Following the establishment of cointegration relationship among the variables, the long run and short run models in equation 5 and equation 6 were estimated to get these long run and short run coefficients as reported in **Table 7** below. The results revealed that CO_2 emission is positive and significant at 1% level of significance. Meaning that 1% increase in CO_2 emission is associated with 0.242% increase in energy demand in the long run period.

Real gross domestic product is also positive and significant in explaining changes in energy demand. Specifically, 1% increase in RGDP is associated with 0.386% increase in energy demand in the long run period and this corroborates the findings of Hassan (2018). Urbanization is negative and significant in explaining changes in energy demand in the long run period. Precisely 1% changes in URB is associated with 0.378% decrease in energy demand in Nigeria. This supported the findings of Hassan (2018) and contradicts the findings of Chidinma et al. (2018).

Coming down to the short run outcome also reported in the **Table 7**, the results indicates that CO_2 emission and RGDP are positive while URB is negative and significant at 1% level of significance in explaining changes in energy demand. Meaning that 1% increase in CO_2 emission and RGDP are associated with 0.182% and 0.290% increase in energy demand in the short run period. While 1% increase in URB is associated with -0.346% decrease in energy demand in the short run and this finding corroborates the result of Hassan (2018) and this is contrary to the result of Chidinma et al. (2018). The error correction value of -0.37 satisfied the econometrics requirements of negative value, less than one and significant which means that the feedback or convergence rate to long run equilibrium is 37%. Precisely, the error correction term value also indicates that the long-run deviation from the energy demand is corrected by 37% every year.

The R-square value of 0.922 signifies that 92% variation in energy demand can be jointly explained by the explanatory variables and only 8% variation in energy demand is explained by the error term. The Durbin Watson value of 1.336 implies that the model is not free from first order serial correlation as the value is not within the range of 1.50 to 2.50. The F-statistic which is the test for the overall significant of the model indicates the value of 45.084 which is highly significant at 1% level of significance. Meaning that the all the explanatory variables in the model are jointly significant in explaining the changes in energy demand. The error correction value of -0.751 satisfied the econometrics requirements of negative, less than one in value and significant which means that the feedback or convergence rate to long run equilibrium is 75%. The error term value indicates that for every short run disequilibrium, about 75% of the disequilibrium is corrected each year.

Table 7: Long run and Short run coefficients for ARDL (1, 0, 0, 0, 0) using Schwarz criterion (SIC)

Dependent Variable = $\ln ED_t$				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
$\ln CO_{2t}$	0.242	0.071	3.414[a]	0.002
$\ln RGDP_t$	0.386	0.075	5.134[a]	0.000
$\ln URB_t$	-0.461	0.124	-3.701[a]	0.001
$\ln AE_t$	0.098	0.082	1.183	0.251
C	6.595	0.735	8.967[a]	0.000
Dependent Variable = $\Delta \ln ED$				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
$\Delta \ln CO_{2t}$	0.182	0.040	4.472[a]	0.000
$\Delta \ln RGDP_t$	0.290	0.063	4.588[a]	0.000
$\Delta \ln URB_t$	-0.346	0.097	-3.539[a]	0.002
$\Delta \ln AE_t$	0.073	0.065	1.122	0.275
ECM (-1)	-0.751	0.150	-5.010[a]	0.000

$ecm = \ln ED_t - 0.242 \times \ln CO2_t - 0.387 \times \ln RGDP_t + 0.461 \times \ln URB_t - 0.098 \times \ln AE - 6.595$

R^2: 0.922, Adjusted R-squared : 0.901, DW-statistic: 1.336, F-stat: 45.084[a] (0.000), Schwarz criterion: -5.174, Akaike info criterion: -5.466

Sources: Authors computation using EViews 9; Note. ECM = Error Correction Model. [a & b] and are significant at 1% & 5% levels of significance.

To guarantee the reliability of the estimated coefficients, the reliability tests of serial correlation using Breusch-Godfrey serial correlation LM test, functional form using Ramsey RESET test, normality test using Jarque-Berra and the heteroskedasticity using Autoregressive conditional heteroscedasticity (ARCH) were engaged and the outcome is reported in **Table 8** below. The outcome showed that the null hypotheses for the serial correlation LM test, normality test and heteroskedasticity test could not be rejected for the model. This shows that the model reliable for policy making and statistical inferences.

Table 8 Residuals of the Autoregressive Distributed Lag Diagnostic Tests.

Test statistics	**LM version**	**F-version**
Serial correlation	CHQ (2) = 3.334 [0.188]	F(2,17) = 1.308 [0.296]
Heteroscedascity	CHQ (5) = 3.342 [0.647]	F(2,24) = 0.586 [0.710]
Functional form	Not applicable	F(1, 18) = 0.128 [0.724]
Normality	JB = 0.018 [0.600]	Not applicable
CUSUM	Stable	
CUSUMSQ	Stable	

Sources: Authors computation using EViews 9; Note. The values in [ ] are the probability values. LM = langrange multiplier test, CHQ = chi-square.

In determining the stability of the estimated coefficients of energy demand equation for Nigeria, the cumulative sum (CUSUM) and cumulative sum of squares (CUSUMSQ) tests as suggested by Pesaran and Pesaran (1997) were utilized.

From the figure 1 and 2 of CUSUM and CUSUMSQ, it can be noticed that both the CUSUM and CUSUMSQ plots do not pass through the 5% critical boundaries, indicating that over the entire sample period of 1987 to 2017, there is an existence of stability among the estimated coefficients. Therefore, the estimated coefficients are reliable and suitable for policy making in Nigeria.

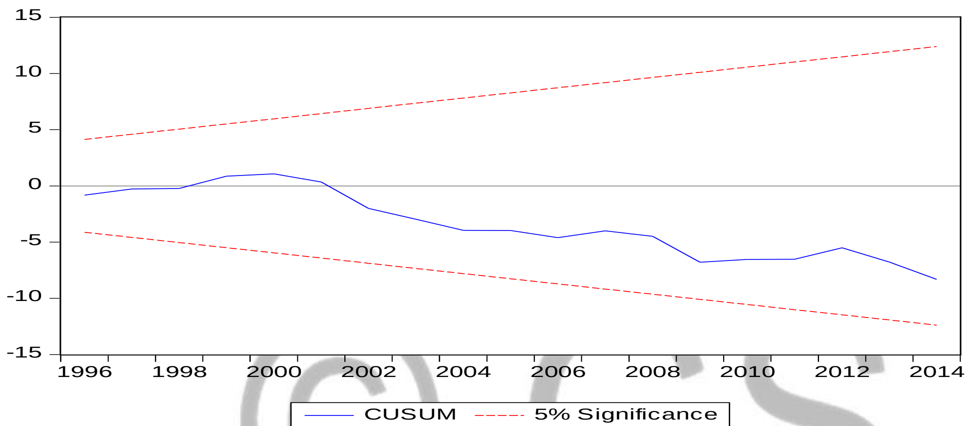

Figure 1: Stability test for assessing the key drivers of energy demand in Nigeria

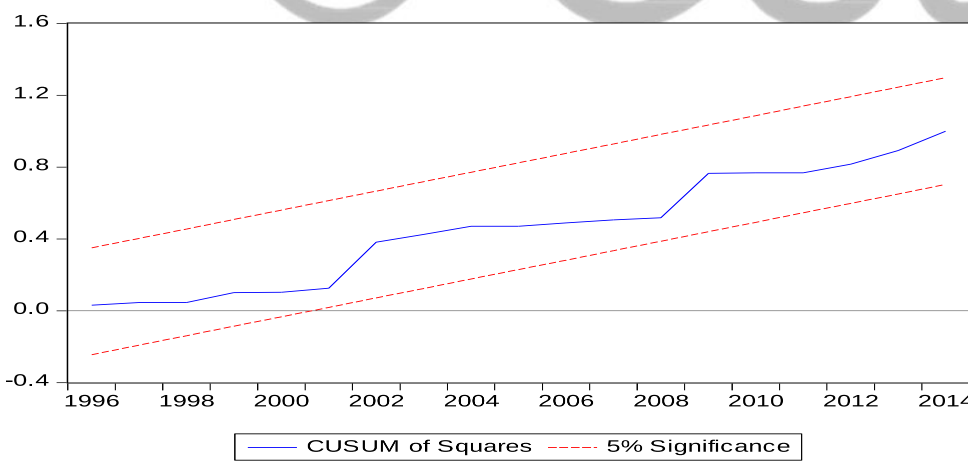

Figure 2 Stability test for assessing the key drivers of energy demand in Nigeria

As strength checks to the ARDL results, we have employed dynamic OLS, fully modified OLS and Canonical CR, and their coefficients are reported in **Table 9**. The outcome demonstrate that in all the three estimators CO_2 emission and real GDP have are positive and significance whereas urbanization is negative and also significant in influencing changes in energy demand in the long run in Nigeria. However access to electricity appears to be negative and insignificant in explaining changes in energy demand in accordance with the DOLS, FMOLS and CCR results. These findings corroborate the long run ARDL estimates depicted in **Table 7** above.

Table 9 Estimated results for the assessment of key drivers of energy demand using time Series DOLS, FMOL and CCR.

Dependent Variable $= \ln ED$**:**	**DOLS**		**FMOLS**		**CCR**	
Regressors	**Coefficients**	**SE**	**Coefficients**	**SE**	**Coefficients**	**SE**
CO_2 Emission	0.193^b		0.179^a		0.178^a	
	(2.783)	0.069	(3.848)	0.046	(3.396)	0.052
Real GDP	0.455^b		0.338^a		0.335^a	
	(2.724)	0.167	(5.674)	0.059	(5.578)	0.060
Access to Electricity	0.506		0.089		0.092	
	(1.789)	0.283	0.981)	0.091	(1.025)	0.090
Urbanization	-0.722^c		-0.389^a		-0.386^a	
	(-2.365)	0.305	(-3.733)	0.104	(-3.461)	0.111
Constant	8.474^b		6.474^a		6.467^a	
	(4.360)	1.943	(9.798)	0.660	(8.466)	0.763
R^2	0.975		0.906		0.975	
Adjusted R^2	0.911		0.886		0.911	
Normality test:	0.898 [0.638]		0.390 [0.822]		0.893 [0.637]	

Sources: Authors computation using EViews 9; Note. Numbers in brackets are the t-statistics and Numbers in [ ] are the P-Values. DV = Dependent variable, DOLS = dynamic ordinary least squares; FMOLS = fully modify ordinary least square; OLS = Ordinary Least Square; SE = standard error. $^{a, b}$ & ^{c} indicates significant at 1%, 5% & 10% levels of significance respectively.

After checking the strength of ARDL long run coefficients, then causal link between the variables was checked using VECM granger causality test in a vector autoregressive (VAR) system. The existence of long run relationship as represented in **Table 5** and **Table 6** above suggest the existence of causal relation in at least one direction. The estimated short run and long run causality results are offered in **Table 10** and the summary of causality results is given in **Table 11**. The long run causality results reveal that ECT_{t-1} in access to electricity equation has fulfilled all the econometrics requirements of negative, less than one in value and statistically significant. This suggests that there is a long run causality running from urbanization, real GDP, CO_2 emission and energy demand to access to electricity. In equation with CO_2 emission as dependent variable, the ECT_{t-1} value is also negative, less than one in value and statistically significant. Therefore we conclude that there is long run causality running from urbanization, real GDP, CO_2 emission and energy demand to CO_2 emission.

Apart from the long run causality, the short run causality was also reported in **Table 10**. However, in the short run, there is bidirectional causality from running from real GDP to energy demand and urbanization to real GDP. There is also unidirectional causality running from CO_2 emission to real GDP and from access to electricity to real GDP. The rest of the interpretations with regards to the long run and short run causality results are offered in **Table 11** below.

The VECM reliability tests results are reported in the lower part of **Table 10** which indicates that the model is steady and reliable as all the null hypotheses of the tests were accepted, and therefore its coefficients are acceptable for statistical reasoning.

Table 10 Vector error correction model granger causality test result

	Direction of Causality					
	Short run					**Long run**
Dependent Variables	$\sum \Delta \ln ED_t$	$\sum \Delta \ln AE_t$	$\sum \Delta \ln CO_{2t}$	$\sum \Delta \ln RGDP_t$	$\sum \Delta \ln URB_t$	ECT_{t-1}
$\Delta \ln ED_t$	----	1.148 (0.283)	0.001 (0.972)	4.022^b (0.044)	1.664 (0.197)	0.061 (0.797)
$\Delta \ln AE_t$	0.268 (0.604)	----	0.197 (0.657)	1.003(0.316)	0.7409 (0.389)	-0.922^b (0.049)
$\Delta \ln CO_{2t}$	0.069 (0.791)	0.557 (0.455)	----	1.307 (0.252)	2.001 (0.157)	-0.177^b (0.020)
$\Delta \ln RGDP_t$	4.793^b (0.028)	5.930^b (0.014)	5.428^b (0.019)	----	11.398^a (0.000)	0.583 (0.776)
$\Delta \ln URB_t$	0.633 (0.425)	0.244 (0.620)	1.382 (0.239)	3.396^c (0.065)	----	0.024 (0.099)

Diagnostic tests: Akaike information criteria = -26.524, Schwarz criterion: -24.549, VEC residual serial correlation LM test = 29.985 (0.224), VEC White heteroscedasticity test = 180.816 (0.468), VEC Jarque Bera normality test = 0.093 (0.954)

Sources: Authors computation using EViews 9; Note. Values in parentheses are the P- values. LM = langrange multiplier; VEC = vector error correction $^{a,\ b\ \&\ c}$ indicates significant at 5% level.

Table 11 Summary of VECM granger causality test results

Direction of causality	**Short run (F-statistics)**	**Long run (**ECT_{t-1}**)**
$\ln EA_t$ causes $\ln ED_t$	NO	NO
$\ln CO_{2t}$ causes $\ln ED_t$	NO	NO
$\ln RGDP_t$ causes $\ln ED_t$	At 5% level of significance	NO
$\ln URB_t$ causes $\ln ED_t$	NO	NO
$\ln ED_t$ causes $\ln EA_t$	NO	At 5% level of significance
$\ln CO_{2t}$ causes $\ln EA_t$	NO	At 5% level of significance
$\ln RGDP_t$ causes $\ln EA_t$	NO	At 5% level of significance
$\ln URB_t$ causes $\ln EA_t$	NO	At 5% level of significance
$\ln ED_t$ causes $\ln CO_{2t}$	NO	At 5% level of significance
$\ln EA_t$ causes $\ln CO_{2t}$	NO	At 5% level of significance
$\ln RGDP_t$ causes $\ln CO_{2t}$	NO	At 5% level of significance
$\ln URB_t$ causes $\ln CO_{2t}$	NO	At 5% level of significance
$\ln ED_t$ causes $\ln RGDP_t$	At 5% level of significance	NO
$\ln EA_t$ causes $\ln RGDP_t$	At 5% level of significance	NO
$\ln CO_{2t}$ causes $\ln RGDP_t$	At 5% level of significance	NO
$\ln URB_t$ causes $\ln RGDP_t$	At 1% level of significance	NO

$\ln ED_t$ causes $\ln URB_t$	NO	NO
$\ln EA_t$ causes $\ln URB_t$	NO	NO
$\ln CO_{2t}$ causes $\ln URB_t$	NO	NO
$\ln RGDP_t$ causes $\ln URB_t$	At 10% level of significance	NO

Source: Authors computation using EViews 9.

5.0 Summary and Conclusion

The study utilized of ARDL approach to cointegration relationship to assess the determinants of energy demand in Nigeria. The assessment was done for the sample period of 1987 to 2017. The direction of causality was tested by employing VECM granger causality in both the short run and the long run periods. Firstly, the study tested for the existence of long run equilibrium relationship after determining the optimum lag and found that they variables were cointegrated. Following the cointegrated series, the long run and short run models were estimated and the results revealed that CO_2 emission and real gross domestic product are responsible for increase in energy demand within the study period while urbanization is found to be negative in both the two periods. Access to electricity appeared to be insignificant in explaining the changes in energy demand in both the long run and short run periods. The diagnostic checks were performed on the model and the results indicate that the model is good fit and have fulfilled nearly all the requirements for classical linear regression.

The checking for robustness was done using DOLS, FMOLS and CCR, and their outcomes corroborates the results of ARDL long run model. The VECM granger causality was applied to test the direction of causality, which indicated significant long run causality in the in access to electricity and CO_2 emission equations. In the short run period, there is bidirectional causality running from RGDP to ED and URB to RGDP together with unidirectional causality running from CO_2 to RGDP and from AE to RGDP respectively.

The main conclusion drawn from this research work is that since CO_2 emission, urbanization and real GDP are significance in explaining changes in energy demand in both long run and short run periods in Nigeria over the study period of 1987 to 2017, then these variables are said to be the key drivers of energy demand in Nigeria and policy measures with regards to energy demand in the country should be inform of long run and short run periods.

Declaration of Conflicting Interests
The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.
Funding
The author(s) received no financial support for the research, author-ship, and/or publication of this article.
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