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THE RELATIONSHIP BETWEEN NATURAL GAS, ECONOMIC GROWTH AND THE ENVIRONMENT

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ABSTRACT

The concentration of CO2 in the atmosphere is soon set to pass through the 400 ppm mark. Most climate scientists consider that this represents an unacceptable chemical experiment with the earth's atmosphere. This climate change issue implies that the most efficient use of all available energy sources that is environmentally friendly is paramount. However, growing economic activity requires larger inputs of energy and material, and generates larger quantities of waste by-products and carbon emission to the atmosphere. As a result, global environmental issues are getting more attention especially the increasing threat of global warming and climate change. Despite strong theoretical evidence indicating that natural gas utilization has a positive impact on economic growth and is environmental friendly than other sources of energy, the reality is often to the contrary in the Nigerian context. This study examines the relationship between natural gas and economic growth as well as how it impact on the environment using annual time series data. The study employed the bound testing (ARDL) approach to co-integration to examine the long run relationships between natural gas, economic growth and environmental sustainability. The result reveals that natural gas utilization improves on the environmental quality in Nigeria while economic growth causes environmental degradation. Therefore, we recommend that to achieve environmental sustainability in Nigeria, government should promote natural gas utilization that will reduce the level of carbon emission into the atmosphere.

Keywords: Natural Gas, Carbon Emission, Economic Growth, Environmental Sustainability

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1. INTRODUCTION

The concentration of CO2 in the atmosphere is soon set to pass through the 400 ppm mark. Most climate scientists consider that this represents an unacceptable chemical experiment with the earth's atmosphere. This climate change issue implies that the most efficient use of all available energy sources that is environmentally friendly is paramount. According to international gas union, Natural gas is seen as a cleaner burning fuel than coal and oil, and suggested to offer solutions to the world's economic and environmental challenges. Besides, Economic growth and increase in population worldwide implies a strong increase in world energy demand. In developing countries with high rates of population growth like Nigeria, there is need for energy that improves the local environment with the least possible impact on global emissions.

However, growing economic activity requires larger inputs of energy inputs and material, and generates larger quantities of waste by-products and carbon emission to the atmosphere. As a result, global environmental issues are getting more attention especially the increasing threat of global warming and climate change. Higher global average air and ocean temperatures, and rising global average sea level are some evidence of warming of the climate system. According to the intergovernmental panel on climate change (IPCC) report, there is an increase of about 1.2 to 6.4 °C of the global temperatures and a rise in the sea level of about 16.5 to 53.8 cm by 2100 (IPCC, 2007). This would have tremendous negative impact on half of the world's population which lives in coastal zones (Saboori et al 2012). Increased demand for energy resources, accumulation of waste and concentration of pollutants will therefore overwhelm the carrying capacity of the biosphere and result in the degradation of environmental quality and a decline in human welfare, despite rising incomes.

At the same time, because of climate change, which today is considered one of the biggest challenges facing mankind, efforts have to be directed in all parts of the world towards achieving a low-carbon energy mix. Climate researchers believe the only way to limit the rise in global temperatures by a tolerable 2°C is to halve global emissions of greenhouse gases in the long term, with the industrialised world playing a leading role and developing economies following suite. Globally, natural gas has a key role in meeting this objective. With its low carbon emissions compared to the other available fossil fuels, natural gas provides a solution to the world's economic and environmental challenges in a secure and sustainable way.

It is the fuel of choice for energy efficiency, and is the cleanest of the hydrocarbons this is because when burnt to heat homes or for industrial uses, it releases 25-30% less CO2 than oil and 40-50% less than coal per unit of energy produced. Also, Natural gas emits 50 to 60 percent less

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carbon dioxide (CO2) when combusted in a new, efficient natural gas power plant compared with emissions from a typical new coal plant (NETL 2010). When burnt to generate electricity, it releases around 60 % less than coal for every kWh sent out. By replacing five coal-fired plants with five gas-fired plants the same volume of CO2 emission reduction can be reached as with 9,000 Mega Watts of new wind power.

The significance that the country has placed on crude oil is relatively very high. The over reliance of crude oil in Nigeria is a major challenge because it has failed to diversify its energy consumption and ensure an appropriate energy mix. The consumption for oil is high practically because there is no alternative to it. Fossil fuels like coal are insignificantly mined in the country. The coal located in eastern Nigeria is sub-bituminous which means that it burns slowly and gives out a lot of heat. Subsequently, it is also low in sulphur and ash content. Coal is the oldest commercial fuel used in Nigeria in 1916. Since oil was discovered in Nigeria, coal was given less relevance and became highly dormant. With a reserve of over 2 billion metric tonnes, Nigeria produces about 200000 to 600000 tonnes yearly.

Meanwhile, Nigeria has abundant reserve of natural gas. In energy terms, the quantity of natural gas is at least twice as much as the oil, and the horizon for the availability of natural gas is definitely longer than that of oil. The known reserves of natural gas have been estimated at about 2.4×10^{12} cm^3 and are expected to last for more than a century as a domestic fuel and a major export. Nigeria has the largest natural gas reserves in Africa and is among the top ten in the world. However, due to a lack of utilization infrastructure, Nigeria still flares about 40% of the natural gas it produces, accounts for about 20% of all gas flared worldwide.

In Nigeria, 75% of the associated gas was burnt off that is flared. This wastage was due to the inadequate infrastructure and the remedy is therefore to build suitable infrastructure to reduce this wastage which could have been used to boost supply and increase receipt from sellers of this energy product. Natural gas can be also converted into liquid state known as the Liquefied Natural Gas (LNG). This is a natural gas product whose market is also constantly increasing. Natural Gas has been affirmed to be the fastest growing source of primary energy according to EIA (2004). Nigeria is characterized by excessive dependence on export of primary commodities and natural resources. These types of exports can make for high but not long term economic growth. Nigeria is unable to derive maximum benefits from its abundant natural gas resources without adding value (UNIDO, 2011). This has made the nation to be behind in terms of industrialization. Indeed, Nigeria and most other developing nations are rich in natural gas, but this has not always been a blessing. Despite strong theoretical evidence indicating that natural gasutilization has a positive impact on economic growth and is environmental friendly than other

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sources of energy, the reality is often to the contrary in the Nigerian context. This calls for the study of the relationship between natural gas and economic growth as well as how it impact on the environment. Therefore, the study seeks to achieve the following objectives;

1. To examine the impact of natural gas on economic growth in Nigeria
2. To examine the relationship between economic growth and the environment in Nigeria
3. To determine the relationship between natural gas and environment in Nigeria

2. LITERATURE REVIEW

The relationship between natural gas, economic growth and the environment can be demonstrated using the Environmental Kuznets Curve (EKC). This is due to the fact that economic production, distribution and consumption makes use of energy inputs that can exert anthropogenic pressures on the environment, ranging from carbon emissions to climate change, water, soil and air pollution as well as deforestation (Chuku and Akpan 2010). The environmental impact of energy utilization is encompassing, affecting both the bio and ecosystem at every level of human existence. However, these impacts vary depending on the type of energy mix or source, method of natural resource extraction and consumption, the conversion technologies adopted and regulatory framework. Dealing with sustainability involves three broad dimensions of energy-environment linkages. These are regarded as the indicators of environmental sustainability (Vera &Langlois, 2007). These indicators are aimed at addressing three dimensions of the natural resource-related impacts on the environment as; land resource; the atmosphere; and the water resources.

In specific terms, examining the effect of natural gas on the atmosphere entails an assessment of greenhouse gas emissions, climate change trends and pollutants that adversely affects the quality of air. For that of land resources, issues like deforestation, soil quality as well as waste generation and disposal are addressed, while the water resource dimension uses the level of contaminants discharged in to the water as yardstick for measuring of quality of water resource. When modern theories of economic growth first began to be developed in the 1950s and 1960s, energy and the environment essentially were absent. Economic output flows and rates of output growth were assumed to depend on the applications of services provided by capital and labour. Capital could be augmented by net investment as a result of domestic savings and external capital flows. But the role of energy and the environment as valuable inputs to the growth process remained outside of growth theory at that time, as did possible constraints from the natural world that could lead to more rapid slowing or even a decline in output per capita over time.

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Over the years, as a result of efforts by specialists of both types, theories of growth with various kinds of energy inputs and environmental implications became fairly well developed. Therefore, the theoretical explanation of the relationship between energy, economic growth and environment lies on the environmental Kuznets curve (EKC) initially originated from the inverted U-shaped income distribution curve of Simon Kuznets, known as the Kuznets Curve. The Kuznets Curve hypothesis posits that at lower levels of per capita income, income distribution is skewed toward higher income levels implying that inequality is high but as income rises, skewness is reduced. (Yandle et al., 2004). In 1991, Kuznets hypothesis took a new dimension. It became a tool for describing the income-pollution relationship. That is, how environmental quality (such as concentration of sulphur dioxide emissions) relates with per capita income. Kuznets suggests an evidence of similar inverted U-shaped relationship between level of environmental degradation for some pollutants and per capita income. Lakshmi and Sahn (2012) comments that “The EKC statistical relationship suggests that as development and industrialization progress, environmental damage increases due to greater use of natural resources, more emission of pollutants, the operation of less efficient and relatively dirty technologies, high priority to raise material output and less regard for environmental consequences of growth”

Moreover, for the natural gas-economic growth nexus, the theoretical underpinning could be linked to the Cobb-Douglas production function. In economics, the Cobb–Douglas production function is a particular functional form of the production function, widely used to represent the technological relationship between the amounts of two or more inputs, particularly physical capital and labour, and the amount of output that can be produced by those inputs.

3. Methodology and Data

To examine the impact of natural gas on economic growth the neoclassical Cobb-Douglass production function provides the theoretical framework, while the model to achieve objective two and three is theoretically based on EKC hypothesis.

This is possible to form a linear relationship between natural gas utilization, economic growth and environmental condition. However borrowing the idea of Dina (2004) that the main determinants of environmental pollution are trade openness, mineral resource depletion, demography, and some control variables are added to the model. Given this development, we take into account the effects of energy consumption other than natural gas, using coal, mineral depletion, and energy depletion as proxy for energy consumption, and trade openness, as well as population density on environment (measured by the level of CO_2 emissions). Also, for the

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relationship between gas and economic growth, the link is derived from the aggregate production function depicted as follows:

$$GDP = AK^{\alpha}L^{\beta} \quad (1)$$

Following Ang (2008), Iwata et al. (2010) and Saboori et al (2012) we form the long-run relationship between environment (measured by CO_2 emissions), economic growth and natural gas utilization and control variable, K (which are trade openness and population density) with a view of testing the validity of the EKC hypothesis in logarithm version as follows:

$$\ln Env_t = \alpha_0 + \alpha_1 \ln Q_t + \alpha_2 (\ln Q_t)^2 + \alpha_3 \ln Gas_t + \alpha_4 \ln K_t + \varepsilon_t \quad (2)$$

Where

Env= CO_2 emissions,

Q = Economic growth,

GAS= natural gas

K = control variables

ε = stochastic error

In the context of this study,

NU = (ENEDand MIND)

Where

ENED = energy depletion

MIND = net mineral depletion

Similarly, K = (OPN, POPDEN)

Where

OPN = trade openness

POPDEN = population density

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In this study, the Autoregressive Distributed Lag (ARDL) model, otherwise called the bounds testing approach proposed by Pesaran et al. (2001) is employed to examine empirically the existence of short and long term relationship between natural gas and economic growth, natural gas; economic growth and environmental conditions in Nigeria. The ARDL model is chosen for four major reasons. Firstly, once the model lag order is identified, the ARDL model can be estimated by Ordinary Least Squares (OLS). Secondly, it is possible to estimate the long-run and short-run parameters of ARDL model simultaneously. Thirdly, the ARDL can be applied irrespective of the order of the integration of the regressors, whether purely I(0), purely I(1) or fractionally integrated. However, the procedure will crash if l(2) series is presence. Fourth, this method is efficient especially with small (finite) sample sizes.

Following Pesaran et al. (2001) as adopted by Choong et al. (2005) and Taban (2010), the vector autoregressive (VAR) model of order *p* represented by VAR(*p*) is constructed thus:

$$Z_t = \mu_o + \delta_t + \Sigma\varphi Z_{t-1} + \varepsilon_t \qquad t= 1, 2, - - - T \qquad (3)$$

Where μ_o is (k+1) vector of intercepts and denoting a (k+1) vector of trend coefficients. The vector error correction model (VECM) for equation (4) is given as:

$$\Delta Z_t = \mu_o + \delta_t + \lambda Z_{t-1} + \Sigma\Upsilon_t\Delta Z_{t-1} + \varepsilon_{t,} \qquad (4)$$

where λ and Υ are vector matrices that contain the long-run multipliers and short-run dynamics coefficients of the VECM respectively. Z_t is a vector of x_t and y_t variables respectively, where y_t is the dependent variable defined as GDP in the first model and Environment in the second model and x_i = [GFCF, COAL, GAS, ENED] is a vector matrix of a set of explanatory variables. All the variables are transformed to their logarithmic form. As a requirement, y_t must be an 1(1) variable while x_t explanatory variables can either be 1(0) and 1(1). E_t is a stochastic error term. Following the assumptions made by Persaran et al (2001) in case II, that is, unrestricted intercepts and no trends, the preferred unrestricted error correction model (UECM) is derived as:

$$\Delta Z_t = \mu_o + \lambda Z_{t-1} + \Sigma\Upsilon_i\Delta Z_{t-1} + \varepsilon_t \qquad (5)$$

Decomposing into x_t and y_t, the reduced form of Eq(5) is formulated as:

$$\Delta y_t = C_y o y_{t-1} + {}^{\beta}{}_{xx} X_{t-1} + \Sigma\Upsilon_i\Delta y_{t-1} + \Sigma\Upsilon_i\Delta x_{t-1} + \varepsilon_t (6)$$

Bringing in the variables of interest, the UECM of Eq (7) becomes thus:

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$\Delta GDP_t = C_o + \beta_1 GDP_{t-1} + \beta_2 GAS_{t-1} + \beta_3 GFCF_{t-1} + \beta_4 COAL_{t-1} + \beta_5 ENED_{t-1} +$

$\Sigma \Upsilon_1 \Delta GDP_{t-1} + \Sigma \Upsilon_2 \Delta GAS_{t-1} + \Sigma \Upsilon_3 \Delta GFCF_{t-1} + \Sigma \Upsilon_4 \Delta COAL_{t-1}$

$+ \Sigma \Upsilon_5 \Delta ENED_{t-1} + \varepsilon_{t-1}$ (7)

Where Δ is the first difference operator, βi are long-run multipliers and Υ_i are short-run dynamic coefficients and C_o is the intercept.

The ARDL framework of Eq. (2) of the model is as follows:

$\ln Env_t = \alpha_0 + \alpha_1 \ln GDP_t + \alpha_2 (\ln Q_t)^2 + \alpha_3 \ln Ened_t + \alpha_4 \ln Gas + \alpha_4 \ln Opn + \alpha_5 \ln popd_t + \varepsilon_t$(3)

Data for this study covers the period 1980 to 2015. Data used for analysis are carbon dioxide (CO2) emissions, GDP, population density, trade openness, net energy depletion. Others are gross fixed capital formation (GFCF) and net forest depletion. All data were collected from World Bank's World Development Indicators (WDI). CO2 emissions (E) is measured in metric tonnes, the real GDP (Y) is in constant 2000 local currency unit, energy depletion (Ened) is measured in kg and trade openness (OPN) is measured by the ratio of total trade to GDP.

4. Empirical Analysis and Results

When the variables are non-stationary there is tendency to generate spurious regression results. To avoid this, before carrying out the ARDL bounds test, stationary status of all the variables were examined by conducting test for the order of integration of the individual variables. This helps to authenticate that the variables are not 1(2) stationary. The bound test is based on the assumption that the variables are 1(0) or 1(1) series. The presence of 1(2) series renders the calculated F-statistic invalid thereby crashing the ARDL procedure. From the unit root result, all the variables are either integrated at level or first difference using the Augmented Dickey-Fuller (ADF) test, while the Phillips-Perron technique also shows that there is no variable that is integrated at second difference.

TABLE 1: AUGMENTED DICKEY-FULLER UNIT ROOT TEST

Variable	ADF LEVEL	ADF 1ST diff	1% LEVEL	5% LEVEL	10% LEVEL	INTEGRAT. ORDER
GFCF	-3.508789*	-12.94372	-3.646342	-2.954021	-2.615817	I(0)

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GDP	4.119325	4.503652	-3.646342	-2.954021	-2.615817	I(0)
COAL	-2.763877**	-5.762225	-3.646342	-2.954021	-2.615817	I(0)
OPN	-0.995404	-5.955440	-3.646342	-2.954021	-2.615817	I(I)
EVN	-1.343590	-6.375831	-3.646342	-2.954021	-2.615817	I(I)
MIND	5.225976	4.968977	-3.646342	-2.954021	-2.615817	I(0)
GAS	0.876744	-6.761008	-3.646342	-2.954021	-2.615817	I(I)
POPD	3.590539*	-0.716084	-3.646342	-2.954021	-2.615817	I(0)
ENED	-1.485495	-4.174255	-3.646342	-2.954021	-2.615817	I(I)

Note: * stationary at 5% level, ** stationary at 10% level

Source: computed by the authors

TABLE 2: PHILLIPS-PERRON UNIT ROOT TESTS

Variable	PP LEVEL	PP 1diff	1% LEVEL	5% LEVEL	10% LEVEL	ORDER
GFCF	-3.945634	-12.49023	-3.639407	-2.951125	-2.614300	I(0)
GDP	-5.445120	-29.79792	-3.639407	-2.951125	-2.614300	I(0)
COAL	-2.760456**	-7.819122	-3.639407	-2.951125	-2.614300	I(0)
OPN	-1.010032	-5.962611	-3.639407	-2.951125	-2.614300	I(I)
EVN	-1.304615	-6.361025	-3.639407	-2.951125	-2.614300	I(I)
MIND	1.345776	-6.607795	-3.639407	-2.951125	-2.614300	I(I)
GAS	3.018937*	-6.783014	-3.639407	-2.951125	-2.614300	I(0)
POPD	33.20819	3.595027	-3.639407	-2.951125	-2.614300	I(0)
ENED	-1.666045	-4.169256	-3.639407	-2.951125	-2.614300	I(I)

Source: computed by the authors

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Tables 1 and 2 show the results of the unit root test. The results show that none of the variables are integrated in order two, I(II), showing that natural gas (Gas), trade openness (opn), energy depletion (ENED) and environment (ENV) are integrated at first difference, I(I) while the rest of the variables are stationary at levels with the ADF test. In the Phillip Perron (PP) test, economic growth (GDP); natural gas and population density (POPD) are integrated at level. Others are gross fixed capital formation (GFCF) and coal that are integrated at level I(0) while the rest of the variables are integrated at first difference. Based on this result, the ARDL analysis can be conducted since the assumption of no I(II) level is met. Therefore we moved on to estimate equation 2, which is the first step of the ARDL analysis, to determine whether there is a long run relationship between the variables in the model.

TABLE 3: ARDL BOUND TEST FOR ECONOMIC GROWTH MODEL

VARIABLE	F-STATISTIC	CO-INTEGRATION
	5.666307	CO-INTEGRATED
CRITICAL VALUE	LOWER BOUND	UPPER BOUND
1%	3.74	5.06
5%	2.86	4.01
10%	2.45	3.52

Source: computed by the authors

TABLE 4: ARDL BOUND TEST FOR ENVIRONMENT MODEL

VARIABLE	F-STATISTIC	CO-INTEGRATION
	4.255790	CO-INTEGRATED
CRITICAL VALUE	LOWER BOUND	UPPER BOUND
1%	3.41	4.68
5%	2.62	3.78
10%	2.26	3.35

Source: computed by the authors

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Table 3 and 4 present the result of the co-integration. From the results, given that the F-statistic value is greater than the upper bound of the critical value in the economic model and at 5% and 10% for environment model, we conclude that there is a long run relationship existing between natural gas utilization, economic growth and the environment in the estimated model, hence the empirical findings lead to the conclusion that a long run relationship between natural gas utilization, economic growth and the environment exist. Therefore, the long run coefficients of the ARDL models are estimated.

As shown in the appendix, according to the results, the coefficients of the long run relationship show that natural gas negatively affects the level of carbon emission into the environment. This means that an increase in natural gas in Nigeria will cause a decrease in the level of carbon emission by 5.04 per cent thereby promoting the quality of environment in Nigeria. While natural gas utilization has a positive impact on the level of economic growth meaning that an increase in the use of natural gas will increase the level of economic growth by 0.90 per cent. However, economic growth in the estimated model has a positive impact on the level of carbon emission in the Nigerian economy as an increase in the level of economic growth causes a corresponding increase in the level of carbon emission in the country. This will cause environmental degradation in Nigeria. Population density in the model shows that there is a positive impact of population density on the level of carbon emission. Therefore an increase in the Nigerian population will exerts pressure on the environment causing environmental degradation in the country. Statistically, the explanatory variables in the model are not significant given their t values and probability. But the entire model is statistically significant using the F-statistical ratio and the Durbin-Watson result showing that there is no existence of autocorrelation in the model while the coefficient of determination is very high and has a high goodness of fit.

5. SUMMARY AND CONCLUSION

This paper investigated the relationship between natural gas, economic growth and environmental sustainability through; review of empirical studies; theoretical issues; and centred on empirical findings using econometric method. Annual time series data of macroeconomic indicators in Nigeria from 1980 to 2015 was used. The study employed the bound testing (ARDL) approach to co-integration to examine the long run and short run relationships between natural gas, economic growth and environmental sustainability. The bound test suggested that the variables used in the model are bound together in the long run given the Wald coefficient test result. Also, the long run coefficient reveals that economic growth reduces the quality of the environment in Nigeria by increasing the level of carbon emission into the atmosphere.

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However, natural gas utilization indicates that natural gas is environmental friendly than other energy source; implying that the more natural gas used in the nation, the less the volume of carbon emission into the environment. From the findings we recommend that to achieve environmental sustainability in Nigeria, government should promote natural gas utilization in the country that will reduce the level of carbon emission.

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