Innovations

A quadripartite structural vector auto-regression (SVAR) analysis of climate change, employment rate, health outcome and growth nexus in Nigeria

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Abstract
Problem: *Following wide swings in climatic conditions in Nigeria especially in recent years which has affected households' livelihood and health status, governmental authorities have re-intensified efforts at curbing the ravaging climatic conditions.* ***Design/Methodology/Approach:*** *The empirically investigate the climate change contagion effect on employment rate, health outcome (proxied by life expectancy at birth) and economic growth (proxied by GDP per capita) using quarterly (1981Q1-2020Q4) aggregate data for Nigeria and applying the structural VAR technique.* ***Findings:*** *We find that climate shock adversely affects health outcome, employment rate and economic growth.* ***Conclusion:*** *An important implication for policy which is derived from the study is that climate change mitigation policy should be implemented to minimize disastrous climatic shocks especially on the country's most vulnerable populace.*

Keywords: ***1.****climate; 2.growth; 3.capita; 4.policy; 5.health*
JEL Classifications: *Q25; O40; C22; N17*

1. Introduction

As a global phenomenon, climate change inhibits from functioning maximally (Udemba et al., 2021). Being unable to keep warming to 1.50C over pre-industrial levels,the possibility of facing several dire consequences keeps rising. Climate change affects everything from economies to geopolitics to migration. Climate change touches every aspect of the society. Specifically, climate change includes sporadic shifts and wide fluctuations of weather conditions and a sustained surge in atmospheric temperature(Intergovernmental Panel on Climate Change, IPCC, 2001). It is mainly caused by sporadic rise in the amount of atmospheric greenhouse gases (methane, carbon dioxide, nitrous oxide, etc.) which results in the rise of average temperature.The increase in global temperature has increased weather events such as heat waves, droughts, flood and tropical cyclones. These may have important implications for human and economic development. As such, rapidly growing empirical and theoretical literature established the mechanism through which temperature changes can impact on the economy(Pindyck, 2011; Ali, 2012) The increased impact of climate change on the biosphere and the catastrophe it has caused so far, prompted the 13th SDG which laid much emphasis on climate action with the intention that all nations of the world by 2030 would have adapted a policy measure that will help ease off the effect. Statistics has shown that developing nations such as Nigeria only contribute a little to the global crisis of climate change but they suffer more. So, the level of vulnerability differs because of limited resources, technology, location etc. hence, making it more severe in some countries than the other, which is where the issue of climate change inequality comes in. Cataclysmic climate effectsmore evident in tropical areas such as Nigeria (Williams et al., 2018; Idowu et al., 2011). Nigeria was estimated as being highly susceptible to catastrophic frequency and magnitude in climate change resulting in ravaging effects(World Bank, 2019). As with other regions of the world, it should be noted that most virulent diseases and infections are highly susceptible to climate: humidity, precipitation and temperature. Explicitly, climate change has the potential to exacerbate health challenges (World Health Organization, WHO, 2015), due to extreme weather conditions such as storms, heatwaves, and storms (WHO, 2021). Health risks including cardiovascular respiratory disorders, cerebra-spinal meningitis, malaria, skin cancer, and high blood pressure are exacerbated by climate change Several studies have documented the ravaging effects (economic, social and financial) of climate change in Nigeria (Musibau, 2021; Birnintsaba et al., 2021; Nathaniel, 2020; Cattaneo & Massetti, 2019; Ali et al., 2019; Ogbuabor&Egwuchukwu, 2017; Ebele &Emodi, 2016). For instance, Nigeria and other African economies are losing between 5 percent to 15 percent in terms of per capita growth owing to climate change (Addeh, 2022). As such, a rapidly growing literature investigates the relationship between climate (temperature, precipitation, storms, and other aspects of the weather) and economic performance (agricultural production, labor productivity, commodity prices, health, conflict, and economic growth). For instance, the empirical literature indicates a relationship between temperature shock on macroeconomic aggregates, productivity, and asset valuations (Colacito et al., 2019; Deryugina& Hsiang, 2014; Park 2016; Donadelli et al. 2017; Acevedo et al 2018), climate change, human capital development and growth (Ali et al 2012; Ayinde et al. 2010). Other studies investigate the nexus between temperature shocks, household consumption and health (see Hirvoyen, 2016; Andalon et al. 2016; Amuka et al. 2018; Ogasawara and Yumitori, 2019) climate change, crop yield and food security (see Ayinde et al. 2013; Islam et al 2016). The limitation in the literature especially for Nigeria is that fall in the quality-of-life variables like poverty, unemployment, poor sanitation, poor health outcome, and economic growth has been understood within the context volatility in international commodity prices, volatile exchange rate, and aggressive monetary and fiscal policies. Despite the renewed interest on the subject matter in Nigeria, studies on climate change alongsideits attendant effect on health and employment are rare in Nigeria. How will employment rate be affected by shocks in climate? Do the short-run effects of climate shocks affect health outcome? How will economic growth be affected by shocks in climate? Do such effects persist through the long-run? These constitute our research thrusts.Our contribution to existing literature is twofold in perspective. First, the study examines the effect of climate change on employment and the impact on health outcome. Second, we examine the impact of climate change on economic growth. To the best of our knowledge, this study is the novel in examining effect of climate change as it relates to employment and health outcome. From an empirical viewpoint, the results obtained highlight the importance of making concerted efforts in ensuring that climate change is effectively managed to minimize its ravaging effects. The following section deals with method and Section 3 include data for the study. The results and discussion were presented in Section 4, and Section 5 concludes the study.

2. Methods

We adapted the empirical procedure proffered by Sims (1980) and Blanchard and Quah (1989) which employs short-run restrictions and long-run restrictionsin the VAR model identification scheme. Our study thus employs identification restrictions of structural shocks in both runs. Specifically, in a q-variable system, a total of q(q−1)/2 restrictions are required for just-identification, especially after imposing an identity structural shock covariance matrix. That means that our model which included four variables (climate change, health status, employment, and economic growth) requires six restrictions for just identification. Accounting for the various as endogenously determined, it was appropriate to employ the structural VAR (SVAR) model as defined;

$$\beta_0 Z_t = \alpha + \sum_{t=1}^{p} \beta_i Z_{t-1} + \mu_t \quad (1)$$

Wherez_t = (CC, HO, EMP, GR); *CC* depicts *climate change*; *HO*, *health outcome*, *EMP*, *employment rate* and *GR* denotes *economic growth*.We adapted an infinite-order vector moving average (VMA) given as $\Delta z_t = C(L) \in_t$, where lag operator is denoted by$L$, and $\in_t$ is a (4x1) vector for the covariance matrix of structural shocks and is expressed as$\in_t = [\gamma_t, \tau_t, \omega_t, \delta_t]$. It is imperative to note that γ_t, τ_t, ω_t and δ_t represent shock in climate shock, employment shock, health shock, and output shock, respectively. The variable$\mu_t$in Eq. 1 denotes the vector of serially and mutually uncorrelated structural innovations and $E\mu_t\mu_t^{'} = I$. We clearly adapted a non-recursive identification scheme which indicated no prior imposed ordering of the employed variables. Due to the uniqueness of the climate change variable, our identifying restriction is that climate shock itself is identifies as the only shock with potential long-run effect on climate change. Whereas, all shocks are assumed to not exert influence on climate change in the short-run, economic growth is assumed not to respond to its own shock.

3. Data

We employed quarterly data over the period 1981 to 2020. We adopted the Chow and Lin (1971) interpolation technique to derive the data from annual dataset. The use of quarterly data is highly commendable since a high frequency dataset is essential for an identification framework (Ilzetzki et al., 2013; Blanchard & Perotti, 2002).Data for the study were sourced from theFood and Agriculture Organization (*FAO*) International Financial Statistics (*IFS*), and National Bureau of Statistics (*NBS*) databases. The summary statistics, alongside correlation matrix are presented in Table 1.

4. Results

4.1. Descriptive Analysis

We provided an insight into the nature of the employed data such as aspect of measures of central tendency, symmetric distribution and variations. The values of kurtosis in Table 1 Panel A suggested that employment is the only variable among the series that peaked to the surface or leptokurtic relative to the normal distribution among the series. The statistically significant Jaque-Bera normality test statistics suggest non-normality of the distribution. While the standard deviations of the series are indicative that the series are far from their mean values. One implication of such deviation statistics is the possibility of certain shocks driving the variables away from their trajectory.

Table 1. Descriptive statistics and correlation matrix

Panel A				
	GR	HO	EMP	CC
Mean	6.88	3.87	3.95	0.63
Median	6.74	3.83	4.03	0.60
Maximum	8.08	3.99	4.25	1.34
Minimum	5.60	3.82	3.31	-0.35
Std. Dev.	0.72	0.05	0.24	0.38
Skewness	0.17	0.95	-1.41	-0.08
Kurtosis	1.59	2.35	4.42	2.11
Jarque-Bera	12.70	24.34	60.51	4.92
Probability	0.00	0.00	0.00	0.08
Panel B				
	GR	HO	EMP	CC
GR	1.000000			
HO	0.853185	1.000000		
EMP	0.126317	0.463945	1.000000	
CC	0.671147	0.771834	0.440367	1.000000

The correlation statistics presented in Table 1 Panel Bshow a strong positive relationship between GDP per capita and health outcome variable,and a weak positive link exists between the employment rate and GDP per capita, indicating that high GDP per capita does not translate to effective employment. The correlation between climatic change, economic growth and health outcome is positive and very high indicating that climate change has significant impact on these variables.

Owing to avoidance of spurious results, the study conducted the unit root test using the Augmented Dickey Fuller (ADF) and Philip Perron (PP) approaches. Both outcomesare presented in Table 2. Evidently, all the variables were stationary at first differences, indicative that the variables are integrated of order one I(1*)*. The implication of this is that all the variables were characterized by a unit root, suggesting that they all follow an I(1)process. The prevalence of unit root suggests a further test of cointegration among the variables.

Table 2. Unit Root Test Result

	ADF				PP				
	Levels		1st Diff		Levels		1st Diff		OOI
	C	C&T	C	C&T	C	C&T	C	C&T	
CC	-0.58	-2.76	-3.97	-3.92	-2.27	-3.39	-4.13	-4.09	I(1)
EMP	-2.34	-2.65	-3.34	-3.17	-2.61	-2.66	-4.09	-4.29	I(1)
GR	-1.26	-2.48	-2.81	-2.48	-1.03	-2.12	-3.37	-3.54	I(1)
HO	-0.06	-1.08	-1.49	-3.09	3.67	-0.18	-0.74	-2.36	I(1)

Note: *C and C + T denote constant and constant + trend, respectively. OOI denotes Order of Integration*

4.2. Cointegration Analysis

Having established the level of integration of our variables, it is imperative to check if there is cointegration among the level of variables.The result of the Johansen Cointegration estimates are presented in Table 3. Two cointegrating equations are revealed by the trace test at both the 1 percent and 5 percent significance levels, while the maximum eigen-value test indicates 2 cointegrating at the 5 percent level. Since there is evidence of cointegration between employment(EMP), GDP per capita (GR), climate change (CC) and health outcome (HO), it implies that the study can include the (logarithmic) levels of the variables in the VAR estimation.

Table 3. Test for Cointegration

Unrestricted Cointegration Rank Test (Trace)				
Hypothesized		Trace	0.05	
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None *	0.210571	84.42103	64.25680	0.0004
@ most 1 *	0.178847	51.79150	41.88765	0.0051
@ most 2	0.130247	24.59925	26.94752	0.0724
@ most 3	0.037970	5.341922	15.56798	0.6480
Unrestricted Cointegration Rank Test (Maximum Eigenvalue)				
Hypothesized		Max-Eigen	0.05	
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None *	0.210571	32.62953	31.57462	0.0413
@ most 1 *	0.178847	27.19224	26.93241	0.0338
@ most 2	0.130247	19.25733	19.63874	0.0532
@ most 3	0.037970	5.341922	13.69478	0.5680
Max-eigenvalue and Trace test indicates 2 cointegrating eqn(s) at the 0.05 level * denotes rejection of the hypothesis at the 0.05 level **MacKinnon-Haug-Michelis (1999) p-values				

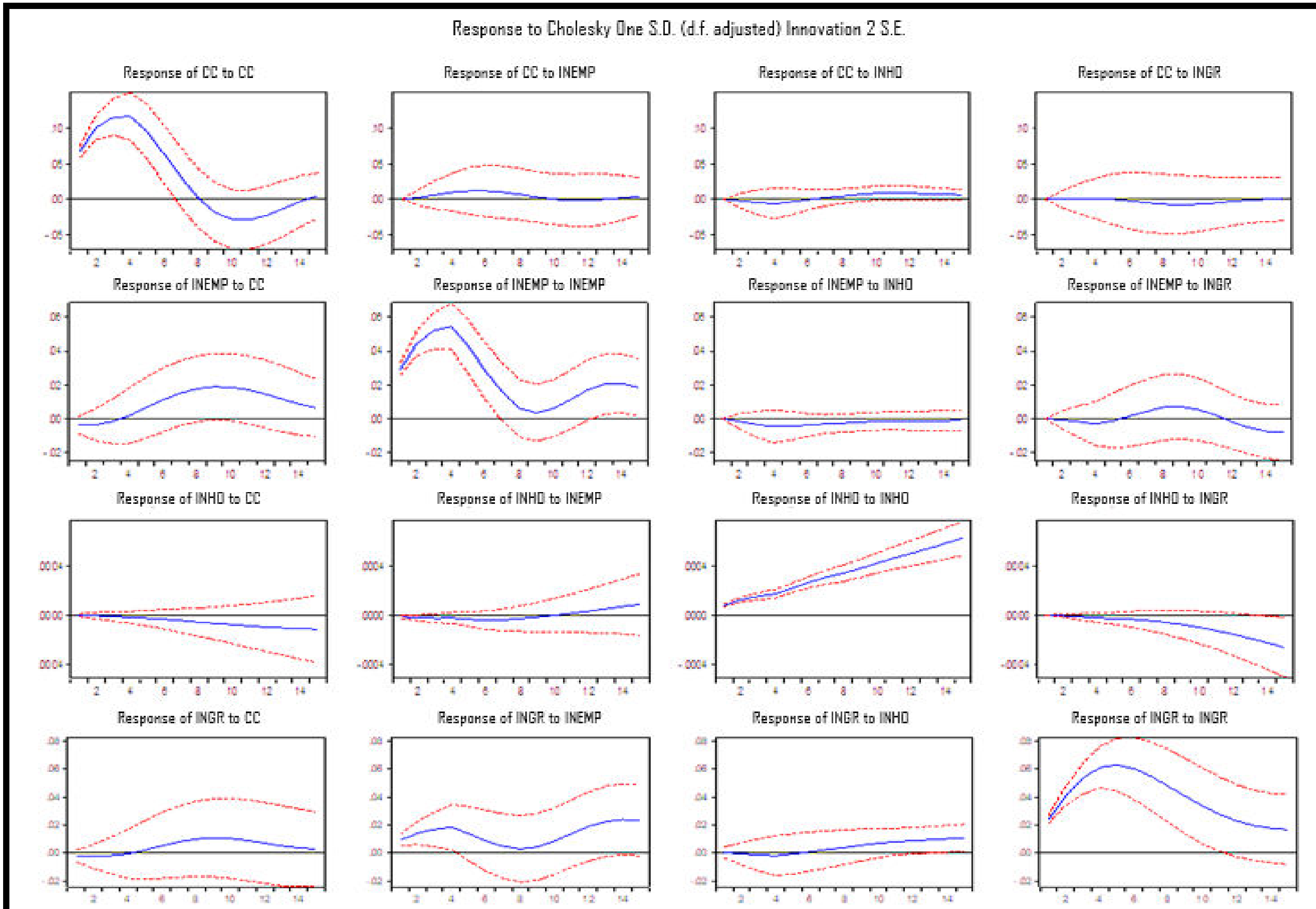
4.3. Econometric Analysis

In presenting the results of the structural VAR, the study first examinedimpulse responses of each variable to a unit positive innovation in each of the fundamental shocks, and thereafterthe variance decomposition of the forecast error based on the VAR was also examined. The unrestricted reduced form VARs were estimated over the period 1981:Q1-2020:Q4, with 6 lags of each variable in the equation.

4.3.1. Impulse Response

The impulse responses in Figure 1, panel 2 shows the response of employment rate to one standard deviation shock, together with standard error confidence bounds. In the short run,climate change leads to increase in employment rate, possibly due to loss of livelihoods of households owing toclimate change ravaging effects. The effect peaked in the 9th and started to decrease afterwards. There isdecrease in employment rate as a result of positive shock to heath outcome.In other words, positive shock to health outcome leads to decrease in employment rate. Similarly, positive shock to GDP per capita decreases employment in the short run, however, employment later increased and peaked in the 9th quarter which later decrease.

Figure 1. Impulse Response Function



In response to climate shock, health outcome proxied with life expectancy at birth, is negatively affected all through the horizon in the short run, indicating that life expectancy at birth is at risk in the event of climate shock (*see*Panel 3). This result confirms to previous studies (Muanya, 2021;Monday, 2019; Borokinni, 2017; Adewuyi &Adefemi, 2016; Abdussalam et al., 2014; Akingbade, 2010). Also, the response of GDP per capita (GR) to climate shock shows some remarkable semblance to the impact of climate shock to employment rate. Climate shock negatively impact short run GDP per capita.It increases between the 6th and the 9th quarter and decreases afterward. Positive shock to health outcome decreases GDP per capita up till the 6th quarter, and thereafter takes a positive trajectory.

4.3.2. Forecast Error Variance Decomposition (FEVD)

We presented the FEVD for the estimated model in Table 4. It shows for each variable what proportion of FEVD at different forecast horizon can be attributed to each shock in the model. The FEVD for employment rate (EMP) shows that variation to EMP is influenced significantly by its own perturbation (97.22%) and climate shock accounted for 1.58 per cent while the other two variables do not contribute in the first quarter. By the 15th period horizon, climate shock accounted for 14.11 percent; the influence of employment rate to its own shock has dissipated to 83.28 per cent, while proportion of shock to health outcome and output shock accounted for 0.59 and 2.00 per cent respectively.

Table 4. FEVD Estimates

	Variance Decomposition of EMP				Variance Decomposition of HO				Variance Decomposition of GR			
$Qtrs$	γ_t	τ_t	ω_t	δ_t	γ_t	τ_t	ω_t	δ_t	γ_t	τ_t	ω_t	δ_t
1	1.58	97.22	0.00	0.00	0.00	2.47	96.81	0.00	0.66	13.06	0.02	86.52
	(2.2)	(2.2)	(0.0)	(0.0)	(0.9)	(2.9)	(3.0)	(0.0)	(1.6)	(5.2)	(0.9)	(5.4)
2	0.91	98.89	0.19	0.03	0.11	2.75	97.09	0.11	0.43	11.21	0.03	88.41
	(2.0)	(2.1)	(0.4)	(0.4)	(1.3)	(3.2)	(3.6)	(0.4)	(1.5)	(5.5)	(1.0)	(5.7)
3	0.51	99.18	0.24	0.07	0.35	2.67	96.66	0.35	0.27	10.14	0.09	89.67
	(2.0)	(2.2)	(0.7)	(0.8)	(1.9)	(3.6)	(4.2)	(1.0)	(1.7)	(5.9)	(1.2)	(6.1)
5	0.71	98.69	0.59	0.17	0.97	2.51	95.09	1.16	0.19	7.97	0.07	91.73
	(2.7)	(3.5)	(1.3)	(1.8)	(2.9)	(4.0)	(5.3)	(2.0)	(2.3)	(6.3)	(1.5)	(6.8)
8	5.97	92.75	0.65	0.69	1.79	1.82	94.86	1.87	0.95	5.29	0.19	93.70
	(6.9)	(7.9)	(1.5)	(3.7)	(4.2)	(4.0)	(6.5)	(3.1)	(4.4)	(5.9)	(1.7)	(7.8)
11	12.77	85.38	0.65	1.27	2.55	0.77	92.80	3.99	1.83	5.41	0.62	92.16
	(10.1)	(10.9)	(1.4)	(5.3)	(3.3)	(7.5)	(4.8)	(9.1)	(6.5)	(6.6)	(1.9)	(9.0)
13	14.17	83.57	0.66	1.31	2.79	0.61	90.81	6.32	2.10	9.22	1.36	86.97
	(10.8)	(11.7)	(1.4)	(5.9)	(5.9)	(3.4)	(8.4)	(6.1)	(7.0)	(7.7)	(2.3)	(10.0)
15	14.11	83.28	0.59	2.00	2.88	0.96	87.68	8.91	1.98	11.25	1.87	85.19
	(10.7)	(11.8)	(1.6)	(5.5)	(6.2)	(4.1)	(9.1)	(7.5)	(7.1)	(9.3)	(2.8)	(10.9)

Note: γ_t, τ_t, ω_t, *and* δ_t *denotes climate shock, employment shock, health outcome shock, and output shock, respectively. Standard errors are reported in parentheses. Approximate standard errors were computed using the Monte Carlo simulations with 1000 replication.*

The variance decomposition result for health outcome shows that it is more responsive to its own shock in the first quarter (96.81%).Climate and output shocks do not contribute in the first quarter, while shock as a result of employment rate contributed 2.47 percent. Health outcome own shock variation which stood at 96.81 per cent in the first quarter fell to 87.68 per cent in the 15th quarter. This is followed by output shock which increased to 8.91 per cent.Climate shock also increased to 2.88 per cent which indicated that output shock contributed more to health outcome compared to climate change.

The FEVD for GDP per capita (GR) showed that its more responsive to its own shock in the first quarter (86.52%), shock to employment rate contributed 13.06 per cent while climate shock and shock to health outcome contributed marginally. The own shock variation in GR fell to 85.19 per cent in the 15th quarter.The contribution to shock as a result of employment rate decreases to 11.25 per cent, while climate shock and shock to health outcome increase to 1.98 and 1.87 per cent respectively.

5. Concluding Remarks

Nigeria is home to diverse ecological zones and a wide range of economic activities which can affect can be influenced by climate change. While the country has shown it commitment to reduce emissions (greenhouse gas) unconditionally by 20 percent, and 45 percent via international support, it is imperative to appraise the growth effect of climate in Nigeria. This was the main drive of the study. We employed a structural VAR model to investigate the structural disturbances in climate change, employment, health outcome, and economic growth. Specifically, it appraises the effects of climate shock on employment, health outcome, and economic growth. The specified model allows for 4 shocks hitting the economy.By employing quarterly data between1981 and 2020, the result shows that there is cointegration among our variables which indicate a long run relationship. We obtain some new empirical evidence in Nigeria, indicating that climate shock has impact on employment rate, economic growth and health outcome. Drawing from the above, the Nigerian government needs to intensify efforts in the awareness and adaption of climate policies.With regards to climate change, the adaptation policies should focus on the people and region. This proposition is similitude to the agreement of very common but differentiated obligations arrived at by United Nations Framework Convention on Climate Change (UNFCCC) over environmental equity and global development.Nigeria should conduct a national assessment of climate change vulnerability, impacts, and adaption for quality health and employment to ensure economic growth.

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