(t)L(t)}$$

$k(t) = sy(t) - \delta k(t) - nk(t) - gk(t)$

Since the production function $Y(K,AL)$ has constant returns to scale, it can be written as output per effective unit of labour.

$$y(t)=\frac{Y(t)}{A(t)L(t)} = \frac{K(t)^{a} A(t)L(t)^{1-a}}{A(t)L(t)} = \frac{K(t)}{A(t)L(t)} = k(t)$$

Therefore, $y(t)= \frac{K(t)}{A(t)L(t)} = k(t)a$ and

$$y(t)= k(t)^a$$

Since $y(t)= k(t)^a$, we substitute k for y and factor out $k(t)$in the capital accumulation equation we then have

$k(t) = sk(t)-(n+g+\delta)k(t)$ (The key equation of the Solow-Swan model)

where $sk(t)$ is the actual investment per unit of effective labour and $(n+g+\delta)k(t)$is the break even investment (the amount of investment that must be invested to prevent k from declining. The equation implies that $k(t)$ converges to a steady-state value defined by $sk(t)-(n+g+\delta)k(t)$,at which there is neither an increase nor a decrease of capital intensity. The main significance of the model is the dynamics of capital intensity k, the capital stock per unit of effective labour given by the key equation of the Solow-Swan model.

The Solow-Swan growth model was used by Frankhauser and Tol (2005) to model climate change and economic growth. The effect of capital accumulation was isolated by comparing GDP predictions with the direct impacts of climate change. Just as in original Solow-Swan model, saving is an exogenously given fraction of income and technological progress is also exogenous.

The Solow-Swan Model incorporates climate change
The production function

$$Y(t)=\frac{A(t)K^aL^{1-a}}{1+\beta T(t)^2}$$

Where Y is the output, A is the productivity, K is the capital, L the labour, a is production elasticity, T the temperature and t the time. Here, the output is inversely related to temperature (T) which represents climate change which means higher temperature results in lower output. However, this model ignores the importance of human capital in growth and climate change modelling. The capital accumulation equation is specified just as in Solow-Swan without climate change

$$k = s(t)Y(t) - \delta K(t)$$

where s is the savings' rate and $\delta =$ the depreciation rate.

In précis, the Solow-Swan model is a convenient starting point for various extensions in economic growth modelling.

The Ramsey – Cass-Koopmans Growth Model

The Ramsey – Cass – Koopmans (RCK) model is also a neo- classical model of economic growth and is attributed to frank Ramsey (1928), David Cass (1965) and Tjalling Koopmans (1965). The RCK model is an extension of Solow-Swan model and only differs from the Solow-Swan model in the consumption is micro founded; therefore, the saving rate is endogenised. Per se, the saving rate in RCK model may not be constant along the transition to the long-run steady state and the outcome is Pareto optimal, not only as a result of endogenizing savings rate but also as a result of the infinite nature of the planning horizon of the agents. Just like the Solow-Swan model, RCK model begins with Cobb-douglas aggregate production function:

$Y(t) =F(K(t),(A(t)L(t))=K(t)^a(A(t)L(t))^{1-a}$ (Production function)

Where K is capital, L is labour and A is labour-augmenting technology. The quantity of labour is equal to the economy's population which grows as a constant rate n. Similarly, the level of technology grows at a constant rate g.

$k(t)= fk(t) – c – (n+g+\delta)k(t)$ (The key equation of the RCK model)

This equation is the law of motion for capital accumulation in RCK model

Where k = Capital intensity (capital per worker)

k = Change in capital per worker over time $\frac{dk(t)}{dt}$

c = Consumption per worker

$f(k)$= Output per worker

δ = Depreciation rate of capital

The key equation of RCK model states that investment or increase in capital per worker is that part of output which is not consumed, less the rate of depreciation of capital. Thereupon, investment is the same as savings, under the assumption that there is no population growth or increase in technology level. The complete optimisation problem is formulated thus:

$$max\int_0^{\infty} u(c)e^{-vt} \quad \text{(Utility function)}$$

Subject to

$k= k^a – c – (n+g+\delta)k$ (Capital accumulation equation)

bringing in climate change into the Ramsey – Cass – Koopmans growth model Frankhauser and Tol (2005) used the original model structure of DICE by (Nordhaus, 1994) where saving rates are determined endogenously by intertemporal optimisation, and are therefore affected by climate change. Conversely, technical progress is exogenous. The comparison of this specification with the Solow-Swan model provides insights into the extent of the effect of savings. Two endogenous growth specifications can be used to see how the dynamic effects differ if investment decisions also affect human capital accumulation and technical progress.

$$max\int_0^{\infty} u(c,T)e^{(n-p)\,t}\,dt \quad (1)$$

subject to

$$K = F(K, L, T) – cL - \delta(T)K \quad (2)$$

$$L = n(T)L, \qquad L_0 = 1 \quad (3)$$

Where u is utility function, c is the per capita consumption; F, the output; K, the capital, δ the depreciation rate of capital; and ρ the discount rate; L is labour supply, n growth rate of labour supply, starting from an initial, normal level of 1. Growth rate of labour supply 'n' is exogenous and reveals changes in population (p) and labour productivity (x), $n = p + x$, with x an endogenous variable. Climate change is represented by time independent exogenous indicator, T (temperature). The larger the T, the more the impacts of climate change. The effects of climate change can be grouped into four optimising levels:

First, the non-market impacts which is the value of climate and the effect on recreational and environmental assets. The utility function is directly affected by non-market impacts which are assumed to be negative – $\partial u/\partial T = u_T < 0$ (Smith et al., 2001). Secondly, the market impacts which is exemplified in change in agricultural yields in the production function and its net impact is assumed to be negative – $\partial F/\partial T = F_T < 0$. However, some researchers argued that market impacts may be positive at the onset for some regions and that the fall in output is as result of low productivity or damage done by climate change (Mendelsohn and Neumann, 1999 and Tol, 1999). Thirdly, health and mortality impacts are revealed in the widespread of diseases such as malaria, meningitis, cholera, etc. These affect

population growth and subsequently the labour force and productivity negatively – $\partial n/\partial T = nT<0$ (McMichael *et al.*, 2001; Haines *et al.*, 2006 and Dube and Chimbari, 2009). Finally, the impact of climate change on the longevity of capital according to Fankhauser and Tol (2005) is sparsely established in literature. However, it was revealed that a continuously changing climate will necessitate more frequent adjustments in the capital stock, particularly as regards defence expenditures. Ergo, more frequent extreme events will also affect the longevity of capital, leading to an increased speed of capital depreciation – $\partial\delta/\partial T = \delta T>0$. For output which is homogeneous of degree one in labour and capital, we have

$$K = \frac{K}{L}, \quad k = \frac{K}{L} - \frac{K}{L}\frac{L}{L}, \quad f(k) = F(k, 1, T), \quad Lf(k) = F(K, L, T) \tag{4}$$

Combining Equations 2 and 3 gives

$$k = f - c - \delta k - nk. \quad \text{(Capital accumulation equation)} \tag{5}$$

and solving Equation (5) yields:

$$c = -\frac{u_c}{u_{cc}}(f_k - \delta - \rho), \quad \text{(Consumption utility path)} \tag{6}$$

where subscripts represent derivatives. These derived equations (5 and 6) are equations of motion that drive the system. The steady state is defined by $c = k = 0$, which implies that

$$f_k = \delta + \rho, \tag{7}$$

$$c = f - \delta k - nk \tag{8}$$

Looking at the impact of climate change on capital accumulation, the savings rate exogenously fixed to isolate the capital accumulation effect. Savings rate is set at a constant fraction of output, $s = 1 - c/f$, as agents are not allowed to adjust their savings behaviour in response to climate change. Therefore, equation (8) above is written as:

$$\bar{sf} = (\delta - n)k. \tag{9}$$

Which is the steady-state of Solow-Swan model and its total differentiation gives

$$\frac{\partial k}{\partial T} = \frac{k(\delta_T + n_T) - st_T}{\bar{sf}k - \delta - n} \tag{10}$$

The denominator in this expression is negative as the savings function $\bar{sf}(k)$ which is concave is less than the depreciation schedule, $(\delta + n)k$ which is intersects from above at the steady state. This equation (10) reveals that the four channels of climate change impacts identified earlier affect the capital-labour ratio.

Capital accumulation is not affected by non-market impacts $uT < 0$, as climate change is exogenous and thus acts only to rescale utility. Also, market impacts (reduction in output), $fT < 0$, have a negative effect on capital accumulation. Less output means a lower absolute amount devoted to capital accumulation; hence, capital-labour ratio, k, is reduced. Health impacts of climate change, $nT < 0$ reduces the amount of labour available in the steady state and finally, the capital stock reduces more because its depreciation is faster, $\delta T > 0$, ceteris paribus and this reduces the capital-labour ratio.

According to (Fankhauser and Tol, 2005), the effect of climate change on the accumulation of capital is generally ambiguous. Nevertheless, it appears safe to speculate that the effect of capital accumulation will perhaps be negative. Literature puts it forward that health effects is more in vulnerable poor countries. Human health can also be related to growth via its impact on savings. Assuming gross saving per capita (sG) is defined as output minus consumption, the eight equation can be used to derive the equation below:

$$S^G = f - c = (\delta + n)k. \tag{11}$$

Differentiating S^G with respect to T yields

$$\frac{\partial s^G}{\partial T} = (\delta_T + n_T)k + (\delta + n)\frac{\partial k}{\partial T} \quad \text{(Gross savings)} \quad (12)$$

By total differentiation of the equation (7) we have the following expression for $\partial k/\partial T$

which is the impact of climate change on capital accumulation.

$$\frac{\partial k}{\partial T} = \frac{\delta_T - fkT}{f_{kk}} \quad (13)$$

Substituting equation (13) into equation (12), we have

$$\frac{\partial s^G}{\partial T} = \delta_T\left(k + \frac{\delta + n}{fkk}\right) + {}_{nTk} - \frac{(\delta + n)\, fk_T}{fkk} \quad \text{Gross savings} \quad (14)$$

Where climate change affects marginal product of capital ($f_{kT} < 0$) resulting in a decline in capital stock ($f_{kk} < 0$). Savings is also affected negatively ($n_T < 0$) and capital depreciation effect is higher ($\delta_T > 0$). Therefore, this equation shows that four climate change impacts of the model affect saving, investment and hence, output in the following manner: savings effect is undetermined because the capital depreciation effect, $\delta_T > 0$, is to some extent positive. It is believed that agents save more to make up for accelerated capital depreciation and according to theory this could make amends for other negative effects of climate change on saving.

To look at net savings, $s^N = nk$, equation (14) is simplified thus

$$\frac{\partial s^N}{\partial T} = \frac{nTk}{} + \frac{n}{f_{kk}}\frac{\delta_T - f_{kt}}{} < 0 \quad \text{(Net savings)} \quad (15)$$

Equation (15) expresses that savers will not save extra to compensate for all negative effects, as the equation is explicitly negative. Another point is lower discount rate leads to higher savings in the face of climate change. However, climate change will cause a more negative reaction at this higher savings level. Moreover, marginal productivity of capital is lower when capital is much and investment can be reduced with smaller effect of productivity. This can be expressed mathematically by substituting equation (7) into equation (12).

$$\frac{\partial s^G}{\partial T} = (\delta_T + n_T)\, k + (f_k - \rho + n)\frac{\partial k}{\partial T} \quad (16)$$

The lower the ρ (discount rate) the more negative, the expression becomes.

The Mankiw – Romer – Weil Growth Model

This growth model is accredited to Nicholas Gregory Mankiw, David Romer, and David Weil in 1992. The threesome created a human capital augmented version of the Solow-Swan model that has the ability to explain the failure of international investment to flow into poor countries. This model reveals lower output and the marginal product of capital for poor economies because of low human capital base when compared to rich economies. The production function here is also similar to Solow-Swan model. The difference is the human capital factor which is introduced into the model. This addition, basically is due to the fact

that human capital will help a long way to model not only education human capital but also human health capital if need be.

$$Y(t) = F(K(t), H(t)\,(A(t)L(t)) = K(t)^{a}\,H(t)^{\beta}\,(A(t)\,L(t))^{1-a-\beta}$$

Where $H(t)$ = Stock of human capital which depreciates at the same rate as physical capital this growth theory assumes the same function of accumulation for both physical capital and human capital. Meanwhile in Solow-Swan, a fraction of the income, $sY(t)$ is saved each period; oppositely, in this case the fraction is split up and invested partly in physical capital and partly in human capital. Hence, we have $s = s_k + s_H$ resulting into two basic dynamic equations in Makiw-Romer-Weil growth model.

$$k = s_k k^{a} h^{\beta} - (n + g + \delta)k \qquad \text{(Physical capital accumulation equation)}$$

$$h = s_H k^{a} h^{\beta} - (n + g + \delta)h \qquad \text{(Human capital accumulation equation)}$$

The steady-state growth path is determined by $k = h = 0$. This implies that, both physical and human capital accumulation must be equal to zero at long-run equilibrium.

$$s_k k^{a} h^{\beta} - (n + g + \delta)k = 0$$

$$s_H k^{a} h^{\beta} - (n + g + \delta)h = 0$$

Solving for the steady-state level of k and y yields:

$$k = \left\{\frac{s_K^{1-\beta} s_H^{\beta}}{n + g + \delta}\right\}^{\frac{1}{1-a-\beta}}$$

$$k = \left\{\frac{s_K^{a} s_H^{1-a}}{n + g + \delta}\right\}^{\frac{1}{1-a-\beta}}$$

In the steady state, $y^{*} = (k^{*})^{a}\,(h^{*})^{\beta}$

As stated by Mankiw *et al.* (1992) and Fankhauser and Tol (2005), the Mankiw-Romer–Weil growth model reveals that while technological progress is exogenous, in contrast, saving is also given. The fundamental distinction of this model is that in addition to physical capital, the model also takes account of human capital. This model shows how climate change affects human capital accumulation. The output elasticities of physical and human capital are assumed to be the same and their sum equals to the output elasticity of physical capital in the Ramsey – Cass – Koopmans model to arrive at the Mankiw – Romer – Weil specification. Also, it is assumed that in the base year, physical capital and human capital are of equal size, and half of the physical capital in the Ramsey – Cass – Koopmans model. Here, the savings rate is the same as the savings rate in the Solow-Swan model, aside from spreading equally over investments in physical and human capital. The total factors productivity is used to calibrate the output of the Mankiw – Romer –Weil model to the output of the Solow-Swan model for all periods.

Mankiw – Romer – Weil Model with climate change

$$Y(t) = \frac{A(t)K^{a}H^{a}L^{1-2a}}{1 + \beta T(t)^{2}}$$

Where Y is the output, A the productivity, K the physical, H is human capital, L the labour, T the temperature, a is production elasticity and t the time.

$$K = s(t)Y(t) - \delta K(t)$$

$$H = s(t)Y(t) - \delta K(t)$$

Here, the savings rate follows the original Solow-Swan model or Ramsey – Cass Koopmans model. At each point in time in Mankiw – Romer – Weil model, productivity is set so that output is the same as in the Solow-Swan; however, productivity is affected as a result of depreciation in human capital accumulation due to the consequences of climate change; hence, the inverse relationship between $Y(t)$ and T in the production function.

Empirical Models

This research study specified its models by adopting the relevant variables expounded in the conceptual framework. It follows that anthropogenic carbon dioxide emissions can cause climate change; climate change impairs human health both directly and indirectly and impaired human health in turn results in low productivity of labour and ultimately decline in economic growth. Poor health (poor physical and mental capabilities) reduces workers' productivity, as they both physically and mentally destabilised.

The health damage of climate change induced by air pollution causes economic loss (market impact) and also reduces people's happiness (non-market impact). The importance of the link from CO_2 to climate change; from climate change to human health and from human health to labour productivity and economic growth cannot overemphasised. Hence, we specify the different models below according to the conceptual framework specified.

Carbon dioxide and Climate Change Variation

Carbon dioxide is the primary greenhouse gas emitted through human activities and has been identified from the background to this study as the major cause of global warming which changes climate patterns, while variation in climate change is the deviation in long-term continuous changes in average condition of the climate. According to Hansen *et al.* (2011) the standard deviation of local surface temperature measures the typical magnitude of year-to-year variations of mean surface temperature. Hence, the study would have employed the standard deviation of the mean temperature in addressing this objective. However, Engle (2001) posited a preference for GARCH variance to correct for the deficiencies of least squares like assumption of homoscedasticity. Therefore, the data on variation in temperature was generated from the mean surface temperature data using the standard tools of autoregressive conditional heteroscedasticity (ARCH) and generalized autoregressive conditional heteroscedasticity (GARCH).

The conceptual framework showed among others, two main variables of interest for this particular analysis: Carbon dioxide and climate change variables, as literature has it that CO_2 is a major compound that influences climate change because of its prevalence over other GHG and the decomposition of other GHG into CO_2 (McMichael, 2009 and Odjugo, 2010a). Thus, we measure CO_2 and climate change variation with CO_2 emissions in kilo tonnes and GARCH variance temperature series, respectively.

Therefore, Equation 3.1.4 below is the empirical model for the second objective that accounts for the extent at which CO_2 emissions explain variation in climate change in Nigeria. This model makes use of both the global and the local CO_2 in explaining variation in climate change in Nigeria.

Drawing from the conceptual framework, the implicit form of the model is specified as;

$$LMTEMPV = f\ (LCO_2, GCO_2) \quad (3.1.1)$$

This equation states that *LMTEMPV* is a function of LCO_2, and GCO_2, which means the value of *LMTEMPV* is determined by the values of LCO_2, GCO_2.

Grossman and Krueger (1991) posited that growth leads to more air pollution at the initial stage which implies more CO_2 and more warming of the earth's surface temperature. Hence, we add RGDP to the equation above for the measurement of growth. Therefore, we assume that the economy is at the initial stage of growth. Hence, we have the model extended below:

$$LMTEMPV = f(LCO_2, GCO_2, RGDP) \quad (3.1.2)$$

Further empirical literature also establishes that there are negative correlations between rainfall and temperature (Cong and Brady, 2012); therefore, we add rainfall variable to our model and we have:

$$IMTEMPV = f\ (LCO_2, GCO_2, RGDP, LMRFALL) \quad (3.1.3)$$

The econometric representation of Equation 3.1.3 which is the main implicit model for the second objective of this study is specified thus:

$$LMTEMPV = \beta_0 + \beta_1\ LCO2 + \beta_2\,\mathrm{GCO2} + \beta_3\ RGDP + \beta_4\ LMRFALL + u \quad (3.1.4)$$

Where;

LMTEPTV = Variation in local mean temperature
LCO2 = Local carbon dioxide emissions
GCO2 = Global carbon dioxide emissions.
RGDP = Real gross domestic product
LMRFALL = Local mean rainfall
u = Error term

A priori expectations: $\beta_1>0,\ \beta_2 > 0,\ \beta_3 > 0,\ \beta_4 < 0$

Long-run Effect of Climate Change on Human Health

.Climate change is represented by the global and local mean temperature, while human health is measured by life expectancy variable. Other relevant variables that explain human health are added to the model to the model. For instance, Lleras-Muney (2005) put forward that education is an important factor that influence human health, as they found that each year of education increases life expectancy in the United States. This means spending on education increases people's awareness and decisions on healthy lifestyles; also, people with higher level of education are most likely to get better income to attend to health issues. Furthermore, Gani (2009) posited that spending on health also enhances human health – spending on health care facilities improves human health. Therefore, we use 'social community services' data to proxy for spending on education and health (human capital spending) as a determinant of human health.

Also, Pritchett and Summers (1996) and Dollar (2001) argued that income is a very important determinant of human health and here, we use RGDP to measure income. Furthermore, Thornton (2002) argued that externalities as a result of urbanization are

important determinants of health. The positive externalities could be in the form of improved livelihood and better access to health-improving infrastructure and facilities, the negative ones could be pollution; hence, we use urban population growth and carbon dioxide emissions to measure urbanization and pollution respectively. Also, Fayissa and Gutema (2005) and Haliciglu (2010) posit that food availability goes a long way in explaining the status of human health; therefore we include in this model, food availability variable (food production index).

The implicit form of the model:

$$LEXP = f\,(GMTEMP, LMTEMP, RGDP, LCO2, URBAN, HCS, FOODP) \quad (3.2.1)$$

For the long-run effect of climate change on human health; we specify the general VAR model below

$$[LEXP_1] = [c_1] + [a_{11}\ \ a_{12}...a_{17}]\begin{pmatrix} GMTEMP_{t-1} \\ LMTEMP_{t-1} \\ RGDP_{t-1} \\ GCO2_{t-1} \\ HCS_{t-1} \\ URBAN_{t-1} \\ FOODP_{t-1} \end{pmatrix} + ... + [a_{11}\ a_{12}...a_{17}]\begin{pmatrix} GMTEMP_{t-P} \\ LMTEMP_{t-P} \\ RGDP_{t-P} \\ GCO2_{t-P} \\ HCS_{t-P} \\ URBAN_{t-P} \\ FOODP_{t-P} \end{pmatrix} + [e_{It}] \quad (3.2.2)$$

Where

LEXP	= Life expectancy
GMTEMP	= Global mean temperature
LMTEMP	= Local mean temperature
RGDP	= Real gross domestic product
GCO2	= Global carbon dioxide emissions
URBAN	= Urbanization rate
HCS	= Human capital spending
FOODP	= Food production index
u	= Error term

Climate Change, Human Health and Economic Growth

Equations 3.3.1 to 3.3.6 are for the research objective of analysing the dynamic relationship among climate change, human health and economic growth in Nigeria and it follows both the conceptual framework and Mankiw – Romer – Weil growth model which allows for the inclusion of human capital. The variables of interest here are *RGDP*, *LEXP* and *GMTEMP/LMTEMP* and since, the variables are dynamic, they are respectively dependent variables; hence, we specify the implicit function below.

The implicit representation:

$$RGDP = f\,(LEXP, GMTEMP) \quad (3.3.1)$$
$$LEXP = f\,(RGDP, GMTEMP) \quad (3.3.2)$$
$$GMTEMP = f\,(RGDP, LEXP) \quad (3.3.3)$$
$$RGDP = f\,(LEXP, LMTEMP) \quad (3.3.4)$$
$$LEXP = f\,(RGDP, LMTEMP) \quad (3.3.5)$$
$$LMTEMP = f\,(RGDP, LEXP) \quad (3.3.6)$$

For the dynamic interaction among climate change, human health and economic growth; we specify the general VAR model for both the GMTEMP and LMTEMP:

$$\begin{pmatrix} RGDP_t \\ LEXP_t \\ GMTEMP_t \end{pmatrix} = \begin{pmatrix} c_1 \\ c_2 \\ c_3 \end{pmatrix} + \begin{bmatrix} a_{11}\ a_{12}\ a_{13} \\ a_{21}\ a_{22}\ a_{23} \\ a_{31}\ a_{32}\ a_{33} \end{bmatrix} \begin{pmatrix} RGDP_{t-1} \\ LEXP_{t-1} \\ GMTEMP_{t-1} \end{pmatrix} + \ldots + \begin{bmatrix} a_{11}\ a_{12}\ a_{13} \\ a_{21}\ a_{22}\ a_{23} \\ a_{31}\ a_{32}\ a_{33} \end{bmatrix} \begin{pmatrix} RGDP_{t-p} \\ LEXP_{t-p} \\ GMTEMP_{t-p} \end{pmatrix} + \begin{pmatrix} e_{1t} \\ e_{2t} \\ e_{3t} \end{pmatrix} \quad (3.3.7)$$

$$\begin{pmatrix} RGDP_t \\ LEXP_t \\ GMTEMP_t \end{pmatrix} = \begin{pmatrix} c_1 \\ c_2 \\ c_3 \end{pmatrix} + \begin{bmatrix} a_{11}\ a_{12}\ a_{13} \\ a_{21}\ a_{22}\ a_{23} \\ a_{31}\ a_{32}\ a_{33} \end{bmatrix} \begin{pmatrix} RGDP_{t-1} \\ LEXP_{t-1} \\ GMTEMP_{t-1} \end{pmatrix} + \ldots + \begin{bmatrix} a_{11}\ a_{12}\ a_{13} \\ a_{21}\ a_{22}\ a_{23} \\ a_{31}\ a_{32}\ a_{33} \end{bmatrix} \begin{pmatrix} RGDP_{t-p} \\ LEXP_{t-p} \\ GMTEMP_{t-p} \end{pmatrix} + \begin{pmatrix} e_{1t} \\ e_{2t} \\ e_{3t} \end{pmatrix} \quad (3.3.8)$$

Estimation Techniques

Research objectives with respect to the extent to which carbon dioxide emissions explain variation in climate change in Nigeria; the long-run effect of climate change on human health in Nigeria; and the dynamic relationship among climate change, human health and economic growth in Nigeria were expressed in equations and were achieved by the use of econometric techniques.

RESULTS AND DISCUSSION

Presentation and Interpretation of VECM Result for RGDP, LEXP and GMTEMP

Table 3
VEC Long-Run Equilibrium Relations for RGDP, LEXP and GMTEMP

Cointegration Equation	
RGDP(-1)	1.000000
LEXP(-1)	-13.34256 (3.03596) [-4.39484]
GMTEMP(-1)	24.85423 (9.27924) [2.67848]
C	-25.02578

The first part of the result is the cointegrating equation and it is summarised thus:

RGDPt-1 = 25.02578 + 13.34256LEXPt-1 - 24.85423GMTEMPt-1

This is the long-run equilibrium relationship for Nigeria in the periods 1980 to 2025. The coefficients were found to be significant and could be interpreted as long-run elasticity. This means the degree of responsiveness of economic growth to improvement in human health is more than proportionate and so, is the negative impact of global climate change on economic growth in Nigeria.

In précis, increase in economic growth is related to improvement in human health and decrease in economic growth is also related to increase in global climate change in the long run. The short-run dynamics in Table (5.15) is the error correction section of the result and the cointegration equation relates economic growth (RGDP) to human health (LEXP) and global climate change (GMTEMP). The error correction coefficient (0.094) of the cointegrating equation in this VEC result is positive and insignificant with a statistic of 0.55. This implies that there is no convergence of the short-run disequilibrium to its long-run equilibrium. The result also showed a negative error correction coefficient of roughly 4

percent for global climate change, suggesting convergence; however a long-run equilibrium was not established for this particular equation.

This result suggests that the variables with the significant error correction coefficients might not have dynamic relationship with economic growth whose insignificant error correction term also suggests that it might be an exogenous variable. This could be partially confirmed, as the Eviews User Guide 7 revealed that when a lag length of zero is added to the lag length selection report by the package, it means there is an exogenous variable in the model; however, it is not identified.

Table 4
VEC Short-Run Error Correction Relations for RGDP, LEXP and GMTEMP

Variables	D(RGDP)	D(LEXP)	D(GMTEMP)
CointEq1	0.094361 (0.17247) [0.54710]	0.000467 (0.00023) [2.05626]	-0.035052** (0.01577) [-2.22253]
D(RGDP(-1))	-0.119279 (0.25087) [-0.47546]	-0.000595 (0.00033) [-1.80206]	0.062337** (0.02294) [2.71740]
D(LEXP(-1))	83.12281 (132.753) [0.62614]	2.947892** (0.17477) [16.8669]	14.78432 (12.1391) [1.21791]
C	0.021329 (0.02967) [0.71892]	0.000109 (3.9E-05) [2.78852]	-0.002233 (0.00271) [-0.82296]
R-squared	0.322968	0.999746	0.568230
Adj. R-squared	-0.059703	0.999602	0.324186

(*) = Standard error; [*] = t statistic; ** = 5%.

Therefore, to further verify the direction of movement in this supposed dynamic relationship between climate change, human health and economic growth, we carried out the Granger causality test to authenticate our VECM report, as posited by Engle and Granger (1987). The result showed that there was no link between economic growth and human health; also, there was no link between human health and global climate change; however, a unidirectional causality exists between climate change and human health and this is significant at 95 percent confidence interval. Meanwhile, the fact that there is no directional link, does not actually signify that there is no ‘indirectional’ link. For instance, there is an indirect link between economic growth and human health, and also between human health and global climate change. Ipso facto, no unidirectional link might suggest that there is an indirect relationship between the variables and this unobserved indirect link might be ‘national development strategies’, e.g. good employment means good provision for health. Also, good health means better productivity that might result in increased emission of CO2 that causes climate change. Hence, we still looked at the impulse response dynamics of this result.

Table 5
Pairwise Granger Causality Tests for RGDP, LEXP and GMTEMP

Null Hypothesis	F-Statistic	P Value
LEXP does not Granger Cause RGDP	1.87606	0.1415
GMTEMP does not Granger Cause LEXP	3.01888	0.0338
LEXP does not Granger Cause GMTEMP	1.77001	0.1619

Identification of weakly exogenous variable in VECM

Masih and Masih (1996) gave a straight forward method of identification of weakly exogenous variable in VECM; they asserted that the endogeneity of a dependent variable is evidenced through the significance of the t statistic and the F statistic of the lagged error term. Since the t statistic of the coefficient of economic growth is insignificant amongst the three variables and also its F statistic, according to the short-run error correction result in the Table, it can be treated as exogenous; hence, we re-specified our model and the result in the Table was obtained.

Table 6
VEC Short-Run Error Correction Relations for LEXP and GMTEMP

Cointegrating Equation:		
LEX		
GEMTEMP(-1)	-2.119976 (0.65847) [-3.21957]	
C	1.807145	
Error Correction	D(LEXP)	D(GMTEMP)
CointEq1	-0.005463 ** (0.00188) [-2.90497]	0.231722 (0.14372) [1.61228]
D(LEXP(-1))	2.924428 (0.15889) [18.4059]``	12.35226 (12.1431) [1.01722]
D(LEXP(-2))	-3.279671** (0.43927) [-7.46623]	22.58672 (33.8203) [0.66785]
D(LEXP(-3))	1.615877** (0.44252) [3.65155]	22.58672 (33.8203) [-0.63166]
D(LEXP(-4))	-0.270514 (0.44252) [3.65155]	-7.874362 (12.4662) [-0.66785]
D(GMTEMP(-1))	-0.006705 (0.00388) [-1.72797]	-0.242201 (0.29656) [-0.81671]
D(GMTEMP(-2))	-0.007718** (0.00345) [-2.23471]	-0.196670 (0.26394) [-0.74512]

D(GMTEMP(-3))	-0.009046** (0.00312) [-2.89888]	-0.089346 (0.26394) [-0.74512]
D(GMTEMP(-4))	-0.005826** (0.00089) [-2.33260]	0.142290 (0.19088) [0.74543]
C	-0.002824** (0.00089) [-3.17456]	0.121542 (0.06799) [1.78771]
RGDP	0.00288** (8.9E-05) [3.21893]	-0.011921 (0.00684) [-1.74308]
Summary Statistic		
R-squared	0.999716	0.416690
Adj.R-squared	0.999607	0.192341

This result showed that there is a long-run relationship between human health and global climate change and its short-run adjustment coefficient—the error correction coefficient of 0.5 percent is negative and significant, suggesting that the speed of adjustment of human health to its long-run equilibrium is abysmally slow, as only 0.5 percent disequilibrium is corrected every year by human health. This means it will take a whole lot of 200 years before convergence to equilibrium can be achieved. This result agrees with previous studies though they did not adopt this econometric method, as Odjugo (2010a) quoted Ayoade (2003) who asserted that variations in climate that occurs over a period of 100 to 150 years may not qualify as climate change. Therefore, this study is authenticated a climate change study by this result. Generally, climate change and its consequences on human health are of a long-run phenomenon, as the consequences of climate change on human health that are observed now are as a result of changes in mean climate for past decades of years or longer caused by anthropogenic forcings that are definitely not about to be halted, especially in the developing world. This might suggest why virtually all the studies recommended adaptation and mitigation. This means ‘adaptation’ to the consequences of climate change because the world would keep pursuing growth at any rate and ‘mitigation’ by swoping to the use of renewable energy because it is obvious that the environment cannot return itself to being green in the presence of anthropogenic forcings which are off-roots in the pursuit of economic growth. Hence, conscious efforts by nations of the world, especially the highest emitters are needed to return the world to a green globe.

Forecast Error Variance Decomposition for LEXP and GMTEMP

Table 7
Error Variance Decomposition for RGDP, LEXP and GMTEMP

	Variance Decomposition 1		Variance Decomposition 2	
Period	**LEXP (1)**	**GMTEMP (1)**	**LEXP (2)**	**GMTEMP (2)**
1.	100.0000	0.000000	0.001056	99.99894
2.	99.11100	0.88898	0.096149	99.90385
3.	97.16866	2.831345	1.572496	98.42750
4.	94.75214	5.247863	5.216122	94.78388
5.	91.66706	8.332941	9.819242	90.18076
6.	87.93330	12.06670	14.64254	85.35746
7.	83.70625	16.29375	18.46704	81.53296
8.	79.17823	20.82177	20.55234	79.44766
9.	74.52527	25.47473	21.20982	78.79018
10.	69.90765	30.09235	21.16914	78.83086

In the Table 7, the second period horizon of the first segment showed that about 1 percent of variance in human health was accounted for by global climate change shocks and the rest 99 percent variance in human health was accounted for by human health shocks in Nigeria and this means in the short run, changes in human health are explained by innovations in human health shocks themselves while global climate change has little or no predictive power over human health in Nigeria. Taking the second period horizon in the second segment, the results showed that about 0 percent of variance in global climate change was accounted for by human health shocks and 100 percent of variance in global climate change was accounted for by innovations in global climate change shocks in Nigeria. This suggests that changes in global climate change are explained by innovations in global climate change shocks; ergo, human health has no predictive power over global climate change in Nigeria.

CONCLUSION AND RECOMMENDATIONS

This result showed that there is a long-run relationship between human health and global climate change and its short-run adjustment coefficient—the error correction coefficient of 0.5 percent is negative and significant, suggesting that the speed of adjustment of human health to its long-run equilibrium is abysmally slow, as only 0.5 percent disequilibrium is corrected every year by human health. This means it will take a whole lot of 200 years before convergence to equilibrium can be achieved

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