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Effect of Economic Growth, Industrialization, and Urbanization on Energy Consumption in Nigeria: A Vector Error Correction Model Analysis

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ABSTRACT

Poor energy production and consumption bedevils the state of Nigeria, for which distribution of energy is concentrated in the wealthy and urban middle class with the country's large poor population denied access. The current annual production is very low, and development of the sector is a challenge. Basically, additional infrastructure is needed to increase production which can feasibly be acquired through raising energy prices. However, a rise in price prohibits access to services for a large part of the population. Inability to raise energy production has a substantial impact on individuals and businesses alike. For businesses, frequent power outages bring inefficiency in the production of goods and services, resulting in stunted growth for local companies and discouraging international investors. For individuals, poor energy consumption impacts negatively on living standards. The accumulative effect of poor energy production and consumption over the years can greatly impact on the continent's economic growth and development. Present economic conditions may worsen with high population growth and rising urbanisation, hence, the need for a rapid and intensified strategy for energy development of the nation. Consequently, this study analyses the relationship between energy consumption on the one hand and economic growth, industry growth and urban growth for the nation. Using data for the period 1980-2016, a VEC model is analysed with the Granger causality test, impulse response function and variance decomposition. Using the Johansen cointegration test, one cointegrating relationship is found which led to conducting the vector error correction model (VECM). It is found that a long run causal relationship exists only for gross domestic product (GDP) growth. That is, GDP only possess the correct sign and statistically significant level with the speed of adjustment back to equilibrium at 14%. No short-run causal relationship is observed between energy consumption on the one hand and economic growth, industry growth and urban growth. Only foreign direct investment as a control variable has a bidirectional short-run causal relationship with energy consumption.

Keywords: Energy Production, Economic Development, Industrialization, Urbanization, Energy Challenges
JEL Classifications: L16, O13, Q43

1. INTRODUCTION

Rising urbanisation, industrialisation, insecurity, political violence, and rising unemployment are some of the several issues confronting the African continent, and particularly Nigeria and a fast-growing population may compound issues for the nation. Currently, Nigeria is the 7th largest country in the world with a population of over 185 million people (WDI, 2017) and it is projected to be the 3rd largest country by 2050 just after China and India, with a population of over 240 million people (UN, 2017). Given these projections challenges and opportunities are abound. Basic livelihoods need to be met which includes adequate feeding, shelter, clothing and adequate health care for everyone which implies increased pressure on available resources.

Furthermore, the growing population is shifting base from rural settlements to urban settlements. Globally, urbanisation is projected to increase from about 54% in 2014 to 66% by 2050 (UN, 2014). Specifically, due to rising population growth, an additional 2.5 billion people are expected to move to cities by 2050 (UN, 2014), and Nigeria is no exempt in this trend. Nigeria is projected to add 212 million urban dwellers by 2050, just after China of 292 million and India with the highest of 404 million (UN, 2014). As Nigeria's urban population rises numerous challenges arise in meeting the needs of the growing population which includes education, health care, housing infrastructure, employment and energy. Although a successful urban planning agenda can offer important opportunities for economic development and for expanding access to basic services of health and education for a large number of people. In addition, providing the basic needs of housing, water, electricity and transportation for all can be easier and cheaper to meet in densely settled cities than in sparsely populated rural areas.

Given the rising trend in population growth and urbanisation, industrialisation in Africa and particularly in Nigeria is inevitable. Industrialisation involves transforming a natural resource-based economy into a manufacturing based economy. The African continent is well endowed with natural resources worth over US$82 trillion (AFDB, 2017). The Nigerian economy is chiefly governed by oil and natural gas, and while the oil sector provides almost 30% of the gross domestic product (GDP) and accounts for 90% of the total export capacity, the manufacturing sector provides just around 4% (Chete et al., 2014). Given the projected rise in Nigeria population to about 240 million by 2050 (UN, 2014) and the forecast that the country's economy will grow to over $1.6 trillion by 2030 (McKinsey Global Institute, 2014) then obviously industrialisation is inevitable. The present government is making efforts towards achieving economic reform that will replace the present oil dependent nature of the country that of manufacturing and agriculture-driven system. Rising trend in population, urbanisation and industrialisation may put pressure on economic growth and subsequently energy consumption. Hence this study examines the impact of economic growth, industrialisation and urbanisation on energy consumption in Nigeria. In the section that follows, past papers on the topic are reviewed for countries across the world, the third section presents the methodology and analysis of results, and the fourth section concludes the paper.

2. LITERATURE REVIEW

The relationship between energy consumption and economic variables especially economic growth has been studied since the 1970s since the oil crises, but the empirical result is inconclusive as regards if energy consumption causes economic growth or vice versa (Ozturk, 2010). The following reveals empirical studies of energy consumption and economic variables across the globe.

Lebe and Akbaz (2015) investigate the effect of financial development (FD), economic growth urbanisation and industrialisation on energy consumption in Turkey using annual data for the period 1960-2012 with structural vector autoregression model. It is found that there exists a long-term relationship between these variables and that significant effects of economic growth, industrialisation and FD exists on energy consumption, although no significant relationship is observed in the case of urbanisation and energy consumption. A similar study is conducted in the case of Abdouli and Hammami (2017), who examined the nexus between economic growth, foreign direct investment (FDI) inflows and energy consumption from a group of 17 countries from Middle East and North Africa countries namely: Saudi Arabia, Qatar, Oman, Kuwait, Lebanon, United Arab Emirates, Iraq, Turkey, Iran, Syria, Jordan, Yemen, Egypt, Morocco, Tunisia, Algeria and Libya, using a growth modelframework estimated with generalized method of moments methodology for the period 1990-2012. Results indicate the existence of a bidirectional causalrelationship between energyconsumption and economic growth and a unidirectional causal relationship between energy consumption to FDI inflows with increases in energy consumption resulting in the increase in FDI inflows. Phong et al. (2018) examines the impacts of crucial factors associated with Vietnam's socio-economic development including globalization, industrialization, urbanization, energy consumption and GDP per capita on carbon dioxide (CO_2) emission from 1985 to 2015 by using autoregressive distributed lag (ARDL) method. They found that energy consumption, industrialization and GDP per capita increase CO_2 emission in the long-run while, in contrast, globalization negatively influences it, which implies pragmatic suggestions for policymakers in promoting pertinent strategies for sustainable economic development in Vietnam.

In another study by Doğan and Değer (2018), the importance of energy is assessed given the rising trend in technological developments, population growth and international trade. Hence the need to study the relationship between energy consumption and economic growth to ascertain which variable causes the other, for reasons of economic policies development. Doğan and Değer (2018) employed data from 7 countries namely: Brazil, China, Indonesia, India, Mexico, Russia and Turkey for the period 1990-2016. Using the common correlated effects method developed by Hashem (2006), the long-run cointegration coefficient is determined. It is found that for all the countries involved a positive relationship between the economic growth and energy consumption which invariably implies that for the entire panel a positive relationship is observed. Although the direction of the relationship is unknown, the authors fail to identify the direction of causality. Shahbaz et al. (2017) investigate the relationship between urbanization and energy consumption in case of Pakistan for the period of 1972Q1-2011Q4 by employing the Stochastic Impact by Regression on Population, Affluence and Technology model. The results show that urbanization adds in energy consumption. Affluence (economic growth) increases energy demand. Technology has positive impact on energy consumption. An increase in transportation is positively linked with energy consumption. The causality analysis indicates the unidirectional causality running from urbanization to energy consumption.

A similar study is conducted in Adegboye and Babalola (2017) to examine the causal relationship between energy consumption and economic growth in Nigeria for the period 1981-2013 employing an ARDL and error correction model Granger Causality test and finds a unidirectional relation between energy consumption and economic growth and that changes in energy consumption results in changes in economic growth with a significant positive relationship exists between the two variables which are robust to the two estimation method employed.

In Alper and Alper (2017) the relationship between carbondioxide emission, economic growth and energy consumption for Turkey is examined using time period 1985-2014. In order to achieve this, the ARDL methodology is employed for the relationship between carbon dioxide emission, economic growth and energy consumption. The results indicate the existence of a long-term relationship among the variables where carbon dioxide emission represents the dependent variable such that a 1% increase in economic growth results in 80% increase in carbondioxide emission and a 1% increase in energy consumption (proxied by oil consumption) results in 11% increase in carbon dioxide. Hence, it can be said that economic growth and energy consumption contributes to environmental pollution in turkey. Again the author failed to identify the causal relationship that exists between the variables. For Arora and Shi (2016) the relationship between energy consumption and real GDP in the USA is examined using Granger Causality test for US data spanning 1973Q1-2014Q2. In the analysis, the relationship between total energy consumption and real GDP is observed on the one hand, and then the various energy types (that is oil, natural gas and coal) are each analysed against real GDP. Results show the existence of a bi-directional relationship between total energy consumption and real GDP for the period covered until 2000, much of the period after indicates a unidirectional relationship from US real GDP to energy consumption. For specific energy types, a similar pattern is observed just as in total energy consumption with the exception of natural gas. It is concluded that natural gas and real GDP are independent variables. The authors exposed the fact that breaks in directional relationships do occur.

In Esen and Bayrak (2017) an examination of the relationship between economic growth and energy consumption for energy-importing countries is conducted. For the period 1990-2012, a total of 75 countries are examined in 2 forms. That is, the first form of examination focused on the percentage of energy being imported by the countries resulting in the formation of two groups: Countries with <50% imported energy (40 countries) and countries with >50% imported energy (35 countries). The second form of examination is based on income level of the countries and is classified into four groups: Low-income economies (5 countries), lower-middle-income economies (20 countries), upper-middle-income economies (19 countries) and high-income economies (31 countries). The study employed dynamic ordinary least squares (OLS) and fully modified OLS for short-run estimates. However, in addition, for long-run estimates Pooled Mean Group and Mean Group estimators are employed. The findings revealed that in the long run a positive and statistically significant relationship between energy consumption and economic growth. It is found for the various groups analysed, that the impact of energy consumption on economic growth falls as the income level of the country increases and that energy consumption contributes more to economic growth as the import dependency of the country decreases.

According to George and Oseni (2012), the relationship between electric power and the unemployment rate is examined for Nigeria between 1970 and 2015. The motive of the paper rests on the fact that the authors consider the need for Nigeria to develop its power sector for development of its industrial sector and then the economy, hence the need to assess the impact of electricity supply in industrial sector on the unemployment rate. The study employed the OLS methodology for its assessments. The result indicates an inverse relationship between electricity consumption in the industrial sector and unemployment rate, such that a 1.3 unit increase in industrial energy consumption results in a 1 unit fall in unemployment rate.

For South Africa, a similar study is conducted by Ilesanmi and Tewari (2017). The study investigates the dynamic causal relationship between energy consumption, human capital investment and economic growth for the period 1960-2015 employing VECM. Model results indicate the existence of a bidirectional causal relationship between economic growth and energy consumption. Gungor and Simon (2017) investigate the relationship between energy consumption, FD, economic growth, industrialization and urbanization in the case of South Africa for the period of 1970-2014. The results confirm that there is a long-run equilibrium relationship between these variables in case of South Africa. More so, urbanization, FD, and industrialization are positively correlated to the energy consumption in the long run. The results obtained also shows the long run bi-directional causality between industrialization and energy utilization, FD and energy consumption and also FD and industrialization. Comfort et al. (2018) examined the dynamic impact of energy consumption on the growth of Nigeria economy between 1986 and 2016 using symmetrical ARDL model approach. Findings from the study revealed that electricity consumption has not had a significant impact on the growth of the Nigerian economy. It shows that due to fluctuations in electricity supply, the growth of Nigerian economy has been on the decline. However, petroleum consumption was discovered to have a significant impact on economic growth in Nigeria; while gas consumption was discovered to have no significant impact on the growth of Nigeria economy.

Ha et al. (2018) examine linear and nonlinear causal relationship between energy consumption and economicgrowth in China for the period 1953-2013. The linear relationship is examined using vector autoregression estimator while the nonlinear relationship is examined using estimator developed by Nishiyama et al. (2011) with wavelet analysis. The wavelet analysis makes possible the causal relationship between energy and growth at the different time periods that is short, medium, and long run. The model result indicates that both linear and nonlinear causality tests on the original timeseries signify no causal relationship is observed between economic growth and energy consumption in China. However, with wavelet analysis applied to linear and nonlinear estimators, the result indicates that no nonlinear causal relationship exists in both short and medium term, but a bidirectional relationship exists in the long run. Also, the wavelets analysis for linear relationship indicates that in the short run a unidirectional relationship from energy consumption to energy growth exists, in the medium term also a unidirectional relationship exists from economic growth to energy consumption, and finally a bidirectional relationship exists in the long run. Study results indicate that results for causal relationship vary with time period and linearity.

In Kasperowicz and Streimikiene (2016), a panel data approach is used to investigate the relationship between energy consumption and economic growth for 18 countries for the period 1995 to 2012. The countries are grouped into two groups namely a group of V4 countries (Czech Republic, Hungary, Poland, Slovakia) and another group of 14 European countries (Belgium, Denmark, Germany, Ireland, Spain, France, Italy, Luxembourg, Netherlands, Austria, Portugal, Finland, Sweden, United Kingdom). In order to estimate the relationship between the variables of interest, panel least squares are used, and results show that for the V4 countries significant positive relationship exists between GDP growth and energy consumption while also for the 14 EU countries positive significant relationship exists.

Lu (2017) studies the dynamic relationship between energy consumption, economic growth and international tourism in Taiwan for the period 1965-2010. This study examines the causal relationship between the variables using Granger causality analysis. The study concludes that no causal relationship exist between economic growth and international tourism, a bidirectional causal relationship exist for both economic growth and energy consumption on the one hand and international tourism development and energy consumption on the other. Similarly in Liu et al. (2013) which investigates the causal relationship that exists between energy consumption, economic growth and greenhouse gas emissions for a group of 16 Asian countries in Asia for the period 1990-2012. The countries employed are four newly-industrialising and developing Asian countries, which include Singapore, Hong Kong, Korea and Taiwan; the Southeast Asian countries of China, Bangladesh, India, Indonesia, Malaysia, the Philippines, Thailand, Vietnam, Brunei, Nepal and Sri Lanka. This study focuses on energy consumption and its impact on the environment. The methodology employed for the analysis is the Granger Causality test. The empirical findings suggest that a bidirectional relationship exists between energy consumption and economic growth amongst other findings such as confirming the nonlinear quadratic relationship between greenhouse gas emissions, energy consumption and economic growth (environmental Kuznets curve).

In Parsa and Sajjadi (2017), the causal relationship between energy consumption, economic growth and trade openness is observed for Iran for the period 1967-2012. This study employs VECM, variance decomposition method and impulse response functions methods to assess the dynamic relationships that exists amongst the variables. Study's results reveal the existence of a bidirectional long-run relationship between economic growth and energy consumption while a unidirectionalcausal relationship exists from energy consumption to trade openness in the short run (Table 1).

In this paper, existing literature is extended by analysing the relationship between energy consumption, economic growth, urbanisation and industrialisation for Nigeria employing VECM.

3. DATA, METHODOLOGY AND ANALYSIS

The focus of this study is on Nigeria, and it uses annual data covering the period 1990-2015 obtained from the World Development Indicators (WDI, 2017). The variables of concern are energy consumption, urbanization, industrialization, economic growth, FDI and trade. Energy consumption is measured as energy intensity level of primary energy, which is the ratio between energy supply and GDP measured at purchasing power parity. Energy intensity is an indication of how much energy is used to produce one unit of economic output (World Bank, 2017). Urbanization is measured by percentage of urban population of the total population. It refers to people living in urban areas as defined by the national statistical offices. Industrialization is measured by the industry value added as a percentage of GDP (World Bank, 2018). It comprises value added in mining, manufacturing, water and gas. Economic growth is measured by GDP per capita at 2011 constant international $. FDI is measured as the net inflows of investment to acquire a lasting management interest in an enterprise operating in an economy other than that of the investor (World Bank, 2018). Trade is the sum of exports and imports of goods and services measured as a share of GDP (World Bank, 2018).

This study uses a log-linear model following Shahbaz and Lean (2012) so that the study model gives:

$$ENC_t = f(GDP_t, URB_t, IND_t, TRD_t, FDI_t)$$

Where ENC represents energy consumed, GDP is the natural log of real GDP per capita, URBis natural log of urban population as a percentage of total population, IND represents industry value added as a percentage of GDP, TRD measures the sum of import and exports as percentage of GDP and FDI is the net inflow of direct investment into the country.

Economic growth is known to have an indirect relationship with energy consumption through industrialisation. Industrialization drives economic activities, and its growth invariably implies economic growth, however, when the industrial sector is growing, there is increase in energy consumption. Thus a prior expectation is that higher economic growth implies higher energy consumption.

Urbanization is the gradual increase in the population of people residing in urban areas. It implies the movement of population from rural to urban residency. Urbanization exerts influence on energy consumption because urbanisation implies increased transportation, more light and more heated water needed. A prior expectation is that rising urbanisation leads to rise in energy consumption. However, rising energy consumption encourages the development of energy saving gadgets which may reduce/ eliminates rising effect of energy consumption due to urbanisation.

Trade and FDI exist in the model as control variables. FDI and trade are expected to have a positive relationship with energy consumption. In the case of FDI, direct investment into any sector will invariably require consumption of energy and the higher the rate of investment then the higher energy consumed. The summary statistic of the data is given in Table 2.

This study employs the methodology of VECM for it analysis, and in addition, uses the Granger causality test, impulse response function and variance decomposition methods. The first stage is to assess the stationarity of the variables in the model by conducting the unit root test. The Augmented Dickey-Fuller test is employed, and for purposes of robustness check, the Phillips-Peron test is also conducted. Result is displayed in Table 3, and it indicates ENC, GDP, IND, FDI and TRD all have unit root and are stationary at first difference while only URB is stationary at level.

The next step involves the selection of the lag length criteria for which the result is revealed in Table 4. The VAR lag order selection process is undertaken, and resultshows that LR, FPE, AIC and HQ all select one lag, while SC selects 0 lag. In this paper HQ criteriais adopted and thus one lag is used.

Given that the level series are not stationary, then the rank of the cointegrating relationship amongst the series is examined using

Table 1: Summary table of existing empirical research

Authors	Countries	Econometric techniques	Results
Panel A: Country specific studies			
Lebe and Akbas 2015	Turkey (1960-2012)	VAR	EC→EG, FIN, IND
Adegboye and Babalola, 2017	Nigeria (1981-2013)	ARDL and ECM	EC→EG
Alper and Alper 2017	Turkey (1985-2014)	ARDL	EC and EG→Carbon
Arora and Shi (2016)	USA (1973Q1-2014Q2)	Granger causality	EC↔GDP (1973-1999) EC←GDP (2000-2014)
George and Oseni (2012)	Nigeria (1970-2015)	OLS	IND→UNEMP, EC
Illesanmi and Tewari (2017)	South Africa (1960-2015)	VECM	EC↔EG
Ha et al. (2018)	China (1953-2013)	VAR	EC↔EG Wavelet long-run relationship
Lu (2017)	Pakistan (1965-2010)	Granger causality	EC↔EG EC↔Tourism
Parsa and Sajjadi (2017)	Iran (1967-2012)	VECM	EC↔EG (long run) EC→Trade Openness
Panel B: Multi-countries studies			
Abdouli and Hammami (2017)	17 countries: Middle East and North Africa (1990-2012)	GMM	EC↔EG EC→FDI
Doğan and Değer (2018)	Seven countries (1990-2016)	Common correlated effect	EC←EG
Esen and Bayrak (2017)	75 countries (1990-2012)	DOLS, FMOLS, PMG and MG	EC→EG
Kasperowicz and Streimikiene (2016)	18 Countries (1995-2012)	Panel least squares	EC→EG
Liu et al. (2013)	16 Asian Countries (1990-2012)	Granger causality test	EG↔EC

EC: Energy consumption, EG: Economic growth, FIN: Financial development, IND: Industrialization, OLS: Ordinary least squares, VECM: Vector error correction model, FDI: Foreign direct investment

Table 2: Summary statistic

Statistics	ENC	FDI	IND	GDP	TRD	URB
Mean	8.515284	3.358476	37.93085	3837.947	56.36229	37.70227
Maximum	10.48134	10.83256	52.99716	5671.901	81.81285	47.77600
Minimum	5.628944	0.650345	20.38195	2750.072	21.12435	29.68000
Std. Dev.	1.964575	2.210823	8.886331	1115.566	14.58975	5.703289
Skewness	−0.280867	1.873760	−0.254078	0.447497	−0.593739	0.274260
Kurtosis	1.267334	6.957714	2.096808	1.516261	3.011608	1.772165
Observations	26	26	26	26	26	26

GDP: Gross domestic product, FDI: Foreign direct investment

Table 3: Unit root test

At level	ADF	P-value	PP	P-value	Decision
ENC	−2.442967	0.3507	−2.446584	0.3491	Unit root exist
GDP	−2.285591	0.4259	−2.277723	0.4298	Unit root exist
URB	−4.631531	0.0057	−4.351675	0.0205	No unit root
IND	−1.500180	0.7997	−3.129372	0.1214	Unit root exist
FDI	−3.447590	0.0677	−3.332969	0.0840	Unit root exist
TRD	−2.478108	0.3349	−2.382294	0.3789	Unit root exist
At first diff	**ADF**	**P-value**	**PP**	**P-value**	**Decision**
ENC	−4.494047	0.0081	−4.487415	0.0082	I (1)
GDP	−3.920199	0.0270	−3.920199	0.0270	I (1)
IND	−8.047984	0.0000	−7.391884	0.0000	I (1)
FDI	−5.397895	0.0011	−7.243186	0.0000	I (1)
TRD	−1.940295	0.5948	−10.91034	0.0000	I (1)

Source: Authors' compilation

the methodology by Søren (1988). Result is displayed in Table 5. The result shows that both Trace test and Max-Eigen test are only statistically significant at 5% to reject the null hypothesis of rank (r) = 0. Hence the conclusion that only one longruncointegration relationship between energy consumption and its determinants.

3.1. The VECM Model

Given the unit root result, the research model is set up as follows. Let

$Z_t^{'}$ = [ENC, GDP, URB, IND, FDI, TRD] represent the vector of variables in the model

Z_t^{o} = [ENC, 1, GDP, URB, IND, FDI, TRD] represent the vector of variables in the model with a constant term. Hence the VECM model becomes

$$\Delta Z_t = \varphi + \theta \Delta Z_{t-1} + \alpha Z_{t-1}^{o} \pi + U_t$$

- φ represents the 6 by 1 vector of the constant terms of the model
- θ represents the 6 by 6 matrix of the coefficients in the model
- α represents the 6 by 1 vector of the error correction term
- π represents the 7 by 1 vector of the long run equilibrium terms for the model inclusive of the constant term (due to one cointegrating relationship obtained from the Johansen cointegration test).

U represents the residual in the model.

Estimating the model above gives the following long run equation:

$$ENC_{t-1} = 75.84047 – 8.368536\ GDP_{t-1} – 0.049120\ IND_{t-1} + 0.738984 URB_{t-1} + 0.000401\ TRD_{t-1} – 0.013945 FDI_{t-1}$$

S.E (0.18502) (0.00531) (0.12654) (0.00391) (0.01793)

t-stat [45.2304] [9.24575] [−5.83977] [−0.10261] [0.77779]

The rest of the VECM result is displayed in the appendix.

Result in Table 6 shows that the GDP only possess the correct sign and statistically significant level with the speed of adjustment back to equilibrium at 14%. This implies that in the occurrence of a shock to the system in the short run, LGDP will converge back to 14% of the previous year deviation from equilibrium.

3.2. Short Run and Long Run Causality Test

With the existence of cointegration relationship amongst the variables, the Granger causality test within the VECM framework to assess the short run causal direction between energy consumption, economic growth, urbanisation, industrialisation, trade openness and FDI. The dynamic causal interactions among the variables is phrased in a vector error correction form to allow the assessment of both long-run and short-run causality represented by the t-test of the error correction terms and the chi-square test of the lagged first difference terms for each right-hand variable respectively. The result of the tests is presented in Table 7. With regards long-run causality is determined by the error correction such that if it is significant, then long run causality from the explanatory variable exists to the dependent variable. In a bivariate model, it is easier to know which explanatory variable causes the dependent variable unlike in a multivariate model. Table 7 reveals that the significant coefficient of the error correction terms for energy consumption, GDP, industrialisation, FDI, depicts that long run causality exist for the variables against their respective variables. For short-run causality, result reveals that there is a bidirectional short-run causal relationship between FDI and energy consumed while no other short-run causal relationship existswith regards energy consumption in the short run. Hence it can be said that neither does urbanisation, GDP growth, Industrialization and trade Granger cause energy consumption nor does energy consumption cause GDP growth, urbanisation, industrialisation and trade in Nigeria.

3.3. Forecast Error Variance Decompositions

Variance decomposition or the Forecast error variance decomposition decompose the proportion of the variation in the dependent variable explained by the independent variables over

Table 4: Lag length selection criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	−168.5285	NA	0.157152	15.17639	15.47261*	15.25089
1	−120.1773	67.27133*	0.060482*	14.10237*	16.17588	14.62385*
2	−93.54396	23.15940	0.298973	14.91687	18.76767	15.88533

Source: Authors' compilation. *Indicates lag order selected by the criterion

Table 5: Johansen cointegration test

Hypothesized no CE (s)	Max-Eigen Statistic	5% critical Values	Trace test Statistic	5% critical Values
None*	50.18179**	40.07757	113.2819**	95.75366
At most 1	26.47921	33.87687	63.10011	69.81889
At most 2	18.02222	27.58434	36.62090	47.85613
At most 3	9.396501	21.13162	18.59867	29.79707
At most 4	8.665087	14.26460	9.202170	15.49471
At most 5	0.537083	3.841466	0.537083	3.841466

Source: Authors' compilation. **Denotes significant at 5% significance levels time such that the strength with which the independent variables explain the variability in the dependent variable is made known. It determines the amount of future uncertainty of one time series that is due to random shocks into each of the other endogenous variable. It measures the relative importance of each random shocks. From Table 8 below, in the first section, it can be seen that for a forecast horizon of 10 years movement in energy consumption is explained by 2% changes in GDP, 3% changes in industrialisation, 26% changes in urbanisation, 1% changes in trade and 7% changes in FDI. It can be seen that shock to urbanisation accounts for much of the future uncertainty in energy consumption.

With regards industrialisation, for a forecast horizon of 10 years movement in industrialisation is explained by 8% changes in energy consumption, 51% changes in GDP, 12% changes in urbanisation, 7% changes in trade and 0.76% changes in FDI. It can be seen that shock to GDP accounts for much of the future uncertainty in Industrialization. With regards GDP, for a forecast horizon of 10 years movement in GDP is explained by 39% changes in energy consumption, 6% changes in industrialisation, 36% changes in urbanisation, 2% changes in trade and 6% changes in FDI. It can be seen that shock to energy consumption and urbanisation accounts for much of the future uncertainty in GDP. With regards urbanisation, for a forecast horizon of 10 years movement in industrialisation is explained by 7% changes in energy consumption, 0.9% changes in GDP, 0.5% changes in industrialisation, 0.56% changes in trade and 1% changes in FDI. It can be seen that shock to itself accounts for much of the future uncertainty in urbanisation. With regards urbanisation, for a forecast horizon of 10 years movement in tradeis explained by 33% changes in energy consumption, 11% changes in GDP, 11% changes in industrialisation, 2% changes in urbanisation and 0.4% changes in FDI. On the last note, movement in FDI for 10 years forecast horizon is explained by 1% changes in energy consumption, 8% changes in GDP, 2% changes in industrialisation, 8% changes in urbanisation and 12% changes in trade. It can be seen that shock to itself accounts for much of the future uncertainty in industrialization.

3.4. Impulse Response Function

The impulse response function indicates the impact of an upward unanticipated one-unit shock in the impulse variables over a given time period. Given the focus of the study, the impulse response function for response of energy consumption to changes in energy consumption, GDP, Industrialization, Urbanization, trade and FDI respectively is discussed. The response of energy consumption to energy consumption falls for the entire time period and only significant in the first and second period. Energy consumption response to a shock in GDP also falls slightly and stabilises over time. Energy consumption response to a shock in industrialisation signify a positive response only in period 3 and a gradual fall for the rest of time period. With regards urbanisation, a one unit shock resulted in a fall for the rest of time periods, result indicating divergence which is statistically significant up to period 8. Response of energy consumption to a shock in trade shows a continuous fall, although a sudden rise in period three is seen. With regards response of energy consumption to a shock in FDI, a sudden fall exists in period 2 and then stabilises by period 6, for which result indicates convergence (Graph 1).

4. CONCLUSION

This study examines the dynamic relationship between energy consumption, economic growth, urban growth and industrial growth within the VECM framework. The test for cointegration

Table 6: Summary results from VEC

Tests	D (ENC)	D (GDP)	D (IND)	D (URB)	D (TRD)	D (FDI)
ECT	0.9166**	−0.1443*	−19.3740*	0.0040	−4.0799	4.7323*
t-statistic	[2.0795]	[−3.3997]	[−5. 1881]	[0.0254]	[−0.3679]	[3.3204]
R^2	0.3549	0.5134	0.7763	0.2830	0.3319	0.6281
F-stat	1.2577	2.4112	7.9318	0.9023	1.1352	3.8597

Source: Authors' compilation. * and **Denote significant at 1% and 5% significance level respectively

Table 7: Granger causality results based on VECM

Independent variables

Dependent variables	Chi-square statistics of lagged 1st differenced term [P-value]						ECT_{t-1} coefficient [t-ratio]
	D (ENC)	D (GDP)	D (IND)	D (URB)	D (TRD)	D (FDI)	
D (ENC)	-	2.1545	3.3064	0.6644	1. 1233	3.9759**	0.9166**
		[0.1421]	[0.0690]	[0.4150]	[0.2892]	[0.0462]	[2.0795]
D (GDP)	2.9151	-	6.9012*	0.3052	1.7874	4.3072**	−0.1443*
	[0.0878]		[0.0086]	[0.5806]	[0. 1812]	[0.0380]	[−3.3997]
D (IND)	0.0692	0.3899	-	9.8227*	6.6891*	0.4501	−19.3740*
	[0.7926]	[0.5323]		[0.0017]	[0.0097]	[0.5023]	[−5. 1881]
D (URB)	0.3538	0.3453	2.0864	-	0.3398	0.3555	0.0040
	[0.5520]	[0.5568]	[0.1486]		[0.5600]	[0.5510]	[0.0254]
D (TRD)	0.0085	0.4316	2.3831	0.0006	-	0.0416	−4.0799
	[0.9265]	[0.5112]	[0.1227]	[0.9804]		[0.8384]	[−0.3679]
D (FDI)	5.1803**	6.7746*	1.3297	0.3317	1.3185	-	4.7323*
	[0.0228]	[0.0092]	[0.2489]	[0.5647]	[0.2509]		[3.3204]

Source: Authors' compilation. * and **denote significant at 1% and 5% significance level respectively

Table 8: Variance decomposition

Period	S.E.	ENC	GDP	IND	URB	TRD	FDI
Variance decomposition of ENC							
1	0.491284	100.0000	0.000000	0.000000	0.000000	0.000000	0.000000
2	0.723108	87.58854	0.107959	0.050065	5.935511	0.916624	5.401299
3	0.928054	80.93274	0.803534	0.838904	10.63406	0.556588	6.234171
4	1.141670	73.59064	1.300817	2.234002	15.82995	0.885603	6.158994
5	1.337523	67.84383	1.690825	2.860652	19.91697	1.091166	6.596554
6	1.502046	64.77459	1.902267	2.920352	22.27486	1.132642	6.995290
7	1.651259	62.97979	1.952133	3.039804	23.74263	1.096223	7.189416
8	1.795282	61.41153	2.023689	3.303675	24.91469	1.106979	7.239431
9	1.929864	60.04381	2.120376	3.448946	25.90500	1.160548	7.321326
10	2.052015	59.12101	2.172926	3.473477	26.62324	1.173351	7.435995
Variance decomposition of GDP							
1	0.047313	91.06443	8.935565	0.000000	0.000000	0.000000	0.000000
2	0.073401	74.98186	8.463825	0.382195	9.834115	1.728132	4.609872
3	0.101312	62.93225	9.333576	3.320814	18.34198	1.059029	5.012347
4	0.131052	52.59366	9.898321	5.498981	25.18246	1.958245	4.868332
5	0.156115	46.89620	10.16840	5.691141	29.53745	2.273922	5.432883
6	0.176564	44.37986	10.16836	5.594582	31.84084	2.207288	5.809065
7	0.195826	42.76545	10.02631	5.867201	33.30533	2.144352	5.891355
8	0.214576	41.20663	10.01636	6.182587	34.47603	2.206122	5.912281
9	0.231494	40.01896	10.06368	6.224744	35.40882	2.269071	6.014720
10	0.246662	39.31636	10.04587	6.207442	36.06200	2.254888	6.113440
Variance decomposition of IND							
1	4.162030	0.002417	27.41813	72.57945	0.000000	0.000000	0.000000
2	6.463773	3.046195	47.71741	38.26677	0.022574	10.90535	0.041701
3	7.295012	7.328193	48.18331	30.76633	4.195386	9.300359	0.226427
4	7.892616	7.505040	46.29166	26.93392	10.48453	8.374292	0.410559
5	8.738550	6.572707	46.69663	28.20861	10.04823	7.708263	0.765552
6	9.512170	6.943674	49.25448	25.50870	9.207187	8.433786	0.652169
7	10.03852	7.927532	50.05480	22.94426	10.71185	7.775857	0.585704
8	10.49839	8.036674	50.02785	21.68408	12.48317	7.125258	0.642963
9	11.04918	7.809525	50.56376	21.59449	12.46296	6.870252	0.699018
10	11.57657	7.992000	51.61314	20.53044	12.29939	6.910824	0.654206
Variance decomposition of URB							
1	0.174805	9.087951	8.354367	1.878297	80.67939	0.000000	0.000000
2	0.255884	8.495338	3.955674	1.626206	84.92788	0.385133	0.609769
3	0.310353	7.955115	2.850730	1.389340	85.63568	1.144597	1.024542
4	0.357009	7.178596	2.154612	1.117113	87.65822	0.986927	0.904535
5	0.403088	6.825137	1.721061	0.885441	88.84074	0.775358	0.952267
6	0.441880	6.892016	1.434042	0.823767	89.09875	0.687349	1.064078
7	0.475219	6.844108	1.245305	0.747726	89.37720	0.708962	1.076697
8	0.507807	6.669282	1.090627	0.657427	89.86588	0.660234	1.056551
9	0.539718	6.585051	0.971129	0.582135	90.19907	0.593031	1.069584
10	0.568885	6.594971	0.874543	0.546308	90.32476	0.560873	1.098545
Variance decomposition of TRD							
1	12.36005	21.17275	0.599531	6.004967	6.723045	65.49971	0.000000
2	14.92178	26.77296	6.507353	9.976838	5.779299	50.89288	0.070669
3	16.93605	28.20548	8.435668	9.120298	4.911013	48.96460	0.362935
4	19.08238	29.21439	8.673271	8.676959	4.485569	48.60692	0.342892
5	21.12313	30.55131	9.116226	10.19474	3.755309	46.08111	0.301294
6	22.84357	31.34876	10.16684	11.20566	3.212774	43.73309	0.332878
7	24.32321	31.82096	10.79547	11.11671	2.868919	42.99583	0.402116
8	25.82682	32.21219	10.89383	11.08214	2.623685	42.77252	0.415627
9	27.30960	32.62277	11.07860	11.54194	2.371236	41.97829	0.407151
10	28.64721	32.93874	11.45200	11.86691	2.161321	41.15940	0.421625
Variance decomposition of FDI							
1	1.588452	3.770776	2.204061	1.412910	0.325311	4.932825	87.35412
2	2.312073	1.815798	8.347755	2.385405	7.921890	10.88177	68.64739
3	2.774112	1.295716	6.643471	4.424764	12.33223	11.76556	63.53826
4	3.120708	1.675979	5.870034	3.630680	12.03122	14.24286	62.54923
5	3.396987	1.785125	7.407682	3.541971	10.57842	12.93666	63.75014
6	3.684296	1.556377	7.984170	3.172034	9.617835	12.04400	65.62558

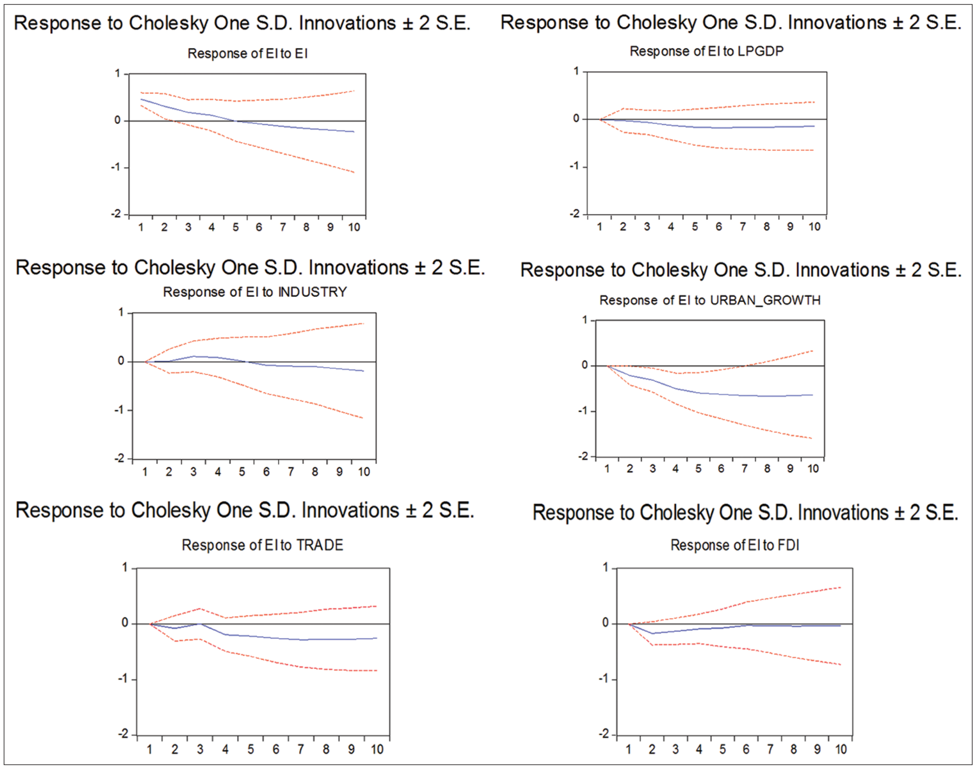
(Contd...)

Table 8: ***(Continued)***

Period	S.E.	ENC	GDP	IND	URB	TRD	FDI
7	3.969462	1.425250	7.543468	2.983527	9.590806	12.81723	65.63972
8	4.200890	1.518441	7.473129	2.691269	9.354342	13.16932	65.79350
9	4.415344	1.532882	7.883376	2.484728	8.808231	12.73553	66.55526
10	4.634898	1.451225	8.055107	2.290363	8.454521	12.48852	67.26027

Cholesky ordering: ENC GDP IND URB TRD FDI

Graph 1: Response of Energy consumption to changes in ENC, GDP, IND, URB, TRD and FDI respectively



indicates one cointegrating relationship exist among the variables in the model. From VECM analysis above, it is seen that GDP possess the correct sign which is statistically significant at 1 % with the speed of adjustment back to equilibrium at 14%. The Granger causality test indicates a bidirectional short-run causal relationship between FDI and Energy Consumption while no other short-run causal relationship existswith regards energy consumption in the short run. On the other hand, long run causal relationships only exist for GDP representing economic growth.

With variance decomposition analysis, it is seen for a forecast horizon of 10 years, movement in energy consumption is explained by 2% changes in GDP, 3% changes in industrialisation, 26% changes in urbanisation, 1% change in trade and 7% changes in FDI. Thus, it can be seen that shock to urbanisation accounts for much of the future uncertainty in energy consumption. Variance decomposition helps to establish if the causal relationship found between the variables will also hold out of sample period. While over the years, a bidirectional causal relationship exist between energy consumption and FDI, the variance decomposition says only about 7% changes in FDI contributes to future uncertainty in GDP. Also, GDP has long run causality, hence for a forecast horizon of 10 years, movement in GDP is explained by 39% changes in energy consumption, 6% changes in industrialisation, 36% changes in urbanisation, 2% changes in trade and 6% changes in FDI. It can be seen that shock to energy consumption and urbanisation accounts for much of the future uncertainty in GDP. The impulse response function for energy consumption with regards the rest of the variables is examined. Impulse responses can help determine the sign of the causality. The response of energy consumption to shock in energy consumption, industrial growth, urbanisation, and trade explodes as response continues to fall with the exception of FDI. A shock to FDI results in a fall in energy consumption and then converges in period 6.

In conclusion, no short-run causal relationship exists between energy consumption, economic growth, industry growth and urban growth. One possible reason for this relationship is that energy consumption has been at very lowlevel over the years, hence its inability to influence economic growth, urbanisation, and industrialisation and to be influenced by these variables. For instance, Nigeria needs to generate about 160,000 MW of electricity given its population size but only generates an average of 4000 MW (Power Africa, 2018). On the other hand, a short run causal bidirectional relationship is observed between energy consumption and FDI. With regards the impulse response function, a shock to FDI have energy consumption responding with an immediate fall and gradually returns to zero by period 6. A long run causal relationship is observed for GDP growth.

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