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Abstract

The energy industry has been identified as one of the sectors most vulnerable to the impact of climate change. In the past years, government had been making a lot of effort at reforming the energy sector and this study attempted to investigate the extent to which the energy sector will be affected in the face of the threats presented by a changing climate. The study seeks to examine the impact of climate change on energy supply in Nigeria for the period 1971-2011 using the vector error correction procedure. We adopted the Johansen and Juselius, and Engle-Granger co-integration analysis to determine the rank of the series long run co-integration. Also the error correction model was used to obtain the long-run estimates and the speed of error adjustment. We corroborate our findings by adopting the Wald exogeneity test to examine the direction of causal relationship between climate change and energy production. The study found a positive relationship between climate change and energy supply, as well as no evidence of causal relationship between climate change and energy supply. This could be due to the nature of energy production in Nigeria whereby in the process of oil exploration, the associated gas is being flared which is the major contributor to increased CO_2 emission in Nigeria. Findings from the study have implications for the economy in terms of adherence to the Kyoto protocol as it can jeopardize productivity activities and economic gains since policies to curtail emission can affect energy production. Also, adaptation efforts should follow careful scenario analysis with a strengthened institutional framework and injection of funds for technological improvement. This could be done in partnership with international organizations and the private sector.

1.0   Introduction

To what extent will changing climate being experienced all across the globe in various dimension impact the energy industry? What coping strategies or mechanism are available in addressing this critical menace that has been regarded as one of the greatest threat to humanity in the 21st century? These are issues on top agenda for policy makers all around the world. Energy is very vital in driving the growth and development of any economy as it is an essential input to a nation's growth and development (Akinbami, 2009) and also strategic to increasing the competitiveness of any economy (Adenikinju, 2008). The energy sector plays a key and central role in the growth and development of any nation, therefore, the reliable and adequate supply of energy is essential to support economic activities and industrialization efforts that will enhance income and standard of living. This is evident in the fact that any form of shock in the sector automatically reverberates into other sectors of the economy as all the sectors require energy for power. The use of energy is, therefore, a prerequisite for virtually all economic activity, and it is crucial to be able to access sufficient amounts of energy at acceptable cost (both from an economic and environmental perspective), which gives rise to the notion of 'energy security' (Greenleaf et al, 2009).

As stated by Oyedepo (2012), access to energy is a crucial enabling condition for achieving sustainable development.   Thus, adequate access to sustainable energy is vital. The emphasis here is on sustainability which will ensure that energy is produced in an environmentally friendly manner sustainable for future generations. This brings to bear the fact that energy as a key driver of social and economic development must be environmentally friendly to bring about sustainable economic development. According to Oyedepo (2012), the fuel driving the engine of growth and sustainable development is the nation's access to reliable and adequate energy. No economy can sufficiently thrive without adequate access to clean, reliable and affordable sustainable energy. This is in line with the fact that many of the developmental goals set by economies of the world ranging from eradication of poverty, improvement in health status, provision of basic human needs, amongst others, may not be achievable in the absence of a sustainable energy. Onyeji (2010) asserted that Africa's long term economic growth and competitiveness fundamentally depend on reliable access to energy. Given this key role that energy plays in the economy, one of

the threats to its sustainability will be environmental degradation one of which is the incidence of climate change.

In the past, national energy agenda have focused on supply security which has been achieved using domestic resources, however, in recent times, environmental and market liberalization debates continues to increasingly dominate policy and influence the fuel mix in new directions (Chalvatzis and Hooper, 2009). Also, most part of key objectives of many energy policies in various economies entails ensuring environmentally sustainable energy production and use. Others cover stability of energy prices, secure energy supplies and a robust infrastructure for delivery and distribution. It is equally evident that the world economy will require an ever-increasing amount of energy to sustain economic growth, raise living standards and reduce poverty in the coming years and the availability of this in an environmentally friendly environment is what will guarantee its sustainability for the coming generation. In placing Nigeria at the fore front of economic development, adequate supply of energy becomes an issue that cannot be overemphasized. In the study conducted by the Building Nigeria's Response to Climate Change (BNRCC, 2011), the vulnerability of various sectors of the Nigerian economy were presented, showing that virtually all the sectors manifested evidence of vulnerability to climate change; one of which is the energy sector.

This paper examines how the energy industry will be affected by climate change which is regarded as one of the greatest threat to humanity in the 21st century. Considerable efforts have been made in assessing the causal link between energy consumption and economic growth, but very few studies have examined how environmental challenges such as the incidence of climate change will significantly impact energy supply which is regarded as the bane of economic growth. Most researches in the aspect of impacts of climate change on the energy sector are in form of technical reports; some others examine how the energy sector contributes to climate change and not so much on how the energy sector will be affected by the incidence of climate change. This paper will attempt to fill this gap in addition to examining the long run relationship between climate change, proxied by CO2 emissions and energy production.

The rest of the paper is organized as follows: Section two discusses the conceptual issues of climate change, energy supply and changing climate affects the energy sector; Section three presents some stylized facts and trends on some climate change indicators and energy supply in

Nigeria; Section four discusses issues in the literature; Section five presents the model and methodology for the paper; while Section six presents the results and policy recommendations.

2.0   Conceptual Issues: Energy Supply and Climate Change.

2.1 Background

The supply of energy entails the generation, transmission and distribution of energy, notably electricity. Nigeria has an abundant supply of energy resources as it is endowed with thermal, hydro, solar, oil resources and yet still described as an energy-poor country (Ubi and Effiom, 2013). Despite considerable efforts by government and stakeholders to enhance energy supply, the country is still marked with low generating capacity relative to installed capacity. Climate change on the other hand, has been variously defined in the literature to be a definite change in the climatic condition of a region which could be attributed to natural variability and anthropogenic (man-made) activities that persists for an extended period of time. According to the Intergovernmental Panel on Climate Change (IPCC) definition, it is the statistically significant variations that persist for an extended period, typically decades or longer. It includes shifts in the frequency and magnitude of sporadic weather events as well as the slow continuous rise in global mean surface temperature (Ideanyi-Obi et al, 2012). It is regarded as one of the major threats to humanity in the 21st century which has sparked off a lot of policy debate even in the international scene as its impact cuts across different sectors of the economy, one of which is the energy sector. As its effect permeates through all sectors of an economy it thus presents implications for sustainable national development in terms of sustainability, equity and growth (Akinbami, 2009).

Climate change manifests in the form of increasing temperatures and variations in rainfall patterns and the experience of Nigeria in recent times where some parts of the country have been experiencing seasonal droughts and excessive flooding are all indications that the change of climate experience is evident in the country. The Nigerian government acknowledges the importance of developing an appropriate response to the climate change issue and one of the steps taken is the establishment of the National Adaptation Strategy Plan of Action on Climate Change in Nigeria (NASPA-CCN).

Global efforts in addressing climate change started in the 1980s with the First Assessment Report of the IPCC in 1990 and the United Nations Framework Convention on Climate Change (UNFCC) in 1992. Also, in 1997, the Kyoto protocol was another form of measure put in place in tackling the issue of climate change and it was aimed at setting emissions reduction targets for most developed countries. The International Energy Agency (IEA) estimated that about one thousand policies have so far been put in place since 1990 to combat the menace of climate change. So it is clear that significant action is being taken, what is, however, less clear is how effective these actions have been (World Energy Council, 2007). In most of these policies, especially climate and energy security policies are often focused on using the energy industry to tackle climate change by calling for significant reduction in CO_2 emissions (one of the main greenhouse gases (GHGs)). This is in view of the notion that the energy sector is the main contributor to the concentration of GHGs which results to global warming. The energy industry in Nigeria can be said to follow this notion as it is regarded as one of the highest gas-flaring nation and this contributes to climate change. The country, like the rest of Africa is also considered highly vulnerable to climate change impact due to characteristics such as, high exposure and sensitivity to climate change; limited adaptive capacity in its current state of development; and large proportions of the population are subjected to other stresses such as poverty, illiteracy, food security, malnutrition and diseases, all of which could interact with climate change (Enete et. al, 2012) and create problems of sustainability.

Closely related to the issue of climate change are mitigation and adaptation options as measures of policy responses to climate change impacts. On one hand, mitigation talks about efforts at reducing the negative impacts of climate change, while adaptation calls for means of adapting to the effects of climate change. While mitigation is necessary to reduce the rate and magnitude of climate change, adaptation is essential to reduce the damages from climate change that cannot be avoided. Dixon (2003) in Ifeanyi-Obi et. al. (2012) defined adaptation as adjustments in practices, processes or structures in response to projected or actual changes in climate with the goal of maintaining the capacity to deal with current and future changes. In other words, adaptation to climate change refers to activities that reduce the negative impacts of climate change and/or takes advantage of new opportunities that may be presented (Ifeanyi-Obi et al, 2012). With adaptation, differences exist in opportunities and capacity to adapt across regions. Global climate is changing and even dramatic curbs to emissions will not prevent it from

continuing to do so and this raises the question of how economies should adapt to changing climatic conditions (Millner and Dietz, 2011). Today, adaptation is increasingly seen as an essential and integral part of proposed and implemented climate policy (Enete et al, 2012). According to IPCC (2007) report, there is high agreement and much evidence that with current climate change mitigation policies and related sustainable development practices, global GHG emissions will continue to grow over the next few decades. This supports the growing call for adaptation as a policy response to climate change especially in developing countries who are regarded as being most vulnerable to climate change impact (due to unfortunate geography and high sensitivity).

2.2   Impacts on Energy Supply

Scientific reports and researches (CCSP, 2008; BNRCC, 2011; Ebinger and Vergara, 2011; Schaeffer et al, 2011; Beecher and Kalmbach, 2012; US Department of Energy, 2013) made available for policy-makers have predicted that climate change will have adverse effect on the energy sector. The US Department of Energy (2013) asserts that changing climate trends which are expected to continue can restrict the supply of secure, sustainable and affordable energy which is critical to the nation's economic growth. Climate change will significantly affect the energy industry through many ways (Schaeffer et al, 2011). This can happen when rising temperature, irregular precipitation, rise in sea level, among others, affects energy infrastructure and the capacity to mainly produce energy through hydro and thermal sources. BNRCC (2011) asserted that hydropower generation is the energy source most likely to be affected by climate change as it is sensitive to the amount, timing and geographical pattern of precipitation as well as temperature. The report stated further that reduced flows in rivers and higher temperature reduces the capabilities of thermal electric generation as higher temperatures also reduces transmission capabilities. Also, excessive drought will lead to higher evapo-transpiration that adversely affects water volume thereby reducing hydroelectric capacity. Furthermore, climate change-induced extreme weather events such as windstorms and floods will exacerbate the rate of failure of transmission system of electric utilities (BNRCC, 2011).

According to Greenleaf et al (2009), extreme weather conditions can temporarily disable energy infrastructures and thus supply of energy. A recent example is the impact of Hurricane Katrina, which hit the Gulf of Mexico in 2005, disabling a significant portion of the US oil and gas

production and processing capacity. The analysis of this impact is essential due to how climate change engages the energy sector closely been that energy is central both to the problem and the solution. It has been forcing governments to redesign the structure of the world energy system and consumption patterns which have made it imperative to consider more efficient and better ways to ensure energy security. Top on the agenda of policy-makers has been the call for increased optimization of renewable source of energy and adoption of low carbon source of modern energy as possible solutions. Over the years, as a means of tackling the negative consequences of climate change, the energy sector has always been the target of policy-makers as the sector is considered the major contributor to the concentration of greenhouse gases in the atmosphere which results to climate change. The same way the energy system significantly contributes to climate change, so also will climate change manifesting in form of rising sea levels, heavy storms, floods, high winds and shoreline erosion likely affect energy facilities and infrastructure.

According to the Climate Change Science Program (CCSP, 2008) report, concerns about climate change impacts could change perceptions and valuations of energy technology alternatives, any of which could have implications for energy policies, decisions, and institutions in the United States, affecting discussions of courses of action and appropriate strategies for risk management. Also as indicated in the BNRCC (2011) report, climate change will most likely negatively impact the already limited electric power supply through its impact on hydroelectric and thermal generation coupled with service interruption which is expected to result from damage to transmission lines and substation equipments being damaged by sea level rise, flash floods and other extreme weather events. Thus, calls towards addressing climate change impacts on energy system often focuses on the optimization of renewable energy and low carbon development as prominent possible solutions. It is important to note that the problems affecting energy sector in developing countries differ from the problems that influence the same energy sector in developed countries (Oricha and Olarinoye, 2012) and with the threat of climate change, the nature of these impacts will differ as well.

In assessing the impact of climate change on the energy industry in United States, the US Department of Energy stated that three main climate trends are relevant to the energy sector and

they include increasing air and water temperatures, decreasing water availability in some regions and increasing intensity and frequency of storm events, flooding and sea level rise. Also, the impact of climate change on the energy sector is often assessed in form of impacts on energy supply, demand, transmission, distribution and infrastructure; or indirect effects through other economic sectors. The most common aspect often analyzed in empirical literature is the demand and supply side. While the demand side examines climate change effects on use of energy by consumers, the supply side considers the effects of climate change on production, distribution and transmission of energy. The focus of this study would, however, be on energy supply. The relationship between climate change and the energy sector is important especially considering the bi-directional flow between the two, where as energy use and production contributes to climate change, policies are also targeted towards the energy industry in tackling the climate change menace. With the energy sector been one of the key sectors most vulnerable to climate change impact, coupled with the current epileptic nature of energy supply in Nigeria, there is a need to explore how energy supply will be affected in the face of the threats presented by climate change. This is given the aim of government at increasing electricity generation capacity to 25,000MW by 2020 from the current installed capacity of 6500MW while also pledging to connect 75 per cent of the population to the grid from the current 40 per cent by 2025 (Gujba et al, 2010).

3.0   Stylized Facts

This section presents some facts and trends in climate change and energy supply in Nigeria. Nigeria is blessed with an abundant reserve of energy resources as presented in table 1 below and these ranges from oil, natural gas, water, solar, to wind energy amongst others. Nigeria sits astride of over 35 billion barrels of oil, 187 trillion cubic feet of gas, 4 billion metric tons of coal and lignite, as well as huge reserves of tar sands, hydropower and solar radiation among others (Adenikinju, 2008). Unfortunately, the country has not been paying adequate attention towards the development of these essential energy resources which results in underutilization. Rather, as asserted by Adenikinju (2008), the attention had been concentrated on the development, exploitation and utilization of crude oil and gas for fiscal objectives. This is supported by Osueke and Ezeh (2011) who stated that only four sources of energy resource (coal, crude oil, natural gas

and hydro) are currently being utilized in processed forms while two others (wood fuel and solar) are used in their crude forms for heating, cooking and lighting.

Table 1: Nigeria's energy reserves/capacity as in December 2005

Resource type	Reserves	Reserves (BTOE)[c]	Reserves $(X10^7)$TJ
Crude oil	36.2 billion	barrels	20.499
Natural gas	166 trillion SCF[a]	4.465	18.694
Coal and Lignite	2.7 billion tonnes	1.882	7.879
Tar Sands	31 billion barrels of oil equivalent	4.216	17.652
Subtotal Fossil		15.459	64.724
Hydropower. Large scale	11,000MW		0.0341/year
Hydropower, small scale	3,250MW		0.0101/year
Fuel wood	13,071,464h[a]		
Animal waste	61 million tonnes/year		
Crop residue	83 million		
Solar radiation	3.5 to 7.0 kwh/m^2/day		
wind	2 to 4 m/s (annual average) at 10m in height		

[a] SCF→ standard cubic feet, [b] Forest land estimate for 1981, [c] BTOE billion tones of oil equivalent
Adapted from Oyedepo (2012)

Also, a close examination of electricity sources for Nigeria and four other countries compared, showed that in both periods, natural gas represented the highest percentage of all the electricity sources closely followed by hydropower. This is presented in table 2. A key point here is that natural gas being the leading source of electricity and as one of the fossil fuels, will have implication for environmental quality.

Table 2: Electricity Sources as percentage of total electricity produced in Nigeria

Year		Coal	Hydro	Natural gas	Nuclear	Oil	Renewable
Nigeria-	1990	0.10	32.59	53.65	0	13.67	0
	2010	0	24.40	64.29	0	11.3	0
South Africa-	1990	94.28	0.61	0	5.11	0	0
	2010	94.23	0.82	0	4.71	0.08	0.16
China-	1990	71.27	20.40	0.44	0	7.88	0.01
	2010	77.24	17.16	1.64	1.76	0.32	1.67
Brazil-	1990	2.13	92.77	0.14	1.01	2.22	1.73
	2010	2.33	80.55	7.07	2.82	3.11	3.28
India-	1990	66.20	24.76	3.44	2.12	3.47	0.01
	2010	67.11	11.92	12.01	2.73	1.77	4.44

Compiled from World Development Indicators (WDI) of World Bank
Adapted from Ogundipe and Adebayo (2014)

It is a known fact that Nigeria's energy demand far outstrips its supply. Even with a population of about 148 million people, only about 51 per cent (WDI 2010 estimate) have access to electricity in Nigeria as against the 76 per cent and 61 per cent for South Africa and Ghana respectively. Most of this electricity is provided by standby generating sets acquired by industries, commercial establishments and individuals. This is evident as the Nigerian energy sector is marked by low generating capacity relative to installed capacity as current generation capacity ranges between 2,500 megawatts to about 3,000megawatts while estimated national consumption is in excess of 10,000 megawatts (Ubi et al, 2012). Despite electricity generation increasing from about 532 MW in 1972 to about 6500 MW in 2005, electricity supply is estimated to still be far below the estimated demand of 10,000 MW (Gujba et al, 2010). A number of factors have been attributed to this inadequate utilization of energy capacity, some of which includes low development in the sector, inadequate funding, mismanagement and lack of maintenance. Present government is however, aiming at increasing power generation capacity from the current 6500 MW to 10000 MW by 2010 and over 25000 MW by the year 2020; with about 75 per cent of the population being supplied electricity by 2025. Gujba et al (2010) however pointed out that these plans will inevitably lead to disruptive changes in the energy systems in terms of environmental, economic and social impacts.

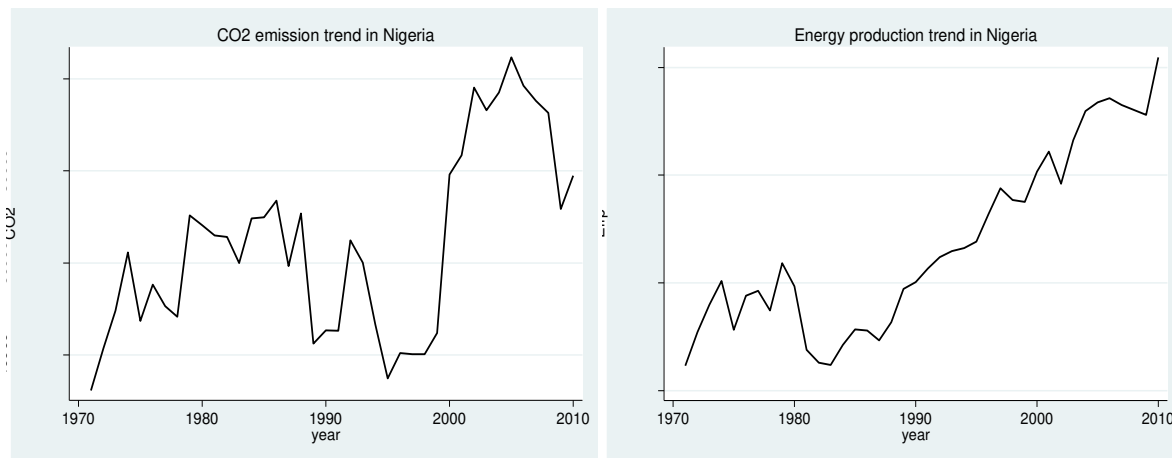Figure 1: CO_2 emission and Energy Production Trend.

Figure 1 above shows the trend of co_2 emission and energy production from 1970 to 2010 and it can be observed that from the 1980s, energy production was on the rise with co_2 emissions fluctuating.

Variations in weather conditions being experienced in Nigeria, coupled with future estimates of changing climate, shows that climate change is indeed here. The Nigeria Meteorological Agency (NIMET, 2008) assessed the Nigerian climate over the period 1941 to 2000 and identified some changes (BNRCC, 2011). The report showed that some regions, notably northeast, northwest and southeast experienced late onset of rains for the period 1941 to 1970, but from 1971 up on until 2000, many other parts of the country had begun experiencing late onset of rains. Also, climate scenarios used for projecting future climate showed that changing climate will keep increasing.

Table 3: Projected Key Climate Change Parameters by ecological zone

Climate variables	Mangrove zone	Rain forest	Tall grass (savanna)	Short grass (Sahel)
Temperature	↑	↑	↑	↑
Rainfall amount	↑	↑	↓	↓
Rainfall variability	↑	↑	↑	↑
Extreme rainfall events - droughts	Likely	Likely	↑	↑
Extreme rainfall events – storms and floods	↑	↑	Likely	Likely
Sea level rise	↑	NA	NA	NA

Legend: ↑ likely increase or increase; ↓ likely decrease or decrease; NA not applicable.
Source: BNRCC (2011)

This shows that for most of the regions in Nigeria, rainfall and temperature will tend to be on the increasing side which supports the many calls for adaptation strategies to be put in place.

Also, between 1970 and 2003, CO_2 emissions, one of the main GHGs grew by about 80 per cent. As stated in Alege and Ogundipe (2013), the High Emission Scenario (HES) suggests that by 2025, Ghana, Nigeria and Sierra Leone will emit 4.4, 54 and 1.2 million tons of carbon respectively which would amounts to seven, six and four folds increase over present emissions. Scientists have noted that the average temperature of the earth has increased by 0.74 degrees Celsius over the past 100 years and if nothing is done, there is going to be more rise in the earth's temperature to the extent that it would be difficult to cope with it (Ifeanyi-Obi et al, 2012).

4.0   Brief Review of Literature

A number of factors affect adequate supply of energy in Nigeria which according to Ubi et al (2012) is the key constraint to industrialization and economic development in Nigeria. This, was attributed to the inability of policy makers to identify the determinants of electricity supply for actual policy formulation and implementation. Also, low level of investment in the electricity

sector equally contributes to low generating capacity of the Power Holding Company of Nigeria (PHCN) in Nigeria (Ubi et. al, 2012). Iwayemi (2008) attributed the poor supply of electricity to high levels of power and revenue losses, both technical and non-technical. In the same vein, Ubi et al (2012) recognized the nature of the energy mix and state of technology in Nigeria to be major determining factors for the supply of energy. However, with all these factors and coupled with recent reports on the vulnerabilities of the energy sector to climate change, changing climate can tend to be a determining factor.

In empirical research, considerable attention has been given to climate change and how it impacts the various sectors of an economy (such as agriculture, construction, health, energy, law, poverty, gender, and so on). However, in the area of energy and climate change, a limited number of studies are available as most studies focus on how the energy sector significantly contributes to the concentration of GHGs in the atmosphere leading to global warming and the relationship between energy consumption and CO_2 emissions. In examining the relationship between energy and its environmental implications, many focus on assessing the linkages among electricity supply, carbon emissions and economic growth (Madison and Rehdanz, 2008). A number of the researches in the area of climate change impacts on the energy sector are often in form of reports prepared for policy makers in various countries. These reports provide informative reviews on specific segments in the energy sector and how vulnerable they will be to the effects of climate change. There is the Climate Change Science Programme (CCSP) Synthesis and Assessment Report (2012) which builds on two previous assessment implications by the CCSP Synthesis and Assessment Report (2007) and the USGCRP Global Climate Change Impacts in the United States (2009). It presents a summary of the currently existing knowledge especially emerging findings since 2007 about implications of climate change for energy use, energy supply (oil and gas, thermal electricity, renewable energy, integrated perspectives and indirect impacts on energy systems) and also future risk management strategies, research gaps and movement towards a self-sustained continuing assessment capacity.

The World Energy Council (WEC; 2007) report examined the impact of existing climate change measures and how they have been in promoting sustainable development, using the "3A's" criteria (accessibility, acceptability and availability). Looking at what drives greenhouse gas emissions from the energy sector and how the policies introduced has so far fared, the WEC

study concludes that government and others have not been up to the challenge. Policies have been too narrowly focused and short term, failing to provide the right signals for cleaner and more sustainable investment. The WEC report showed that no single policy or measure can provide the whole solution or even the main part of the solution as all available measures have their own drawbacks and advantages. Mideksa and Kallbekken (2010) reviewed the impact of climate change on the electricity market by looking at current and existing knowledge on how electricity demand and supply would be affected by climate change.

Schaeffer et al (2011) presented a review of the energy sector vulnerability to climate change impacts throughout the energy chain by examining contributions of a number of authors in this field. Chalvatzis and Hooper (2009) provided a comprehensive theoretical base for the assessment of supply security at the national level and the impact of climate change related regulations for selected European Union countries (Germany, Greece, Poland and the UK). Their study provided insights and suggestions that allow for an improved understanding of the trade-offs and synergies that various policy options may introduce. The report by Greenleaf et al (2009) also indicates that the introduction of a number of climate change policies in the EU will change the structure of the energy system significantly. Matsuo et al (2012) used the MARKAL model which is a linear programming model for energy system analyses, to find the effects that constraints on CO_2 emissions will exert on the world's energy supply, demand, structure and costs for OECD and non-OECD regions.

For Nigeria, a limited study however exists. Akinbami (2009) assessed the implication of the climate change and energy system interactions for sustainable development in Nigeria, calling for a more proactive action by government in terms of mitigation technologies. Enete and Alabi (2011) also examined the influence of climate change on power generation by reviewing key literatures in this area and found indications that climate change undermines power and energy production by increasingly depleting renewable and non-renewable sources. They however proposed that in reducing climate-induced threats on power sector, efforts should be geared towards ensuring that the energy sector is able to withstand the changes to climate by optimizing energy mix, developing low carbon and renewable energy. In the same vein, Nnaji et al (2013) investigated the causal relationship among electricity supply, fossil fuel consumption, CO_2 emissions and economic growth in Nigeria for the period 1971-2009 in a multivariate network.

Their findings indicated that economic growth is associated with increased CO_2 emissions while a positive relationship exists between electricity supply and CO_2 emissions, revealing the poor nature of electricity supply in Nigeria.

As asserted by Nnaji et al (2013), existing literature on energy-economy-environment link over the past two decades indicates that most studies focused on the nexus of energy-economy or environment-economy with controversial and inconclusive results. Gujba et al (2010) set out to analyze the implications of the Nigeria energy policy in Nigeria, presenting the life cycle environmental and economic analysis of the current and future electricity sector. There analysis showed that all the life cycle impacts and economic costs increase significantly over the time period studied where renewable sources proposed by government were recognized to reduce environmental impacts of electricity mix. However, this will require a five-fold increase in grid investments by 2030.

Another solution often advocated for tackling impacts of climate change on the energy system is the adequate mix of energy. This Uzoma et al (2012) related with sustainable development in Nigeria and asserted that no single energy mix can sustainably meet the energy demands of any country. Therefore, integrating all exploitable energy resources is a viable way of achieving stability in energy supply in Nigeria. Using linear regression(Ordinary Least Square) estimation procedure, they found that existing energy mix has not significantly influenced sustainable development given that electricity generation is inadequate and coal is no longer in use. Ubi and Effiom (2013) who explored the relationship between electricity supply and economic growth in Nigeria found per capita GDP, lagged electricity supply, technology and capital to be significant variables that influence economic development in the country.

Ubi et al (2012) carried out an econometric analysis of the determinants of electricity supply in Nigeria using a parametric econometric methodology of OLS and their results showed technology, government funding and the level of power loss to be the statistically significant determinants. Adenikinju (2008) examined the efficiency of the energy sector in enhancing competitiveness of the Nigerian economy. In addition, Oricha and Olarinoye (2012) analysed the interrelated factors affecting efficiency and stability of power supply in Nigeria. Some of the factors highlighted include government policy, economic factor, natural factor, community factor, effective energy management, skilled personnel, efficient technology and security factor.

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In terms of adaptation options, Ebinger and Vergara (2011) focused on energy sector adaptation rather than mitigation in examining how the energy sector might be impacted by climate change and the options available for management. Evidence from their study showed that energy services will be increasingly affected by climate change. On the other hand, Akinbami (2009) recognized the currently commercially available mitigation strategies to include improved supply and distribution efficiency in the power and oil and gas sector, fuel switching from coal to gas, nuclear power, renewable sources (hydropower, geothermal, solar, wind and biomass).

5.0   Methodology

This section presents the model, methodology and data sources of energy supply and climate change. The study adapted a model similar to Ubi et al (2012); the theoretical framework of the model as used by Ubi et al (2012) is rooted in the basic elementary theory of supply. In this study, the elementary supply theory is augmented in order to capture specific uniqueness of the Nigerian economy and to appropriately ascertain the determinants of energy production in the context of weak institutional quality. An application of the model can be represented as follows

$$Eprd = f(clmc, gpci, pwls, invt, estr, tech, inst)$$

The model above can be specific in its explicit form showing the various parameters to be estimated empirically

$$Eprd_t = \beta_0 + \beta_1 clmc_t + \beta_2 gpci_t + \beta_3 pwls_t + \beta_4 invt_t + \beta_5 estr_t + \beta_6 tech_t + \beta_7 inst_t + \varepsilon_t$$

Where $Eprd_t$ is energy production measured in kilowatt tons of oil equivalent, $clmc_t$ is carbon dioxide emissions in metric tons per capita, $gpci_t$ is GDP per capita, $pwls_t$ is the power production and distribution losses, $invt_t$ is investment is government funding, $estr_t$ is a measure of the economic structure, $tech_t$ is the level of technology, $inst_t$ measures the strength of institutional quality and ε_t captures the stochastic term.

Since energy production entails the process of generating, distribution and supply of energy to the end users, the inclusion of power losses, $pwls_t$, is relevant in the model as share of power losses in total power produced linger around 40 percent to 45 percent in the period 1990-2010. The parameter β_3 of the variable is expected to be negative, as continuous power losses impede the amount of energy available for consumption. According to Oyedepo (2012), per capita energy consumption is a measure of the per capita income as well as a measure of the prosperity

of a nation. It implies that demand for energy tends to rise with rapid population growth and increase in the standard of living of the society; this hereby necessitate the inclusion of GDP per capita in determining the level of energy production. Therefore, the parameter β_2 is expected to be positively related with energy production. In the same manner, energy has been adjudged a major driving force of SMEs and socio-economic development of the emerging economies. Since energy also fuels productive activities like commerce, manufacturing and industry, the structure of an economy with respect to concentration of either manufactured or commodity export determines the extent of investment channel towards energy production and adapting of new energy sources; also weak institutions and regulatory quality has thwarted the minimal investment effort in the energy sector. It therefore implies that the parameters $\beta_4, \beta_5, \beta_7$ can either be positive or negative. If the parameters are negative, it implies an unproductive investment, economic concentration on primary export and weak institutions respectively. Finally, energy production has been impeded by frequent breakdown arising from the use outdated and heavily loaded equipments. Though, Nigeria is described primarily as an energy store house accommodating resources such as coal and lignite, natural gas, crude oil, solar, hydro, nuclear, woodfuel, geothermal, tide, biogas and biomail. In spite of the available vast resources, only three sources (crude oil, natural gas and hydro) are currently utilized in processed forms while two others (woodfuel, coal, solar etc) are used in their crude forms for heating, cooking and lighting (Ogundipe and Apata, 2013). There is need to develop appropriate technologies needed to diversify energy sources, adopt new available technologies to reduce wastages and save cost. From the foregoing, we expect the parameter β_6 to be positive.

5.1   Technique of estimation

In an attempt to investigate the effect of climate change on energy production in Nigeria, the study shall adopt the vector error correction procedure. Here, the co-integration analysis based on the Johansen and Juselius approach and Engle-Granger two step analyses was conducted to ascertain the long run equilibrium relationship in the model. Hence, we proceed to estimate the error correction mechanism in order to obtain the speed of error adjustment in long run convergence. Finally we estimate the vector granger causality test in order to determine the directional of causal relationship among the variables specified in the model, especially between the regressor and regresands in the system.

5.1.1 Unit Root Test

Since most economic variables used for policy analysis and forecasting are characterized by persistence and possibly non-stationary behavior. It becomes pertinent to subject these series to pre-test for unit roots in order to determine the appropriate transformation that renders the data stationary (Gospodinov et al, 2013). In accessing the unit root properties, we assume a random walk model (RWM):

$$Y_t = \rho Y_t + u_t \qquad\qquad\qquad -1 \leq \rho \leq 1$$

Where Y_t is a vector of the variables specified in the model, such that, $Y_t = \begin{Bmatrix} Eprd_t \\ clmc_t \\ gpci_t \\ pwls_t \\ invt_t \\ tech_t \\ inst_t \end{Bmatrix}$

In the equation above, we simply regress Y_t on its one-period lagged value Y_{t-1} and find out if estimated ρ is statistically equal to 1; if the latter condition is satisfied, then Y_t is stationary. For ease of estimation of the equation above using OLS, it is hereby transformed as follows:

$$\Delta Y_t = \delta Y_{t-1} + u_t$$

Where $\delta = (\rho - 1)$ and Δ represents the first difference operator. We proceed to estimate equation above and test the null hypothesis that $\delta = 0$, and the alternative hypothesis that $\delta < 0$. if $\delta = 0$, then $\rho = 1$; this implies the existence of a unit root and suggests that the series is non-stationary. Based on the model above, Dicky and Fuller (1979) provided an alternative decision making using critical values of tau statistics on the basis of Monte Carlo Simulations. The Dicky-fuller test assumed that the error term u_t was uncorrelated, but in situation where u_t are correlated; an advanced unit root test was developed known as the augmented Dickey-fuller (ADF) test. The study adopted this new variant of unit root test in order to select appropriate lag length required to overcome the problem of serial correlation in the error term. The ADF test augments the equation above by including the lagged values of the dependent variable ΔY_t.

$$\Delta Y_t = \beta_1 + \beta_2 t + \delta Y_{t-1} + \sum_{i=1}^{m} \alpha_i \Delta Y_{t-i} + \varepsilon_t$$

Where $\Delta Y_{t-1} = (Y_{t-1} - Y_{t-2})$, ε_t is a pure white noise error term. The number of lags to be included is determined empirically. Often times, researchers include the required number of lags

necessary to ensure that the error term is serially uncorrelated and leading to an unbiased estimate for δ (the coefficient of lagged Y_{t-1}).

However, the Philip perron test uses nonparametric statistical methods to take care of the serial correlation in the error terms without adding lagged difference terms. Both ADF and PP share similar asymptotic distribution.

5.1.2 Johansen Co-integration test

The Johansen methodology takes its root in the vector autoregressive (VAR) of order p given by:

$$Y_t = N + A_1 Y_{t-1} + \ldots\ldots\ldots\ldots\ldots + A_p Y_{t-p} + \varepsilon_t$$

Where Y_t is an $n * 1$ vector of variables that are integrated of order one (denoted as I(1)) and ε_t is an $n * 1$ vector of innovations. The VAR specification can be represented as follow:

$$\Delta Y_t = \mu + \pi_{y_{t-1}} + \sum_{i=1}^{p-1} \Gamma_i \Delta y_{t-1} + \varepsilon_t$$

Where $\Pi = \sum_{i=1}^{p} A_i - I$ and $\Gamma_i = -\sum_{j=i+1}^{p} A_j$

If the coefficient matrix Π has reduced rank $r < n$, then there exist $n * r$ matrices α and β each with rank r such that $\Pi = \alpha\beta'$ and $\beta'Y_t$ is stationary. r is the number of co-integrating relationships, the elements of α are known as the adjustment parameters in the vector correction model and each column of β is a co-integrating vector. The Johansen approach proposes two different likelihood ratio tests of the significance of these canonical correlations and thereby the reduced rank of Π matrix. The trace test and maximum eigenvalue test statistics are shown below:

$$J_{trace} = -T \sum_{i=r+1}^{n} \ln(1 - \lambda_i)$$

$$J_{max} = -T \ln(1 - \lambda_{r+1})$$

Where T is the sample size and λ_i is the $i: th$ largest canonical correlation. The trace test tests the null hypothesis of r cointegrating vectors against the alternative hypothesis of n cointegrating

vectors while the maximum eigenvalue test tests the null hypothesis of r co-integrating vector against the alternative hypothesis of $r + 1$ cointegrating vectors. The Johansen methodology as modified by Johansen and Juselius (1990) gives asymptotic critical values, the critical values as used by the maximum eigenvalue and trace test statistics are based on a pure unit root assumption. The test statistics will no longer be correct if variables in the system are near unit root processes (Hjalmarson and Osterholm 2007). For the purpose of ensuring robustness, the engle-granger two step procedure was adopted to corroborate the findings from the Johansen methodology.

5.1.3   Error Correction Model

The error correction model is a dynamic system with the characteristics that deviation of the current state from its long run relationship will be fed into the short run dynamics. The Error Correction Model (ECM) are category of multiple time series models that directly estimate the speed at which the dependent variable, $Eprd_t$, returns to equilibrium after a change in the independent variables. The basic structure of the error correction model is demonstrated below:

$$\Delta Y_t = \alpha + \beta \Delta X_{t-1} + \beta EC_{t-1} + \varepsilon_t$$

Where EC is the error correction component of the model and measures the speed at which prior deviations from equilibrium are corrected.

5.1.4   Granger Causality test

We employ the granger causality test for determining whether one time series is useful in forecasting another. A variable x is said to granger cause another y if past values of x help predict the current level of y given all other appropriate information. Two variables may be contemporaneously correlated by chance but it is unlikely that the past values of x will be useful in predicting y, given all the past values of y, unless x does actually cause y in a philosophical sense. Similarly, if y in fact causes x, then given the past history of y it is unlikely that information on x will help predict y. Granger causality is not identical to causation in the classical philosophical sense, but it does demonstrate the likelihood of such causation or lack of such causation more forcefully than does simple contemporaneous correlation (Geweke, 1984). The model for granger causality test requires estimating the following:

$$Y_t = \beta_{1,0} + \sum_{i=1}^{p} \beta_{1i} , y_{t-1} + \sum_{j=1}^{p} \beta_{1,P+j} X_{t-j} + \varepsilon_{1t}$$

$$X_t = \beta_{2,0} + \sum_{i=1}^{p} \beta_{2i} , y_{t-1} + \sum_{j=1}^{p} \beta_{2,P+j} X_{t-j} + \varepsilon_{1t}$$

Where p is the number of lags that adequately models the dynamic structure so that the coefficient of further lags of variables are not statistically significant and the ε is the white noise. If the p parameters $\beta_{1,P+j}$ are jointly significant then the null hypothesis that X does not Granger cause Y can be rejected. Similarly, if the p parameter $\beta_{2,i}$ are jointly significant then the null hypothesis that Y does not Granger cause X can be rejected.

5.2 Data sources and Measurement

The study covers the period of 1970 to 2012 using annual time series data from the World Bank Development Indicators (WDI) of the World Bank, the World Governance Indicator (WGI) of the World Band, United Nations Conference on Trade and Development (UNCTAD) and data market of Iceland available at http://datamarket.com/.

Table 4: Data sources and measurements

Variable	Symbol	Sources	measurement
Energy production	*Eprd*	World Development Indicators (WDI)	Kilowatt tons of oil equivalent
Climate change	*Clmc*	World Development Indicators (WDI)	CO_2 emissions in Kilowatt tons
GDP Per Capita	*Gpci*	World Development Indicators (WDI)	Constant $US
Power losses	*Pwls*	World Development Indicators (WDI)	Units
Economic structure	*Estr*	UNCTAD	Share of primary export in total merchandise export
Technological level	*Tech*	Data market of Iceland	Number of fixed and mobile telephone line subscriber
Institution quality	*Inst*	World Governance Indicators	Estimates of governance effectiveness

6.0 Discussion of Results

This section presents the results obtained from the empirical investigation of the model specified earlier. We begin the section by examining cross correlation among our explanatory variables. The study adopted the pair wise correlation matrix and the variance inflation factor to test for the existence collinear relationship among the explanatory variable (see table 5 & 6). The results

readily available indicate that multicollinearity does not exist in the model; hence the estimates from the model can be relied upon.

Table 5: Pairwise Correlation Matrix

variable	dlinvt	dlgpci	dlpwls	dlestr	dltech	dlclmc	dinst
dlinvt	1.0000						
dlgpci	0.1165	1.0000					
dlpwls	-0.1312	0.0944	1.0000				
dlestr	0.0066	0.1685	-0.0540	1.0000			
dltech	-0.1981	0.0777	-0.2333	-0.1333	1.0000		
dlclmc	-0.3591	-0.0114	0.1817	0.0313	0.1350	1.0000	
dinst	0.0847	0.1946	0.0915	0.0044	0.1486	0.0607	1.0000

Source: Computed by authors using stata 10.0

As seen in table 5, correlation among the explanatory variable is seen to be weak with the maximum being around 19% between institution quality and GDP per capita. A high or perfect collinear relationship among explanatory variables tends to be very problematic and violates the basic classical assumption of regression model. The variance inflation factor and tolerance factor, as contained in table 6, confirms the evidence of no perfect collinearity obtained using the pair wise correlation in table 5.

Table 6: Variance Inflation Factor

Variable	Vif	1/vif
dlinvt	1.25	0.7996
dlgpci	1.24	0.8068
dlpwls	1.20	0.8348
dlestr	1.19	0.8400
dltech	1.12	0.8959
dlclmc	1.09	0.9148
dinst	1.08	0.9295

Source: Computed by authors using stata 10.0

We start the empirical process by examining the time series properties of the variables used in the model by conducting a unit root test based on Augmented Dickey Fuller (ADF) and Philip Perron (PP) procedure. These procedures tests whether a time series variable is non-stationary using an autoregressive model. Both ADF and PP test tests the null hypothesis of the existence of unit root in the variables.

Table 7: Stationary Test

Variables		Level		First Difference	
		ADF	PP	ADF	PP
DLEPRD		-0.2931	-0.1380	-6.5260	-6.6265
DLINVT		1.8277	-0.6035	-7.8306	-7.9160
DLGPCI		2.7735	6.8488	-7.0016	-4.4505
DLPWLS		-2.1522	-2.0099	-9.2644	-9.4996
DLTECH		3.0842	1.5172	-13.1128	-2.4549
DLESTR		-4.1556	-4.0509	-7.5693	-12.9083
DLCLMC		-2.1518	-2.0783	-7.7262	-7.9352
DINST		-2.8668	-2.8897	-6.7628	-6.8290
Critical	1%	-3.6010	-3.6010	-3.6056	-3.6056
Values	5%	-2.9350	-2.9350	-2.9369	-2.9369
	10%	-2.6058	-2.6058	-2.6069	-2.6069

Note: ADF- Augmented Dickey Fuller test, using lag length of 1 and SIC maxlag of 9
          PP- Phillip Perron test, bandmoth of 3 (newey-west automatic) using Bartlett kernel

H_0: there is unit root and time series is non-stationary $K = 0 \rightarrow (1 - \Psi) = 0$
H_1: there is no unit root and time series is stationary $K < 0 \rightarrow (1 - \Psi) < 0 \rightarrow \Psi < 1$

As indicated in table 7, all the variables were not stationary at level except the indicator of economic structure. This implies the existence of unit root at I(0) and we failed to reject the null hypothesis; this is not unexpected as most economic variables exhibit a very high persistence and non-stationary behavior. In order to obtain a stationary behavior, we subjected the series to differencing and obtain stationary for all the variables at first order of integration, i.e. I(1). Hence, we reject the null hypothesis and accept the alternative of pure unit root processes. This process of differencing our series to obtain stationary series becomes imperative in order to avoid spurious regression and biased estimates that could mislead policy analysis and forecasting.

Having obtained a stationary series, we hereby proceed to ascertain the long run stationary of our model using Johansen co-integrating rank test, and the Engle-granger residual stationary test. These two tests confirm the existence of a unique co-integrating equation in the model. We are able to ascertain this by using the trace statistics and the residual stationary test as specified in the Johansen rank test and Engel-granger residual test respectively. As contained in table 8, there exists a unique co-integrating vector at 5 percent level of significant for the trace statistics while the maximum eigenvalue statistics could not produce a unique co-integrating vector. In accordance to the trace statistics, the Engle-granger technique reveals the existence of long run equilibrium relationship; the relationship holds sway even with interacted variable.

Table 8: Co-integration test

Johansen and Juselius Maximum likelihood Co-integration Rank test					
Eigen value	Trace statistics	Max. statistics	CV@5% Trace	CV@5% Max.	Hypothesized No. of CE(s)
0.864302	242.9249	77.89549	169.5991	53.18784	None*
0.681501	165.0294	44.62133	134.6780	47.07897	At most 1
0.653618	120.4081	41.34830	103.8473	41.07897	At most 2
0.561257	79.05976	32.12935	76.97277	32.12985	At most 3
0.410223	46.92990	20.59239	54.07904	20.59239	At most 4
0.314611	26.33751	14.73296	35.19275	14.73296	At most 5
0.194798	11.60455	8.449799	20.26184	8.449799	At most 6
0.077706	3.154751	3.154751	9.164546	3.154751	At most 7
Engle-Granger Co-integration Residual long-run test					
Variable	coefficient	Std. error	t-statistics	CV @ 1%	CV @ 5%	Prob.*
ECM (-1)	-0.9702	0.1586	-6.1179	-3.6056	-2.9369	0.0000
C	-0.0022	0.0104	-0.2121			0.8332
Engle-Granger Co-integration Residual long-run test (with interacted variable)					
Variable	coefficient	Std. error	t-statistics	CV @ 1%	CV @ 5%	Prob.*
ECM (-1)	-1.0032	0.1558	-6.4391	-3.6056	-2.9369	0.0000
C	-0.0030	0.0109	-0.2799			0.8332

Source: Computed by authors using eviews 7.0

Table 9 reveals the result of the long run normalized coefficients which indicate the magnitude and pattern of long run equilibrium behavior of our model. Here, the table shows an evidence of a significant inelastic response of climate change on energy production. This implies that a change in climatic condition brings about a less proportionate change in the level of energy produced. In the same manner, a positive relationship exists between climate change and energy production. The sign of the indicator of climate change failed to confirm to our apriori expectation, and this might not be unconnected to the recent heavy reliant on crude oil and natural gas (thermal) as the major source of energy in Nigeria, and since gas flaring still remain predominant in Nigeria; it therefore implies that the process of extracting and refining more oil also leads to greater emission. Also another strand of argument that could have generated the result obtain is centered on the fact that inadequate power supply has necessitated domestic and household reliant on power generating plants which has recently constituted a major source of urban pollution in Nigeria. As indicated in the result of table 9, the long-run elasticity of energy production growth with respect to climate change is 0.38 percent, indicating that for each observable change in climate, energy production growth rise by 0.38 percent. This result

confirms to the findings of Nnaji, *et al (*2013); Chebby and Boujelbene (2008) and Omisakin (2009) as observed in studies conducted in Nigeria and Tunisia.

Table 9: Normalized co-integration estimates

Co-integrating coefficient normalized on Energy Production								
DLEPRD	DLINVT	DLGPCI	DLPWLS	DLTECH	DLESTR	DLCLMC	DINST	C
1.000000	0.0391	-0.3810	0.1222	0.0876	-0.3828	-0.3536	-0.5105	0.0197
	(0.0176)	(0.0536)	(0.0211)	(0.0245)	(1.4088)	(0.0485)	(0.0965)	(0.0107)
Prob.*	2.22	-7.11	5.80	3.58	-0.27	-7.29	-5.29	1.84

Source: Computed by authors using eviews 7.0
Note: Since the Johansen co-integation test assumes all variables as endogenous, we alternate the signs of the magnitudes.

In order to control for the role of institutions, we attempted an interaction of the indicator of climate change with institutions (governance effectiveness) to generate a new variable *(clmc_inst)*. The interacted variable, *clmc_inst*, share similar features with the actual climate change indicator; it impacted a significant inelastic variation on energy production, though it impacted a lesser proportionate change on energy production than actual climate change. It hereby implies that strengthening of institutional quality can mitigate the impact of climate change on energy production. Also from table 10, it is obvious that investment, though statistically significant it however varies negatively with energy production. This could be deduced from the insufficient funding, gross mismanagement and diversion of funds that marred the sector hitherto. Likewise, power losses and technological level exerted a significant negative impact on energy production. This results from the fact that as population grows and societal welfare improves, there is need for more energy consumption; and generation and distributional losses lessen the level of energy available for use. Government effectiveness as a measure of institutions exerts a positive significant impact on energy production, it is worthy of note that the long run elasticity of energy production growth with respect to institutions is the highest in the model amounting to 0.5 percent. This indicates that for any change in institutions quality, energy production growth rise by 0.5 percent. This confirms the strand of theory that adjudged strong institutions as pertinent to extractive developing economies. Finally, the structure of the economy does not seem to influence energy production significantly.

Table 10: Normalized co-integration estimates (with interacted variable)

Co-integrating coefficient normalized on Energy Production (with interacted variable)							
DLEPRD	DLINVT	DLGPCI	DLPWLS	DLTECH	DLESTR	CLMC_INST	C
1.000000	0.195992	-0.8309	0.1398	0.1348	-3.8670	-2.1078	0.0799
`	(0.0318)	(0.0941)	(0.0371)	(0.0441)	(2.4157)	(0.6414)	(0.0192)
Prob.*	6.16	-8.83	3.77	3.06	-1.60	-3.29	4.17

Source: Computed by authors using eviews 7.0

Note: Since the Johansen co-integration test assumes all variables as endogenous, we alternate the signs of the magnitudes.

We estimate the equilibrium vector error correction in attempts to adjust the disequilibrium in the co-integrating relationship. This is based on the logic that a long run relationship exists and that there are disturbances in the short-run which needs adjustment back to long run equilibrium (Ogundipe and Alege, 2013).

Table 11: Equilibrium Vector Error Correction

Vector Error Correction Model for Energy Production							
Variable	D(DLEPRD)	D(DLINVT)	D(DLGPCI)	D(DLPWLS)	D(DLTECH)	D(DLESTR)	D(DCLMC)	D(DINST)
ECT_1	-0.4081	-2.7378	0.3829	-2.0762	-0.6875	0.07607	0.8886	0.4744
	(0.2153)	(1.3664)	(1.4792)	(1.4792)	(0.3213)	(0.0169)	(0.5213)	(0.2625)
	[-1.896]	[-2.0037]	[-1.4036]	[-1.4036]	[-2.1400]	[4.4838]	[1.7047]	[1.8069]

Source: Computed by authors using eviews 7.0

The coefficient of the $ECM(-1)$ as seen in table 11 conforms with the theoretical stand, as it is correctly signed (negative), statistically significant and its absolute magnitude being between 1 and 0. It shows that the model has a self-adjusting mechanism for correcting short-run dynamics in the series to their long run path. With the $ECM(-1)$ satisfying the rule of thumb, we can conclude that there exist a long run converging relationship between energy production and its determinants. The $ECM(-1)$ reveals that about 40.8 percent of short run disturbances are adjusted back to equilibrium path in the long run. The speed of error correction tends to be moderate. The statistical significance at about 10 percent significance level and magnitude of 40.8 percent indicates that a deviation in energy production from equilibrium is corrected by 40.8 percent in the successive period.

Table 12: Equilibrium Error Correction (interacted variable)

Variable	Vector Error Correction Model for Energy Production						
	D(DLEPRD)	D(DLINVT)	D(DLGPCI)	D(DLPWLS)	D(DLTECH)	D(DLESTR)	D(CLMC_INST)
ECT_1	-0.2870	-2.5704	0.7512	-1.3967	-0.4063	0.04617	0.0387
	(0.1460)	(0.9307)	(0.2805)	(1.0044)	(0.2226)	(0.0123)	(0.0450)
	[-1.9658]	[-2.7620]	[2.6782]	[-1.3905]	[-1.8253]	[3.7640]	[0.8629]

Source: Computed by authors using eviews 7.0

Also, in the model with the interacted variable, $ECM(-1)$ conforms to the rule of thumb. In this case, speed of error correction seems to be sluggish as about 29 percent of disturbances encountered in the short run are adjusted back to the long run equilibrium path indicating that the error in the model exhibited some form of long memory and weak reversion.

The results in table 13 present the granger causality test for energy production and its determinants. The Wald exogeneity test was adopted to test the null hypothesis of no causality and the probability value gives the decision rule concerning the direction of causality.

Table 13: Wald Exogeneity Causality test

Null hypothesis	Chi2	Prob.*	Decision	Causality
dlinvt does not Granger Cause *dleprd*	1.3171	0.2511	Accept	None
dleprd does not Granger Cause *dlinvt*	0.1381	0.7102	Accept	
dlgpci does not Granger Cause *dleprd*	1.0212	0.3122	Accept	None
dleprd does not Granger Cause *dlgpci*	2.1082	0.1465	Accept	
dlpwls does not Granger Cause *dleprd*	0.0297	0.8631	Accept	Unidirectional
dleprd does not Granger Cause *dlpwls*	3.6927	0.0547	Reject	
dltech does not Granger Cause *dleprd*	8.1176	0.0044	Reject	Unidirectional
dleprd does not Granger Cause *dltech*	0.3806	0.5373	Accept	
dlestr does not Granger Cause *dleprd*	4.4172	0.0356	Reject	Unidirectional
dleprd does not Granger Cause *dlestr*	0.0483	0.8260	Accept	
dlcmlc does not Granger Cause *dleprd*	0.0398	0.8418	Accept	None
dleprd does not Granger Cause *dlcmlc*	0.0003	0.9869	Accept	

Source: Computed by authors using eviews 7.0

Table 13 indicates a unidirectional causal relationship running from energy production to power losses without feedback indicating that changes in energy production affects power losses. This implies that as the economy adapts new energy sources and replaces obsolete power generation and distribution equipments, the level of energy losses tends to be mitigated. Likewise, there is an evidence of unidirectional causality running from technological level to energy production; this implies that change in the level of technology affects energy production. It is therefore imperative for government to invest in relevant technologies to ensure full utilization of all forms of energy sources and training of personnel in order to confront technical problems and adequate

maintenance of power stations which in the words of Oyedepo (2012), is the reason why most of the existing electricity plants in Nigeria are underutilized or not functioning at all. Interesting evidence from our result is the absence of a causal relationship between climate change and energy production. This will not be unconnected with the reality that the effect of climate change is predominate on hydro energy sources but a larger proportion of energy source in Nigeria comes from oil and natural gas (thermal).

In order to ensure the reliability of our result estimates, we conducted a number of result robustness checks. This helps to ascertain that policy implications arising from this study is not misleading and forecasting can be absolutely relied on.

Table 14: Robustness Checks

VEC Residual heteroskedasticity tests (Joint variable test)		
Chi-sq	Df	Prob.*
455.7163	448	0.3903
VEC Residual Normality test: Skewness		
Chi-sq	Prob.*	
-8.8023	0.2672	
VEC Residual Normality test: Kurtosis		
Chi-sq	Prob.*	
4.2213	0.7540	
VEC Residual Normality test: Jarque-Bera		
Chi-sq	Prob.*	
13.0236	0.5247	

Source: Computed by authors using eviews 7.0

The study conducted the vector residual heteroskedasticity test; here we test the null hypothesis for the presence of heteroskedasticity. The insignificance of the probability value as shown in table 14 suggests the rejection of the null hypothesis and concludes the presence of homoskedaticity. Likewise, we collaborated this, by plotting the residual graph and could not observe any known pattern for the residuals. In the same manner, the Skewness, Kurtosis and Jerque-Bera statistics were used to test the normality of the series used in the regression analysis and interestingly the study failed to accept the null hypothesis of no normality.

Table 15: LM Serial Correlation test

Lags	LM statistics	Prob.*
1	41.8456	0.7538
2	60.1924	0.1312
3	40.2835	0.8080
4	62.7673	0.0894

5	49.2237	0.4642
6	61.9111	0.1019
7	34.2281	0.9457
8	64.1691	0.0717
9	51.3125	0.3832
10	69.6457	0.0278

Source: compiled by authors using eviews 7.0

Also, our study employed a sensitivity check to ensure the successive values of our error terms are not serially correlated at the level of lag(s) chosen in the regression procedure. The existence of serial correlation violates a major classical assumption of regression model and could produce unreliable and biased estimates. The study failed to reject the null hypothesis of no serial correlation at second lag, our model is hereby void of serial correlation and the estimates obtained is useful for policy inferences and forecasting.

7.0   Recommendations and Conclusion

This study investigated the impact of climate change on the energy sector with specific focus on energy supply. It examines how the incidence of climate change being widely experienced in most parts of the country, affects the supply of energy and invariably access to adequate energy. A number of studies and reports have indicated that in the face of the threat presented by changing climate, the supply of energy will be adversely affected especially in terms of electricity supply. Applying contemporary econometric methods; the study found a positive relationship between climate change and energy supply. Though this might be against the apriori expectation that as climate change intensifies, energy production should fall. However, the positive relationship between climate change and energy supply could be due to the nature of energy production in Nigeria (an oil-producing economy) whereby in the process of oil exploration, the associated gas is being flared which is the major contributor to increased CO_2 emission in Nigeria. Also, it could Likewise, evidence from causality test shows absence of causal relationship between climate change and energy production which shows that one does not in any way cause the other; they just happen jointly in the process of oil exploration.

Also, the interaction of climate change and institution quality *(clmc_inst)* reveals a positive relationship between *clmc_inst* and *elprd* (energy production), though energy production is less responsive to the interacted variable (*clmc_inst*). A strand of argument that could be valid is the fact that inadequate power supply has led household and businesses to alternative power sources

which has contributed significantly to household and industrial pollution. As shown by the weaker influence of *clmc_inst* on *elprd*, it implies that strengthening of institutions is imperative to mitigate the impact influence of climate change. Also, there is need to ensure appropriate channeling of investment and enhance adoption of relevant technologies to diversify energy sources and develop more clean energy. There is need to intensify efforts at enhancing technological development in the energy sector so as to enhance energy supply as the lack of technological innovation has often be noted as one of the major challenge of the growth of the industry.

Our findings have strategic policy implications especially in regards to the Kyoto protocol commitment. In the light of these results, policy makers and economic advisers in Nigeria needs to trend with caution on the level of productive activities and economic gains to sacrifice in order to ensure adherence to the Kyoto protocol since curtailing emission levels will affect energy production which is currently the mainstay of Nigeria's income. Also, in tackling this, polices on the adoption of appropriate technology and diversification of the economy should be pursued aggressively. The world is gradually switching to alternative sources of energy and low-carbon (Green) economy which is going to render fossil fuel useless. The time to act is now and the need to seek for other means of energy that is sustainable, affordable, accessible and environmentally friendly is paramount. Government should made conscious effort at investing and promoting incentives to enhance research in the development of modern energy sources such as solar, wind, bio-fuel, and so on that contributes little or no harm to the environment.

It is recommended that in intensifying the efforts at tackling climate change and reforming the energy sector for maximum productivity; adaptation efforts by government must be geared towards technological innovation in the industry with consented measures at ensuring adequate energy mix particularly from renewable sources. This is very important as the achievement of low-carbon economy hinges on the nature of energy mix to bring about sustainable development. All these must be within the framework of a strengthened institutional structure that will enhance their adequate implementation which could in partnership with the private sector and relevant international organizations.

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