Dynamics of Climate Change, Human Health and Economic Growth: Evidence from Nigeria

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Abstract

This paper examines the dynamic relationship between climate change, human health and economic growth from 1960 to 2015 employing the structural VAR approach. Restrictions are imposed according to climate modified Mankiw-Romer-Weil theory. The result of the impulse response function reveals that economic growth, climate change and human health are strong predictors of themselves over a long period in both global and local climate models. However, global climate predicts human health and economic growth better than local climate. Variance decomposition shows that approximately 0.3% and 62.9% of the variance in human health are accounted for by economic growth and global climate shocks respectively, compared to 6.7% for local climate shocks. Also, 52.9% variance in local climate in Nigeria is accounted for by economic growth shocks, and only 3.0% and 0.3% variance in local and global climate change are accounted for by human health, respectively. This study concludes that climate change shocks are associated with poor human health status in Nigeria while economic growth shocks have a mild effect on human health status and these reduce man hours, labour productivity and economic growth. It is therefore necessary to simultaneously implement both mitigation and country-specific adaptation strategies as well as monitor the outcomes of the strategies.

Keywords: Climate change dynamics, Economic growth, Human health, Structural restrictions

Introduction

Despite the fact that the blueprint for medium and long-term development strategies clearly indicates that Nigeria needs to optimize her human and natural resource potentials, the probable consequences of climate change on growth have made this unachievable. Likewise, the scheme for the country's Vision 20:2020 is specifically aimed at raising gross domestic product (GDP) and per capita income targets to not less than $900 billion and $4000 per annum respectively by 2020 (UNDP, 2009) while the Economic Recovery Growth Plan (ERGP) targets a GDP growth of seven percent. The relationship between anthropogenic carbon dioxide (CO_2) emissions, climate change and human health is a strong inhibitor to this vision. Accordingly, the 13th goal of sustainable development (climate action) suggests urgent action to combat climate change and its consequences. Nevertheless, climate change remains a global threat to both lives and livelihoods, especially in Africa, which has the poorest and the most vulnerable population.

Research studies have established the atmospheric dominance and persistence of CO_2, among other greenhouse gases (GHGs), as the major cause of the global warming effect which changes the climate (Odjugo, 2010; EPA, 2013; 2017). Studies have equally affirmed that climate change has negative impacts on human health, both directly and indirectly (Haines, 2006; Rettner, 2011) and these impacts range from ill health to death which, in effect, lower labour productivity and ultimately hinder economic growth (Aghion et al., 2010; Peykarjou et al., 2011). Meanwhile, the ERGP is mostly belaboured with tackling desertification; hence, little or no attention is being paid to other diverse pathways in which climate change affects human health and economic growth.

There is no doubt that Nigeria, which reflects a sub-optimal economy, is susceptible to the consequences of climate change. Moreover, studies have shown that no meaningful development goals can be achieved as long as anthropogenic climate change is not controlled (McMichael, 2009 and Mawle, 2010). In fact, a country with a high incidence and prevalence of diseases has a GDP that is five times lower than that of a country that does not have these negative incidences (Gallup and Sachs, 2001). Therefore, to achieve any meaningful development goals in any economy, reducing the impact of climate change on human health is a requisite condition.

Prior studies were mostly medical and meteorological and explored the relationship between climate change and human health status. In addition, they mainly used the descriptive statistics method of analysis (see Kovats et al., 2003; van Lieshout et al., 2004; Haines et al., 2006; Eriksson et al., 2008; Nwoke et al., 2009; Hutton, 2011; Paci, 2014). Also, there are studies on human health and economic growth (see Bloom et al., 2004; Bloom and Canning, 2008; Peykarjou et al., 2011; Ogungbenle et al., 2013; Boachie, 2015). Researchers have also investigated the relationship between climate change and economic growth (Fankhauser and Tol, 2005; Dell et al., 2008; Mendelsohn , 2009; Rahman et al., 2009; Roson and van der Mensbrugghe, 2010; Elshennawy et al., 2016). However, extant studies that have looked into the dynamic relationship among these tripartite variables — climate change, human health and economic growth[1] — are not only few and inconclusive both globally and in Nigeria,[2] but are also mostly cross-country analyses, which might not account for country-specific peculiarities, especially for a country like Nigeria. Thus, it becomes imperative to carry out a critical analysis of the dynamic relationship between climate change, human health and economic growth in Nigeria.

Furthermore, this study clearly departs from studies that adopt descriptive statistics only, which are tagged anecdotal since they lack rigorous methodical controls, or studies which employ climate models which predict changes in climate. It equally departs from computable general equilibrium (CGE) models which rely on wage/income (hedonics) to infer climate values. Though CGE models are economic models, they do

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[1] Ikefuji et al., 2012.

[2] For instance, studies on Europe revealed that the old are more vulnerable to health hazard of climate change, contrariwise, in India, the impact of climate change was found to be more extensive on children between the ages of zero and fourteen years (Haines et al., 2006; Mandal, 2008). Equally, some studies have it that the global effect of climate change is little while other studies argue otherwise (Mendelsohn, 2009; Eboli et al., 2009; Roson and van der Mensbrugghe, 2010; Woodward et al., 1998; Hardee and Mutunga, 2009).

not empirically achieve the expected result in environmental reviews, as they generate incorrect forecast. Moreover, the economic theory underlying CGE models is controversial and its techniques are defective for dynamic analysis (see Ackerman et al. 2001). Hence, this study critically and comparatively analyses the dynamic relationship between climate change, human health and economic growth in Nigeria by employing the Structural Vector Autoregressive (SVAR) model of analysis introduced by Sims (1986) and appropriate for dynamic analysis (Lütkepohl, 2005). The choice of SVAR lies in that it allows the use of economic theory to transform the reduced form VAR model into structural equations which permit the estimation of parameters in contemporaneous structural restrictions.

The next section of this paper is structured to review past literature on climate change, human health and economic growth while third section unveils the research method. The results and discussion of findings follow in the subsequent section while the last section contains the recommendations and concluding remarks.

Review of Empirical Literature

There is a consensus from literature that climate change has negative consequences and poor countries are the most vulnerable to these impacts. Existing studies on climate change have been mostly medical and meteorological and basically adopted descriptive statistics analyses (Haines et al., 2006; Luber and Hess, 2007; Bambaíge et al., 2008; Eriksson, 2008; Nwoke et al., 2009; McMichael, 2009; Hutton, 2011). A few studies adopted climate models (van Lieshout et al., 2004; Rahman et al., 2009) and others employed CGE models — costs-benefits analysis (Zhai, 2009; Eboli et al., 2009; Bezabih et al., 2010; Roson and van der Mensbrugghe, 2012) which do not empirically achieve the expected result in environmental reviews (Ackerman et al., 2001). Furthermore, three quarters of the existing studies are cross-country (see Table 1) and may not account for country-specific peculiarities, as some vital specific facts can be downplayed in cross-country studies (Haines et al., 2006; Mandal, 2008). Also, the studies by Kelly and Adger (2000) and Räisänen, (2006) reveal that global climate models do not give a representative description of local climate, suggesting that local climate might have different properties.

The reviewed studies obviously show that there are studies on 'climate change and human health', on 'human health and economic growth' and also on 'climate change and economic growth'. However, studies that put together climate change, human health and economic growth in a tripartite dynamic framework are few, hence, the only literature reviewed are Rosenberg et al. (2000), Richardson et al. (2009) and Ikefuji et al. (2012). Also, the review shows that their findings are inconclusive, as there is controversy on the extent of the effect of climate change on different regions. For these basic reasons, this study analyses the extent to which climate change (global and local), directly and indirectly, affects human health and productivity of labour, and consequently, economic growth in Nigeria. This is with a view to prescribing relevant and effective policies. See Table 1 for a summary of findings from the literature review.

Table 1: Summary of Literature Review

Titles	Authors	Field/Methodology	Findings
Climate change and human health status	Kovats et al. (2003), van Lieshout et al. (2004), Haines et al. (2006), Bambaíge et al. (2008)*, Eriksson (2008), McMichael (2009), Haines et al (2009), Hutton (2011), Paci (2014), Franchini and Mannucci (2015)	Medicine/ Descriptive statistics	Climate change has negative effects on human health. Using CGE, Roson and Sartori found that only developing countries located in tropical regions will bear these negative impacts.
	Luber and Hess (2007)*, Nwoke et al. (2009)	Environmental and Biological Sciences/ Descriptive statistics	
	Eke and Onafalujo (2012)*, Roson and Sartori (2016)	Economics/ Descriptive and econometrics analysis (Ordinary Least Squares, Integrated Assessment and CGE)	
Human health and economic growth	Barro (1996), Bhargava et al. (2001), Bloom et al. (2004), Mojtahed and Javadipour (2006), Soukiazis and Cravo (2007), Bloom and	Economics/ Mostly panel data Zhai (2009) analysis	Human health engenders productivity and vice versa.

Titles	Authors	Field/Methodology	Findings
	Canning (2008), Peykarjou et al. (2011), Ogungbenle et al. (2013)*, Boachie (2015)		
Climate change and economic growth	Fankhauser and Tol (2005), Dell et al. (2008), Mendelsohn (2009), Zhai (2009)*, Rahman et al. (2009)*, Bezabih et al (2010)*, Roson and van der Mensbrugghe (2012), Tol (2012), Elshennawy et al. (2016)[	Economics/climate /models/Descriptive and Econometrics analyses (Dynamic Integrated-Economy Model[a] (DICE) simulations, panel data, CGE, General Circulation Model (GCM), sample statistics, Bayesian updating, and vote counting[b]	None green growth is the reason for climate change and climate change has a negative effect on growth.
Climate change, human health and economic growth	Rosenberg et al. (2000)*, Richardson et al. (2009)[c], Ikefuji et al. (2012)	Econometrics/descriptive statistics/ Economics (Tobit specification and Ordinary Least Squares; DICE simulations)	Regions respond differently to climate change based on the characteristics and geographical location of the regions

* Country specific study

[a] An integrated assessment model is a scientific model used in the environmental sciences for environmental policy analysis.

[b] The last three were used by Tol (2012) comparatively.

[c] Richardson et al. (2009) is a medical literature.

Research Method

The links between greenhouse gases (carbon dioxide) and climate change; and also, climate change and human health have been established in literature (O'Connor et al., 2008 and Ikefuji et al., 2012). Nevertheless, the greenhouse effect is not the only environmental effect. Producers and consumers also generate dirt that enter into the atmosphere as sulphur dioxide (aerosols), which absorb sunlight from the earth, resulting in a cooling effect referred to as local dimming. Although, the warming of the earth by CO_2 and the cooling effect of aerosols are opposite effects, and one would expect the production of more aerosols to reduce global warming, the fact is aerosols do not counter global warming. Aerosols only have local effect, which implies that local climate[3] is different from global climate.[4] Hence, this research employs both local and global data for climate change since global climate models do not characterise local climate.

Equations (1) to (2) capture the dynamic relationship between climate change, human health and economic growth in Nigeria and they follow the Mankiw-Romer-Weil growth model which allows for the inclusion of human capital (human health) and temperature (climate change). The original Mankiw-Romer-Weil (1992) is stated as:

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

where:

Y = output

K = physical capital

H = human capital

AL = effective labour

The variables of interest here are Y and H. This growth theory assumes the same function of accumulation for both physical and human capital. However, productivity is affected by depreciation in human capital accumulation due to the consequences of climate change, hence, the climate modified Mankiw-Romer-Weil production function is specified below showing inverse relationship between Y and T (temperature) which measures climate change:

$$Y(t) = \frac{A(t)K^{\alpha}H^{\beta}L^{1-\alpha-\beta}}{1+\beta T(t)^2}$$ (See Fankhauser and Tol, 2005)

Given that the variables are dynamic, they are respectively dependent variables. We therefore specify an implicit VAR model:

$$RGDP_t = f(RGDP_{t-i} + MT_{t-i} + LXP_{t-i})$$

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[3] Average atmospheric temperature of a specific country or region.

[4] Average atmospheric temperature of earth's atmosphere.

$$MT_t = f(RGDP_t + RGDP_{t-i} + MT_{t-i} + LXP_{t-i}) \tag{1}$$

$$LXP_t = f(RGDP_t + MT_t + RGDP_{t-i} + MT_{t-i} + LXP_{t-i})$$

where:

$RGDP$ = Real gross domestic product (measures economic growth)[5]

LXP = Life expectancy (measures human health)[6]

MT = Mean temperature (measures climate change)[7]

Structural VAR specification takes the simple form below:

$$\begin{aligned}
RGDP_t &= \varphi^1_{11} RGDP_{t-1} + \varphi^1_{12} MT_{t-1} + \varphi^1_{13} LXP_{t-1} + \varepsilon_{1t} \\
MT_t &= \varphi^1_{21} RGDP_{t-1} + \varphi^1_{22} MT_{t-1} + \varphi^1_{23} LXP_{t-1} + \varphi^0_{21} RGDP_t + \varepsilon_{2t} \\
LXP_t &= \varphi^1_{31} RGDP_{t-1} + \varphi^1_{32} MT_{t-1} + \varphi^1_{33} LXP_{t-1} + \varphi^0_{31} RGDP_t + \varphi^0_{32} MT_t + \varepsilon_{3t}
\end{aligned} \tag{2}$$

$$\begin{aligned}
RGDP_t &= \varphi^1_{11} RGDP_{t-1} + \varphi^1_{12} MT_{t-1} + \varphi^1_{13} LXP_{t-1} + \varepsilon_{1t} \\
-\varphi^0_{21} RGDP_t + MT_t &= \varphi^1_{21} RGDP_{t-1} + \varphi^1_{22} MT_{t-1} + \varphi^1_{23} LXP_{t-1} + \varepsilon_{2t} \\
-\varphi^0_{31} RGDP_t - \varphi^0_{32} MT_t + LXP_t &= \varphi^1_{31} RGDP_{t-1} + \varphi^1_{32} MT_{t-1} + \varphi^1_{33} LXP_{t-1} + \varepsilon_{3t}
\end{aligned} \tag{3}$$

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[5] An increase in aggregate economic activities that persists over successive periods. Data are sourced from World Development Indicators (WDI), 2017.

[6] The state of complete physical, mental, and social well-being of a person and not merely the absence of disease or infirmity. Data are sourced from WDI, 2017.

[7] This is a change in global or regional climate patterns, attributed largely to the increased levels of atmospheric carbon dioxide produced by the use of fossil fuels. The sources of data are Earth Policy Institute for global temperature (GMT) and World Bank Climate Change Knowledge Portal for local temperature (LMT). This study carries out two analyses, one on GMT and the other on LMT. This is for comparative purpose to authenticate the assertions by Kelly and Adger (2000) and Räisänen, (2006).

Imposing restriction on the above, based on the theoretical framework, yields the matrix specification below:

$$\begin{bmatrix} 1 & 0 & 0 \\ -\varphi_{21}^{0} & 1 & 0 \\ -\varphi_{31}^{0} & -\varphi_{32}^{0} & 1 \end{bmatrix} \begin{bmatrix} RGDP_t \\ MT_t \\ LXP_t \end{bmatrix} = \begin{bmatrix} \varphi_{11}^{1} & \varphi_{12}^{1} & \varphi_{13}^{1} \\ \varphi_{21}^{1} & \varphi_{22}^{1} & \varphi_{23}^{1} \\ \varphi_{31}^{1} & \varphi_{32}^{1} & \varphi_{33}^{1} \end{bmatrix} \begin{bmatrix} RGDP_{t-1} \\ MT_{t-1} \\ LXP_{t-1} \end{bmatrix} + \begin{bmatrix} e_{1t} \\ e_{2t} \\ e_{3t} \end{bmatrix} \quad (4)$$

Equation (4) can be written as:

$$A_0 Z_t = A_1 Z_{t-1} + \varepsilon_t \quad (5)$$

where:

A_0 = Long-run coefficients

A_1 = Short-run coefficients

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Descriptive Statistics

The results of the descriptive statistics of variables is presented in table 2.

Table 2: Descriptive statistics of variables

Variables	Mean	Median	Std. Dev.	Skewness	Kurtosis	Jarque-Bera
RGDP	30.69	30.61	0.57	0.51	2.64	2.69** (0 .26)
LXP	3.81	3.83	0.09	-0.38	2.58	1.72** (0.42)
LMT	3.30	3.30	0.02	0.01	2.32	1.08** (0.58)
GMT	2.66	2.66	0.02	1.15	5.99	33.10** (0.00)

Note: Values in "()" parenthesis are probability values and the null hypothesis is normal distribution. ** indicates 5% level of significance.

From Table 2, RGDP deviates slightly from symmetry, as the result of its skewness is not zero as expected; though, other variables tend towards symmetry. This means these variables are normally distributed. Also, the kurtosis of a normal distribution is 3; a kurtosis that exceeds 3 means the distribution is peaked (leptokurtic) and one that is less than 3 means the distribution is flat (platykurtic). In the descriptive statistics result, the kurtosis' value for GMT is peaked while others are relatively normal.

Finally, Jacque-Bera values which show the difference between skewness and kurtosis also reveal normal distribution of the data except for GMT; however, the close values of its mean and median prove the data are relatively normally distributed.

Unit Root, Cointegration and Structural VAR Estimates

An attempt is made to test for the order of integration of the variables to characterise their time series property. To achieve this, the Augmented Dickey-Fuller (ADF), Phillips Perron (PP) and Kwiatkowski, Phillips, Schmidt, and Shin (KPSS) tests are employed. The different results are used in authenticating the correct order of integration for the selected variables. All the variables in this empirical study are in log values. The results of the unit root tests are reported in Table 3 and cointegration is established using the Johansen multivariate cointegration technique based on the fact that the variables of analysis are I(1) series (see Appendix for detailed results).

Table 3: Unit root and stationarity test results

SERIES	ADF	PP	KPSS	FINAL REMARKS
GMTEMP	I(1)	I(1)	I(1)	I(1)
LMTEMP	I(1)	I(0)	I(1)	I(1)
LEXP	I(2)	I(1)	I(1)	I(1)
RGDP	I(1)	I(1)	I(1)	I(1)

Table 4: Johansen Cointegration Test Results

Test of Null hypothesis	Series: LRGDP LLXP LGMT			Series: LRGDP LLXP LLMT		
	Trace Statistic	Max-Eigen Statistic	Decision	Trace Statistic	Max-Eigen Statistic	Decision
CE = 0	40.82800*** (29.79707)	29.97831*** (21.13162)	Reject null	30.44999** (29.79707)	21.61555** (21.13162)	Reject null
CE = 1	10.84969 (15.49471)	9.165161 (14.26460)	Accept null	8.834440 (15.49471)	8.236082 (14.26460)	Accept null
CE = 2	1.684527 (3.841466)	1.684527 (3.841466)	Accept null	0.598358 (3.841466)	0.598358 (3.841466)	Accept null

Note: The null tests the number of cointegrating equations (CE). Values in "()" parenthesis are the associated 5% critical values of the respective statistics.

*** and ** indicates 1% and 5% level of significance, respectively.

The cointegration results show evidence of a long-run relationship among the variables, as there is one cointegrating equation for each model—a necessary condition for analysis. This study therefore adopts the structural VAR framework to trace the shock transmission mechanism from climate change through human health to economic growth. Given the instantaneous impacts of the interactions of the variables, precisely a short-run SVAR is employed to show the contemporaneous effects of the shock passthrough, as dynamic economic models can be specified as restrictions on stochastic processes (Fernández-Villaverde et al., 2005). This VAR model is therefore a recursive dynamic structural model in which economic growth depends on human health and climate change shocks in that order, and this method of analysis is based on theory and extant empirical studies (see Climate weighted Mankiw-Romer-Weil, 1992 in Fankhauser and Tol, 2005; Rosenberg et al., 2000; Richardson et al., 2009; Ikefuji et al., 2012). The scope of the study is from 1960 to 2015 and the lag length for both GMT and LMT models is three, from the values of AIC, BIC and HQC[8] selection criteria.

Table 5: Short-run structural VAR results

Series	Explanation	GMT Model Coefficient	LMT Model Coefficient
C(1)	Effect of D(RGDP(-3)) on D(GMT)/D(LMT)	0.042896***	0.033331 *
C(2)	Effect of D(RGDP(-3)) on D(LXP)	0.000161	0.000184
C(3)	Effect of D(GMT(-3)) on D(LXP)	0.001287	0.001487
C(4)	Effect of D(RGDP(-3)) on D(RGDP)	0.111320***	0.111853 ***
C(5)	Effect of D(GMT(-3))/D(LMT(-3)) on D(GMT)/D(LMT)	0.015106***	0.016292 ***
C(6)	Effect of D(LXP(-3)) on D(LXP)	0.000109 ***	0.000108 ***

*** and * are 1% and 10% respectively

Global climate has a positive and significant relationship with economic growth in Nigeria. A 100% increase in RGDP over time results in a 4.3% increase in GMT at 1%. Although the relationship between RGDP and LXP is positive, it is insignificant at all levels for both models. This suggests that recorded growth over time has not been adequately harnessed

[8] Akaike Information Criterion (AIC), the Schwarz Bayesian Information Criterion (BIC) and Hannan-Quinn Information Criterion (HQC).

to influence human health status and outcomes, confirming the suboptimality of health infrastructure and healthcare service delivery in Nigeria (Durowade et al., 2016; Aregbesola, 2018). Although, a positive relationship exists between LXP and GMT/LMT, LXP does not explain GMT/LMT, as the result is insignificant. Finally, a 100% individual increase in lagged RGDP, lagged GMT/LMT and lagged LXP for both global and local climate models results in an 11.1% and an 11.2% increase in RGDP; a 1.5% and 1.6% increase in GMT/LMT; and a 0.01% and 0.01% increase in LXP respectively. The result of the effect of LXP on itself is very low, suggesting that human health status and outcomes are low, and this is long-established by the low value of life expectancy at birth in Nigeria.

Impulse response for RGDP, GMT/LMT and LXP

The impulse response function of the GMT model over a ten-year period horizon is presented in Figure 1. The first vertical segment shows the impulse response of RGDP, GMT and LXP to RGDP. A one positive standard deviation shock to RGDP results in mostly positive responses of RGDP and GMT. However, LXP maintains equilibrium value of between zero and -0.002, throughout the periods. The middle segment of graphs illustrates the responses of RGDP, GMT and LXP to a one positive standard deviation shock to GMT. A standard positive deviation shock has a positive impact on RGDP and GMT, while its impact on LXP is strong and negative in most of the periods. For the last segment, a positive standard deviation shock to LXP has close to no impact on RGDP and GMT with values between zero and 0.01 for the former and between zero to -0.001 for the latter. Finally, a positive shock to LXP has a strong positive impact on LXP in all the periods.

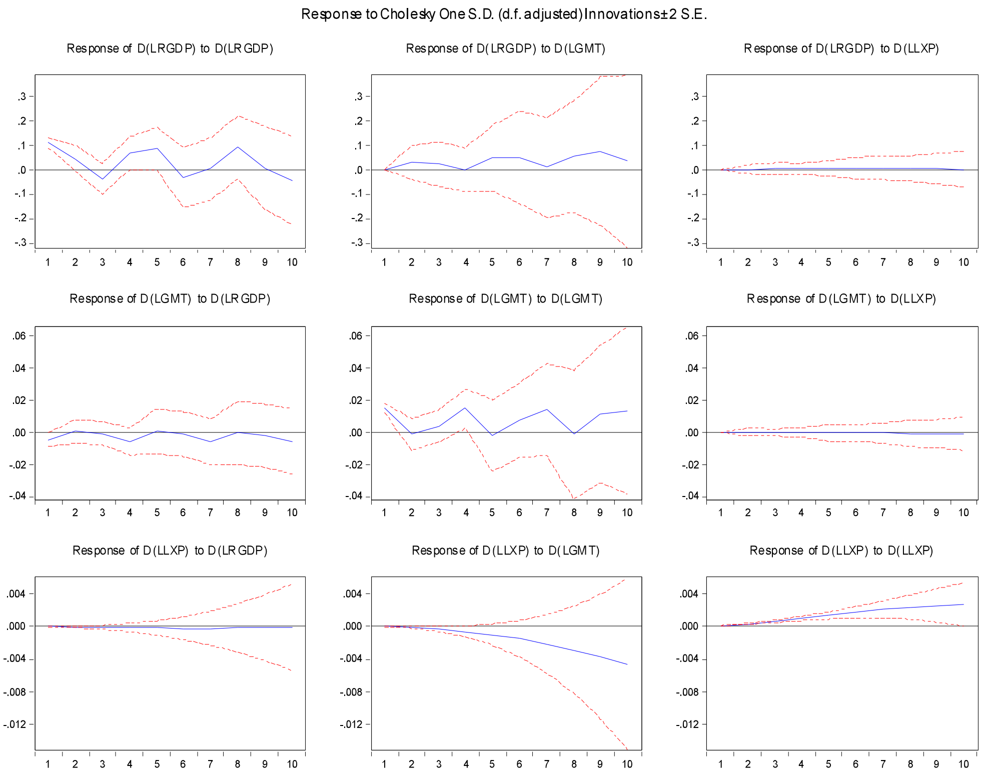

Figure 1: Impulse response to Cholesky One S.D. innovations (RGDP, LXP and GMT)

Source: EViews 10 Statistical Package.

The impulse response function of the LMT model over a ten-year period is presented in Figure 2. The first vertical segment shows the impulse response of RGDP, LMT and LXP to RGDP. A one positive standard deviation shock to RGDP results in mostly positive impact on RGDP, and negative impacts on LMT and LXP. The middle segment shows the responses of RGDP, LMT and LXP to a positive one standard deviation shock to LMT. A standard positive deviation shock has a positive impact on RGDP and LMT, while its impact on LXP is very weak and negative at -0.0001 but became positive in the remaining periods. For the last segment, a positive standard deviation shock to LXP has a weak and positive impact on RGDP and LMT; and a strong positive impact on itself.

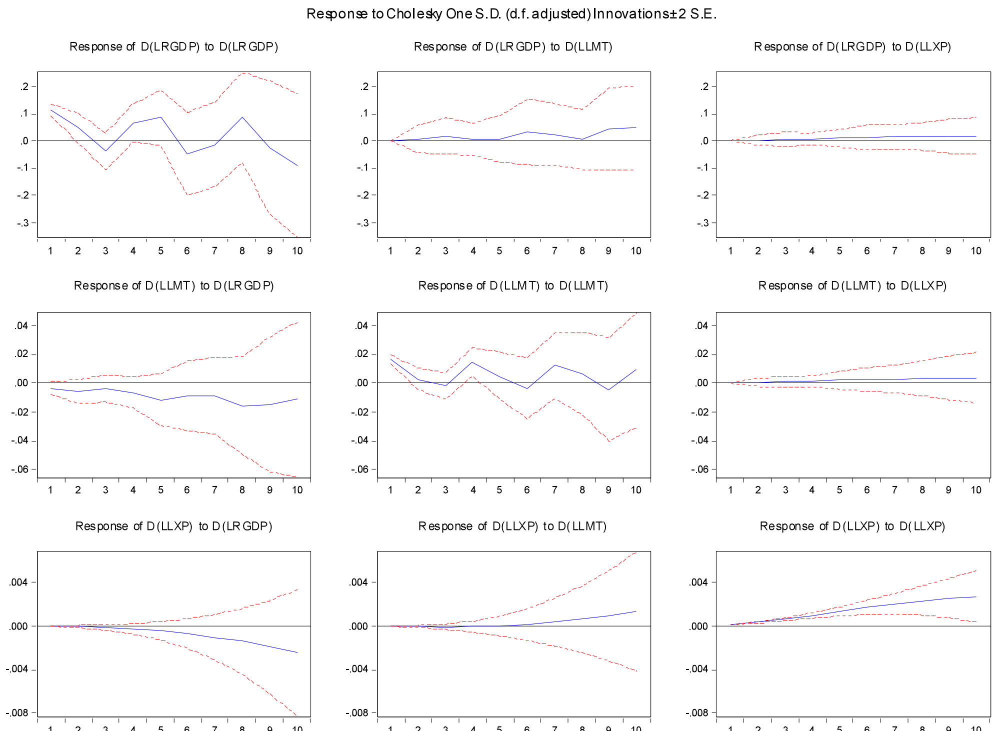

Figure 2: Impulse Response to Cholesky One S.D. Innovations (RGDP, LXP and LMT)

Source: EViews 10 statistical package.

In conclusion, RGDP, GMT/LMT and LXP are strong predictors of themselves over a long period in both models for GMT and LMT. GMT predicts RGDP and LXP better than LMT. This confirms that climate change is a global phenomenon. However, LXP is a mild predictor of RGDP and GMT/LMT, suggesting that human health (effectiveness and efficiency of labour) is not the predictor of economic growth in Nigeria, as the economy is predominantly driven by oil income. This is contrary to what obtains in developed or emergent countries.

Forecast Error Variance Decomposition for RGDP, LXP and GMT

This sub-section shows which variable contributes more to the forecasting power of the other; hence, the estimated forecast error variance decomposition for this model. The estimates in the first period of the first segment in Table 6 show that the forecast error variance of **RGDP** at short horizons is due to itself. This results from the ordering. In the last period, approximately 29.2% and 0.4% of the variance in RGDP are accounted for by GMT and LXP shocks respectively. This implies that in the short run, changes in economic growth are best explained by innovations in its own shocks and that global climate change and human health have little or no predictive power over economic growth in these periods in Nigeria. This equally implies that there might be other variables that directly determine economic growth in Nigeria (Ciccone and Jarociński, 2010).

Table 6: Error variance decomposition for RGDP, LXP and GMT

PRD	Variance Decomposition 1			Variance Decomposition 2			Variance Decomposition 3		
	RGDP	GMT	LXP	RGDP	GMT	LXP	RGDP	GMT	LXP
1	**100.00**	0.00	0.00	9.08	**90.92**	0.00	1.12	3.03	95.85
2	93.97	6.02	0.02	9.15	90.84	0.00	2.30	10.62	87.08
3	91.45	8.47	0.09	8.80	91.19	0.01	2.09	18.19	79.72
4	93.12	6.73	0.16	10.99	89.00	0.01	1.65	24.15	74.21
5	87.93	11.87	0.20	10.93	89.03	0.04	1.35	30.55	68.11
6	81.81	17.88	0.31	10.06	89.87	0.08	1.12	37.25	61.62
7	81.53	18.03	0.44	11.60	88.31	0.10	0.88	43.84	55.29
8	79.56	20.05	0.39	11.58	88.25	0.17	0.64	50.43	48.93
9	70.92	28.71	0.38	10.43	89.34	0.23	0.45	56.85	42.70
10	70.44	**29.20**	**0.37**	**11.19**	88.54	**0.28**	**0.30**	**62.90**	36.80

The first period horizon of the second segment also reveals that the forecast error variance of **GMT** is mostly the result of shocks to itself at short horizons. At the longer horizons, 11.0% and 0.3% of variance in GMT in Nigeria are accounted for by RGDP and LXP shocks respectively. This simply means, in the short run, changes in global climate change are explained by innovations in its very shocks while economic growth and human health have very little predictive power over global climate in Nigeria. This confirms that Nigeria is least responsible for climate change.

Finally, the first period in the last segment also shows that the forecast error variance of **LXP** at short horizons is due to its own shocks. The last period reveals that approximately 0.3% and 62.9% of the variance in

LXP are accounted for by RGDP and GMT shocks respectively. This suggests that changes in human health are explained by innovations in shocks to itself. While economic growth has little predictive power over human health, GMT has a stronger predictive power over human health.

Table 7: Error variance decomposition for RGDP, LXP and LMT

PRD	Variance Decomposition 1			Variance Decomposition 2			Variance Decomposition 3		
	RGDP	LMT	LXP	RGDP	LMT	LXP	RGDP	LMT	LXP
1	**100.00**	0.00	0.00	4.98	**95.02**	0.00	1.82	4.72	**93.47**
2	99.69	0.27	0.03	15.17	84.77	0.06	4.58	3.74	91.68
3	97.76	2.09	0.15	18.61	81.11	0.29	6.33	2.48	91.20
4	97.87	1.81	0.32	17.97	81.63	0.40	7.66	1.26	91.08
5	98.04	1.45	0.52	31.66	67.58	0.77	9.75	0.55	89.70
6	94.28	4.80	0.91	37.20	61.45	1.36	12.71	0.48	86.82
7	92.33	6.19	1.48	36.51	61.75	1.75	16.18	1.12	82.71
8	93.17	5.07	1.76	46.24	51.65	2.12	20.28	2.45	77.27
9	88.73	9.00	2.27	52.42	44.98	2.59	25.16	4.36	70.48
10	86.27	**11.37**	**2.36**	**52.88**	44.13	**2.99**	**30.54**	**6.65**	62.82

The estimates in the first period of the first segment in Table 7 show that the forecast error variance of RGDP at short horizons is due to itself. In the last period, approximately 11.4% and 2.4% of the variance in RGDP are accounted for by LMT and LXP shocks respectively. This implies that in the short run, changes in economic growth are best explained by innovations in its own shocks and that local climate change and human health have low predictive power over economic growth especially when compared to the model with GMT. This might be as a result of the fact that health facilities and health service delivery in Nigeria are poor, as also four-fifths of Nigeria's spending is on consumption expenditure (Ebajemito, 2004).

The first period horizon of the second segment also reveals that the forecast error variance of **LMT** is mostly the result of shocks to itself at short horizons. At the longer horizons, approximately 52.9% variance in LMT in Nigeria are accounted for by RGDP shocks, while only 3.0% variance in LMT is accounted for by LXP. This simply means, in the short run, changes in global climate change are explained by innovations in its very shocks.

Economic growth has a strong predictive power over local climate and human health has very little predictive power over local climate in Nigeria. This buttresses the fact that pursuance of non-green growth is the cause of pollution and anthropogenic climate variability.

Finally, the first period in the last segment also shows that the forecast error variance of **LXP** at short horizons is due to its own shocks. The last period reveals approximately 30.5% and 6.7% of the variance in in LXP are accounted for by RGDP and LMT shocks respectively. This suggests that changes in human health are explained by innovations in its shocks to itself. While economic growth has mild predictive power over human health, LMT has a little predictive power over human health, unlike GMT which accounts for 62.9% of variance in human health. This buttresses the fact that climate change is a global phenomenon.

Discussion of Findings

This study reveals that a relationship exists between GMT, LXP and RGDP, which are the measures for climate change, human health and economic growth respectively. A long-run relationship was established for climate change and the various impulse responses showed that human health and climate change are mild predictors of economic growth, however, economic growth has innate potential to predict itself. This means that human health improves economic growth marginally, although this is incongruent with studies on human health and economic growth in the developed world (Bloom and Malaney, 1998; Bloom, et al., 2001; Peykarjou et al., 2011) and also with studies on climate change and economic growth (Fankhauser and Tol, 2005; Dell et al., 2008; Rahman et al., 2009; ADF, 2010). However, it is analogous to one of the findings by Ogungbenle et al. (2013) where human health did not explain economic growth in Nigeria. This simply suggests that government policies on the improvement of human health status should include building and maintenance of infrastructure for health, reduction of taxes to increase the welfare of the people, and increase in medical allowance, among others.

Also, economic growth, human health and global climate change are predictors of human health (Luber and Hess, 2007; Richardson et al., 2009; Hutton, 2011; Eke and Onafalujo, 2012). However, human health hardly responds to economic growth in the presence of climate change. This implies that economic growth does not mean improved human health status. This is probably because most public spending in Nigeria is channelled towards consumption and not development (Ebajemito, 2004). Furthermore, the present status of human health determines its future state; good contemporaneous health status means better health status in the future and the best ability to withstand the consequences of climate change. In addition, well-predicted climate change by human health simply suggests that GHG is generated as a result of inefficient and ineffective capacity utilisation, which in turn warms the atmospheric temperature. For this, environmental policies that reduce emission of GHG should be employed.

The variance decomposition reveals that short-run changes in economic growth, human health and climate change are super explained by innovations in their own very shocks to themselves. This means that the larger percentages of output variances are caused by the lesser inputs. This implies that human health and climate change have little predictive power on economic growth in Nigeria in the earlier periods. This is contrary to the findings of studies on human health and economic growth, as earlier stated (see Soukiazis and Cravo, 2007; Mojtahed and Javadipour, 2006). In the literature review, human health is revealed to enhance growth both directly and indirectly. 'Directly' means longer hours of effective labour capacity utilisation for maximum productivity which invariably influences economic growth. 'Indirectly', on the other hand, means more work, more wages, more savings, increased investment and consequently, increased growth. Furthermore, the little predictive power of climate change on economic growth sounds great, however, care must be taken so that the country does not underestimate the consequences of climate change as regards the enactment of adequate climate change policies in Nigeria.

Also, this study establishes that economic growth and local climate change have mild and little predictive power on human health in Nigeria, however, global climate has a strong predictive power over human health, corroborating the fact that climate change is a global phenomenon. Ebajemito (2004) has proposed that if 5 percent of national income is channelled towards health and education in Nigeria, we could experience the kind of growth of the Asian Tigers, as literature establishes a positive relationship between economic growth and human health (Currais and Rivera, 1999; Rivera and Currais, 2004). Finally, the study also reveals that economic growth and human health have little predictive power over global climate change, however, economic growth has a strong effect on local climate in Nigeria over the periods under observation. This means that the primary effect of GHG emissions on local climate is much and coupled with its secondary effect on global climate, human health deteriorates rapidly, resulting in loss of man hours, low productivity and decline in economic growth.

Recommendations and Conclusion

Recommendations

This study has revealed that there is very mild dynamic relationship between human health and economic growth in Nigeria over the periods under observation in this study. However, human health explained economic growth in most developed and developing countries. Thus, we conclude that for human health to improve economic growth in Nigeria, it is of great importance that government adopts measures to augment life expectancy by improving the health status of the population, as this will keep the country on the path of growth. This will without doubt increase capacity utilisation of idle resources, since there will be consistent reduction in loss of workdays of the labour force. Furthermore, government can also put in place a medical subsidy for its workers at government hospitals. This will not only improve human health status, it will also be a great incentive for low-capacity sectors in the economy. Also, since two-thirds of the labour force work for government (NBS, 2012), government needs to improve on its health policy to boost the life expectancy of civil workers, since life expectancy is a strong indicator of human welfare. These policy recommendations will serve as a panacea for improving the health status of the labour force as a whole.

In addition, given that the fact that the Nigerian economy is suboptimal and its economic growth mildly improves human health status suggests that the country lacks the right institutional mechanism and capacity to effectively manage disasters. Therefore, it is important to build good health facilities and other aids to encourage rapid response of health workers and increase the speed of health service delivery. In this wise, health workers need reorientation on the sensitivity of their jobs. Selflessness is the keyword, so as to maintain the 99% confidence intervals**[level?]** in the discharge of their duties.

There is also the urgent need to act more on awareness (environmental education in schools) and improve on the adaptation and mitigation technology which are already in place, improve access to infrastructure and technology (renewable energy), and build up zero tolerance for pro-climate change lifestyle, as there is inherent momentum built into climate change. Although Nigeria is not required to reduce specific emissions, neither has she been given limitation targets, and she is only responsible for about 0.003 percent of the global GHG emissions (Global Carbon Atlas, 2014), the human development challenges of Nigeria are worse, as the country is dependent on climatic patterns to thrive. Also, it is a known fact that implementation of policies has been a great challenge and hindrance to development in Nigeria (Okoroajofor and Anuforo, 2012) and this is because of failing communication, resources, dispositions or attitudes, and bureaucratic structure (Makinde, 2005). Nigeria needs to encourage more research and development on climate change and implementation of policies. Policies such as the National Health Development Plan Framework (2009-2015) and National Policy on Climate Change and Response Strategy (NPCC-RS), on health and climate change respectively, were drafted for the use of the economy and their continuity is requisite for excellent health and economic outcomes.

Conclusion

In conclusion, there is a dynamic relationship among climate change, human health and economic growth in Nigeria, although, human health showed little predictive power for economic growth, contrary to what obtains in developed countries. Improved human health is a requisite for growth, however, care must be taken to keep the environment green in the course of the pursuit of growth in Nigeria and the rest of the world. Furthermore, adequate and prompt attention should be given to formulation and implementation of relevant health and climate change policies to combat the consequences of climate change, as Nigeria appears to be vulnerable to climate change by the level of its health status, health care facilities and service delivery. Finally, Nigeria should improve on her adaptation strategies, national ozone programme, National Forestry Development Programme, the presidential afforestation initiative, capacity building, and decarbonisation of the economy, amongst others.

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doi: 10.1186/1744-8603-7-18 The electronic version of this article is the complete one and can be found online at: http://www.globalizationandhealth.com/content/7/1/18

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APPENDIX

ADF

	Level	First	Remarks
LRGDP	0.5149	-5.3081	I(1)
LLXP	-1.6359	-2.4964	I(2)
LLMT	-1.3798	-11.5736	I(1)
LGMT	0.0331	-7.0159	I(1)
5% level	-2.9155	-2.9166	
5% level (LLXP)	-2.9224	-2.9224	
5% level (LLMT)	-2..9177	-2..9177	

PP

	Level	First	Remarks
LRGDP	0.3180	-5.3484	I(1)
LLXP	-1.8807	-3.6331	I(1)
LLMT	-3.7654	-17.1153	1(0)
LGMT	0.9698	-6.7065	I(1)
5% level	-2.9155	-2.9166	

Spectral estimation method for LXP is AR spectral OLS

KPSS

	Level	First	Remarks
LRGDP	0.7991	0.1846	I(1)
LLXP	0.8420	0.2274	I(1)
LLMT	0.8277	0.0687	I(1)
LGMT	1.0334	0.2776	I(1)
5% level	0.4630	0. 4630	
10% level	0.119000	0.119000	

VAR Lag Order Selection Criteria
Endogenous variables: D(LRGDP). D(LGMT). D(LLXP).

Lag	LogL	LR	FPE	AIC	SC	HQ
0	401.1911	NA	1.75e-11	-16.25270	-16.13687	-16.20876
1	491.8797	166.5709	6.26e-13	-19.58693	-19.12363	-19.41115
2	564.5595	124.5938	4.68e-14	-22.18610	-21.37532	-21.87849
3	600.3848	57.02812*	1.58e-14*	-23.28101*	-22.12276*	-22.84157*
4	607.7762	10.86072	1.73e-14	-23.21535	-21.70962	-22.64408
5	612.7696	6.725900	2.11e-14	-23.05182	-21.19861	-22.34872
6	625.2141	15.23817	1.93e-14	-23.19241	-20.99172	-22.35748

VAR Lag Order Selection Criteria
Endogenous variables: D(LRGDP). D(LLMT). D(LLXP).

Lag	LogL	LR	FPE	AIC	SC	HQ
0	409.6795	NA	2.38e-11	-15.94821	-15.83458	-15.90479
1	506.3717	178.2170	7.64e-13	-19.38712	-18.93258	-19.21343
2	591.8435	147.4808	3.83e-14	-22.38602	-21.59056	-22.08205
3	630.1534	61.59634*	1.22e-14*	-23.53543*	-22.39906*	-23.10119*
4	638.8183	12.91236	1.26e-14	-23.52229	-22.04501	-22.95777

Global Climate Regression Result

Structural VAR Estimates
Date: 11/05/18 Time: 11:29
Sample (adjusted): 1964 2015
Included observations: 52 after adjustments
Restrictions: @VEC(L3). = "1, NA, NA, 0, 1, NA, 0, 0, 1"
Iterated GLS convergence achieved after 20 iterations
Estimation method: Maximum likelihood via Newton-Raphson (analytic derivatives)
Convergence achieved after 12 iterations
Structural VAR is just-identified

Model: Ae = Bu where E[uu']=I				
A =				
1	0	0		
C(1).	1	0		
C(2).	C(3).	1		
B =				
C(4).	0	0		
0	C(5).	0		
0	0	C(6).		
	Coefficient	Std. Error	z-Statistic	Prob.
C(1).	0.042896	0.018819	2.279446	0.0226
C(2).	0.000161	0.000143	1.128710	0.2590
C(3).	0.001287	0.001004	1.282071	0.1998
C(4).	0.111320	0.010916	10.19804	0.0000
C(5).	0.015106	0.001481	10.19804	0.0000
C(6).	0.000109	1.07E-05	10.19804	0.0000
Log likelihood	585.0919			
Estimated A matrix:				
1.000000	0.000000	0.000000		
0.042896	1.000000	0.000000		
0.000161	0.001287	1.000000		
Estimated B matrix:				
0.111320	0.000000	0.000000		
0.000000	0.015106	0.000000		
0.000000	0.000000	0.000109		
Estimated S matrix:				
0.111320	0.000000	0.000000		
-0.004775	0.015106	0.000000		
-1.18E-05	-1.94E-05	0.000109		
Estimated F matrix:				
-0.806756	1.559813	0.175602		
0.024377	-0.060840	0.014684		
0.094574	-0.095163	0.019778		

Local Climate Regression Result

Structural VAR Estimates
Date: 11/05/18 Time: 11:09
Sample (adjusted): 1964 2015
Included observations: 52 after adjustments
Restrictions: @VEC(L3). = "1, NA, NA, 0, 1, NA, 0, 0, 1"
Iterated GLS convergence achieved after 16 iterations
Estimation method: Maximum likelihood via Newton-Raphson (analytic derivatives)
Convergence achieved after 16 iterations
Structural VAR is just-identified

Model: Ae = Bu where E[uu']=I

A =		
1	0	0
C(1).	1	0
C(2).	C(3).	1
B =		
C(4).	0	0
0	C(5).	0
0	0	C(6).

	Coefficient	Std. Error	z-Statistic	Prob.
C(1).	0.033331	0.020199	1.650151	0.0989
C(2).	0.000184	0.000137	1.341791	0.1797
C(3).	0.001487	0.000918	1.619909	0.1053
C(4).	0.111853	0.010968	10.19804	0.0000
C(5).	0.016292	0.001598	10.19804	0.0000
C(6).	0.000108	1.06E-05	10.19804	0.0000
Log likelihood	581.6615			

Estimated A matrix:		
1.000000	0.000000	0.000000
0.033331	1.000000	0.000000
0.000184	0.001487	1.000000
Estimated B matrix:		
0.111853	0.000000	0.000000
0.000000	0.016292	0.000000
0.000000	0.000000	0.000108
Estimated S matrix:		
0.111853	0.000000	0.000000
-0.003728	0.016292	0.000000
-1.50E-05	-2.42E-05	0.000108
Estimated F matrix:		
0.269765	0.200949	-0.115279
0.015616	0.011796	-0.034082
0.052814	0.002880	-0.017191