Econometric modelling of the link between investment and electricity consumption in Ghana

Asuamah Yeboah, Samuel

Sunyani Technical University

28 October 2018

Econometric modelling of the link between investment and electricity consumption in Ghana

Samuel Asuamah Yeboah

Faculty of Business and Management Studies
P. O. Box 206
Sunyani Technical University, Sunyani, Ghana
Email: nelkonsegal@yahoo.com
Phone: +233244723071

ABSTRACT

The study examines the long run effect of investment (proxied by gross fixed capital formation) on electricity consumption for Ghana, for the period 1971-2011, by employing annual time series secondary data from World Bank database (World development indicator). The Augmented Dickey Fuller (ADF) and Kwiatkowski-Philips-Schmidt-Shin (KPSS) tests were used to analyse the stationarity features of the data used in levels and in their first differences. The empirical verification was done using the Autoregressive Distributed Lag model (ARDL). The findings of the study indicate the data used are non-stationary in levels, however, stationary in their first difference. Investment and electricity consumption are cointegrated according to the cointegration test performed. There are both stable short run and long run relationship between investment and electricity consumption. Investment is an appropriate policy tool for electricity consumption management in both short run and long run. Further studies in the area of stationarity with structural breaks, cointegration with structural breaks, causality analysis, and multivariate modelling of investment-electricity consumption link is worth doing since the current study did not consider these issues.

KEYWORDS: Cointegration, energy, long run, fixed capital formation
JEL CODES: D92, E22, F21, G31, H54, O13, O16, P28, P45, P48, Q42, Q43, R42, R53

INTRODUCTION

Electricity consumption globally and nationally has increased and continues to increase and this persistent increase in consumption has attracted attention in the energy literature because of the gap between the consumption and supply (De Vita et al., 2006; Ziramba, 2008; Ekpo et al., 2011; Ubani, 2013). Ghana and many developing countries have suffered power shortages over the years and that has led to the collapse of many firms and business (Ubani, 2013; Clerici, Taylor, Taylor, 2016; Kumi, 2017; Energypedia, 2018).

Electricity consumption theoretically and empirically is supported as a variable that plays significant role in economic development and wealth creation (Ferguson, Wilkinson, and Hill, 2000; Korea, Soytas & Sari, 2003; Fatai, Oxley, & Scrimgeour, 2004; Oh & Lee, 2004; Altinay & Karagol, 2005; Hatemi & Irandoust, 2005; Lee & Chang, 2005; Yoo, 2005; Wolde-Rufael, 2006; Lorde, Waithe, Francis, 2010; Kasperowicz, 2014) and that has in addition, attracted attention in the energy literature on the factors that influence energy consumption in order to ensure sufficient electricity energy supply.

The citizenry uses electricity for various purposes such as heating, cooling, lighting, transportation (private and public), operating appliances such as computers and other machines. These important uses have also led to studies on the factors that influence electricity consumption (Bildirici, Bakirtas, Kayikci, 2012; U.S. Energy Information Administration report, 2018).

The literature on the relationship between investment and electricity consumption are found in the works of various authors (Mielnik & Goldemberg, 2002; Antweiler et al., 2001; Chima, 2007; Xiaoli et al., 2007; Dube, 2009; Hai, 2009; Hubler, 2009; Tang, 2009; Sadorsky, 2010; Bekhet & Othman, 2011; Bento, 2011; Zheng et al., 2011; Zaman et al., 2012; Alam, 2013; Lee, 2013; Sbia, Shahbaz, & Hamdi, 2013; Dritsaki & Dritsaki

2014; Omri & Kahouli, 2014; Sbia et al., 2014; Leitão, 2015). The findings of these studies is that investment positively or negatively influenced electricity consumption, during the periods under discussion.

That is, the empirical findings are mixed. For example, Tang (2009) in his Malaysia study, reported that investment positively affect electricity consumption. Sadorsky, (2010) examined the long run effect of investment on electricity consumption for 22 developing countries and reported that investment positively influence electricity consumption. Bento (2011) studied the relationship between investment and electricity consumption in Portugal. The findings of the study indicate negative influence of investment on electricity consumption. In the United States and China, Zheng et al. (2011) reported that investment (proxied by foreign direct investment-FDI) is positively linked to electricity consumption.

The findings of Zaman et al. (2012) study indicated that investment positively influence electricity consumption. Alam (2013) study of the influence of investment on electricity consumption for India and Pakistan produced mixed findings. In Alam (2013) study, whereas electricity consumption influences investment in India, investment influences electricity consumption in Pakistan. Lee (2013) studied investment-electricity nexus for G20 countries and reported of neutral link between investment and electricity consumption for the period under discussion.

In UAE, Sbia et al. (2014) examined the investment (proxied by FDI)-electricity consumption nexus and reported of negative link between investment and electricity consumption. Omri and Kahouli (2014) used 69 high- income countries, middle-income and low-income to investigate the long run effect of investment on electricity consumption, and concluded that investment positively influence electricity consumption. Leitão (2015) research on the effect of investment and electricity consumption show positive relationship between investment and electricity consumption.

The studies reviewed used various estimation methodologies such as dynamic panel data (GMM system) estimator, Autoregressive Distributed Lag model (ARDL), Vector Error Correction model (VEC), and Granger causality. The channel of effect of investment on electricity consumption is direct. Investment increases the liquidity status of consumers and they are able to demand products, install new pants and put up factories that use electricity.

The current study is necessitated by the fact that the role of investment in electricity consumption is relatively studied and the fact that the empirical findings are inconsistent (Omri, 2013). The purpose of the study is to analyse the effect of investment (proxied by gross fixed capital formation) on electricity consumption to add to the few empirical studies that exist in the study area. The paper specifically assesses both short run and long run relationship between investment and electricity consumption. The paper is based on the questions such as what is the nature of the relationship between investment and electricity consumption? The assumption underlying the study is that investment significantly positively affect electricity consumption in both short run and long run.

The study is not without challenge. The bivariate modelling approach might suffer from omission variable error (Miller, 1991; Stern, 1993; Stern, 2000; Chang et al., 2001). In addition, the cointegration test did not consider the issue of causality, and structural breaks.

The rest of the paper is organised into 3 sections. Section 2 considers the methodology, whereas section 3 deals with empirical results, with section 4 concluding the study.

2. METHODOLOGY

2.1 Design/Data

The study is based on quantitative design and time series modelling of the link between investment and electricity consumption. The quantitative design is used since the study quantifies the influence of investment on electricity consumption. Time series annual secondary data for the period 1970-2011 was employed in the empirical study, for Ghana. The data source is the World Bank database (World Development Indicator). The description of the data, proxies, and sources are reported in Table 1.

Table 1 Data Description, Proxies and Sources

Data Description	Source
Investment (INV) (proxied by gross fixed capital formation)	World Bank World Development Indicator (WDI)
Electricity consumption (EC)	World Bank World Development Indicator (WDI)

2.2 Estimation Method

The data used was initially examined for stationary by employing the ADF and KPSS tests. The null assumption of the ADF test is that the data set are stationary in their levels, whereas, the alternative assumption is that they are not stationary in their levels but in their first difference. The KPSS test is the confirmatory test for the ADF test. it has opposite assumptions to the ADF test. The null assumption is that the

The ADF test is first used and it is based on the null hypothesis that the variables under investigation are unit root in levels against the alternative hypothesis that the variables in the study model are not unit root in levels (Dickey, & Fuller, 1979; Dickey, 1984; Greene, 2002).

The KPSS test used after the ADF test is performed as a confirmatory test, and it is based on the hypothesis that there is non-unit root around a deterministic trend. The alternative hypothesis is that the variables in the study model are unit root around a deterministic trend (Bhargava, 1986; Kwiatkowski, Phillips, Schmidt, & Shin, 1992)

The long run effect of investment on electricity consumption was examined by employing the ARDL method of cointegration following the assessment of the stationarity properties of the data. The main advantage of the ARDL model is that, it can be used without knowing the stationarity properties of the data set if and only if they are not integrated of order two. In addition, it is robust in small sample studies (Pesaran, & Shin, 1999; Pesaran, Smith, & Shin, 2001).

2.3 Conceptual Framework and the Empirical Model

The model for the study of the link between investment and electricity consumption is shown in equation (1), in a bivariate model, investment (INV) as the regressor and electricity consumption (EC) as the regressand.

$$\ln EC_t = a + \beta \ln INV_t + e_t \text{...(1)}$$

3. EMPIRICAL RESULTS

3.1 Descriptive Statistics

3.1.1 Results of Central tendencies and Dispersion

The analysis begins with the assessment of the basic features of the data by employing the descriptive statistics as a starting point. Averages, standard deviations, variances, kurtosis and skewness were used. Table 2 reports the results. The model is well fitted as the mean values indicate. Results on investment indicate that investment falls as low as 3.532 and rises as high as 29.002, whereas electricity consumption falls as low as 92.359GWh and rise as high as 421.233GWh. In relation to volatility, electricity consumption is less volatile than investment, as measured by the coefficient of variation. The coefficient value of kurtosis for both EC, and INV are less than 3 which means the distribution produces fewer and less extreme outliers than what normal distribution produces. Electricity consumption is negatively skewed, whereas, investment is positively skewed.

Table 2 Summary Statistics, using the Observations 1970-2011

Var	Mean	Min.	Max.	S.D	CV.	SK.	KUR.
EC	311.580	92.359	213.630	71.435	0.229	-0.897	0.867
INV	15.168	3.532	29.002	7.269	0.479	0.163	-1.129

Source: Author's computation, 2013. SK=Skewness; KUR. =Kurtosis; CV=Coefficient of Variation; Min. Minimum; Max. =Maximum; S.D=Standard Deviation

3.1.2. Correlation Analysis

Correlation matrix was employed to assess the multi-collinearity between electricity consumption and investment. The results are reported in Table 3. The results as reported in Table 3 show that electricity consumption and investment are negatively related. Overall, the magnitudes of the correlation coefficients (-0.143) indicate that multi-collinearity is not a potential problem in the regression models and the dataset together with the variables are appropriate for the current study.

Table 3 Correlation Matrix for Test's Variables

Var	EC	INV
EC	1.000	
INV	-0.143	1.000

Source: Author's computation, 2013:
NOTE: 5% critical value (two-tail) = 0.3044: * denotes significance at 5%

3.2 Regression Results

The analysis in this section is started by examining the unit root properties, cointegration relationship between electricity consumption and investment, the short run and the long run estimates, as well as the model diagnostic test.

3.2.1. Unit Root Test Results

3.2.1.1. The ADF Test

The results on the ADF test for unit root test are reported in Table 4. The results of the ADF test for unit root in levels show that the series are non-stationary in intercept for investment. In the examination of the unit roots in their first difference, the null hypothesis of unit root was not accepted for all the series.

Table 4: ADF Stationarity Test Results with a Constant and Trend

Variables	t-statistics	ADF/P-Value	Results	Lag length
INV	-2.9298	0.1642	Not stationary	1
INV-1st dif.	-6.3363	0.0000***	Stationary	1
EC	-3.4705	0.0426**	Stationary	1
EC-1st dif.	-5.2808	0.0005***	Stationary	1

Source: Author's computation, 2013: Note: *** and ** denote significance at 1% and 5% levels of significance

3.2.1.2. The KPSS Test

The KPSS tests results are reported in Table 5 in levels and in first difference. The results show the data are stationary in levels and on first differenced. The series variables are integrated of other zero, I(0).

Table 5: KPSS Stationarity Test Results with a Constant and a Time Trend

Variables	t-statistics	P-Value	Results	Lag length
INV	0.1398	0.0670	Stationary	3
INV-1st dif.	0.1478	0.0520	Stationary	3
EC	0.0650	n.a	Stationary	3
EC-1st dif.	0.0477	n.a	Stationary	3

(Author's computation, 2013): Critical values at 10%, 5% and 1% significant levels are 0.122 0.149 0.212 respectively

3.2.2 Results of Autoregressive Distributed Lag (ARDL) model/Bound Approach to Cointegration for Electricity Consumption and Investment

The results reported in Table 6 indicate significant cointegration between electricity consumption and investment since the calculated F-statistics of 5.5309 in model 2 and 43.7289 are greater than the critical values of the upper bounds at the 90% and 95% levels of significance for model 2 and 90%, 95% and 99% for model 1. The null assumption of no cointegration is rejected in model 1 and 2. The results indicate that investment (proxied by gross fixed capital formation) is a long-run equilibrium variable that explains electricity consumption during the period under discussion.

Table 6: Test for Cointegration Relationship

Critical bounds of the F -statistic: intercept and trend						
Models	90% level		95% level		99% level	
	$I(0)$	$I(1)$	$I(0)$	$I(1)$	$I(0)$	$I(1)$
	2.915	3.695	3.538	4.428	5.155	6.265
	Computed F -Stat		**Decision**			
1. F_{EC}(EC/INV)	43.7289***		Cointegrated			
2. F_{INV}(INV/EC)	5.5309**		Cointegrated			

Source: Author's computation, 2013: Note: critical values are obtained from Pesaran et al., (2001) and Narayan, (2004): Note *** and ** denotes significance at 1% and 5% levels of significance

3.2.3. Results of Long-Run Elasticities of ARDL Model

The long-run determinant of electricity consumption was estimated using the model in which electricity consumption is the dependent variable. The results are reported in Table 7. The results indicate that investment statistically and significantly determine electricity consumption in the long run. The coefficient of investment has expected a priori theoretical sign, which is positive (0.4038). This means in the long run 1% increase in investment leads to about 40.4% increase in electricity consumption.

Table 7: Estimated Long-Run Coefficients. Dependent Variable is $lnEC$

Variable	Coefficient	Std. Error	T-ratio	P-value
Constant	5.1522	0.3557	14.4859	0.0000***
Trend	-0.0218	0.0093	-2.3305	0.0260**
lnGFC	0.4038	0.1913	2.1107	0.0420**

Author's computation, 2013. Note: *** and ** denotes statistical significance at the 1% and 5% levels. ARDL (2) selected based on Akaike Information Criterion

3.2.4. Results of Short-Run Elasticities of ARDL Model

The results of short-run dynamic equilibrium relationship coefficients estimated with trend, intercept and error correction term (ecm) are reported in Table 8. The results on the nature of the short run coefficients are not different from that of the long-run coefficients in relation to the sign of the coefficient. Investment is significant determinant of electricity consumption in the short run. In the short run, 1% increase in investment leads to about 19.22% increase in electricity consumption. The error correction mechanism serves as a means of reconciling short-run behaviour of an economic variable with its long-run behaviour. The error correction term (ecm) is statistically significant at 1% level of significance and have the theoretical expected sign which is negative. The coefficient of -0.47588 indicates that, after 1 percent deviation or shock to the system, the long-run equilibrium relationship of electricity consumption is quickly re-established at the rate of 47.58% percent per annum. The value does not indicate stronger adjustment.

Table 8: Short-Run Representation of ARDL Model. ARDL (1) Selected Based on Schwarz Bayesian Criterion. Dependent Variable: $\Delta lnEC$

Variable	Coefficient	Standard error	T-statistic	P-value
Constant	2.4518	0.6723	3.6256	0.0010***
Trend	-0.0104	0.0043	-2.4269	0.0210**
$\Delta lnEC_{-1}$	0.4234	0.1425	2.9709	0.0050***
ΔlnGFC	0.1922	0.0817	2.3518	0.0250**
ecm (-1)	-0.4759	0.1141	-4.1719	0.0000***
ecm = LNEC-5.1522C + 0.0218T-0.4038LNGFC ……………...(2)				
R-Squared 0.6509		R-Bar-Squared 0.6098		
S.E. of Regression 0.1867		F-stat. F(4, 34) 15.8481[0.0000***]		
Mean of Dependent Variable 5.7033		S.D. of Dependent Variable 0.2989		
Residual Sum of Squares 1.1855		Equation Log-likelihood 12.7818		
Akaike Info. Criterion 7.7818		Schwarz Bayesian Criterion 3.6229		
DW-statistic 2.1108				

Source: Author's computation, 2013. Note: ** and *** denotes statistical significance at the 5% and 1% levels respectively

3.2.5. Results of Diagnostic Tests

The diagnostic tests of the short-run estimation to examine the reliability of the results of the error correction model are reported in Table 9. The null hypothesis of no serial correlation could not be rejected using the Lagrange multiplier test and the F-statistics. The RESET test showed evidence of incorrect functional specification of the model through a rejection of the null hypothesis. The estimated model did not pass the normality test. The model passed Heteroscadasticity test indicating the variances are constant over time. The R^2 (0.6509) and the adjusted R^2 (0.6098) are not an indication of a very well behaved model. The coefficient indicate approximately 65.01% of the variations in electricity consumption are attributed to the explanatory variable.

Table 9: Short-Run Diagnostic Tests of ARDL Model

Test Statistics	**LM Version**	**F Version**
A:Serial Correlation	CHSQ(1)= 0.5789[0.4470]	F(1, 33)= 0.4972[0.4860]
B:Functional Form	CHSQ(1)= 0.5932[0.4410]	F(1, 33)= 0.5097[0.4800]
C:Normality	CHSQ(2)= 8.7508[0.0130]	Not applicable
D:Heteroscedasticity	CHSQ(1)= 7.1911[0.0070]	F(1, 37)= 8.3647[0.0060]
A:Lagrange multiplier test of residual serial correlation		
B:Ramsey's RESET test using the square of the fitted values		
C:Based on a test of skewness and kurtosis of residuals		
D:Based on the regression of squared residuals on squared fitted values		

Source: Author's computation, 2013.

The stability of the long-run estimates was determined by employing the cumulative sum (CUSUM) and cumulative sum of squares (CUSUMSQ) procedures. This was determined using the residuals of the error-correction model indicated by equation (2). The CUSUM test of stability determines the methodological arrangements of the estimates and its null hypothesis states the coefficients are stable. The null assumption is rejected when the CUSUM surpasses the given critical boundaries, which demonstrate unstable nature of the estimates. The CUSMSQ determines the stability of the variance. Both tests as shown Figure 1 and 2 revealed that the estimates and the variance were stable as the residuals and the squared residuals fall within the various 5% critical boundaries. The null assumptions are rejected in both tests.

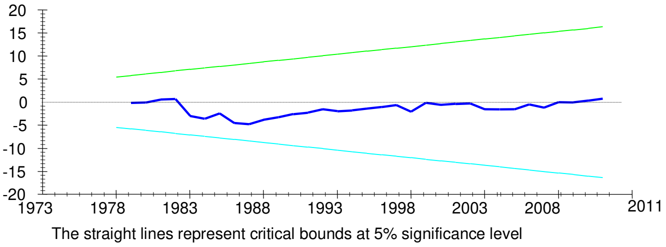

Figure 1: Plot of Cumulative sum of recursive residuals

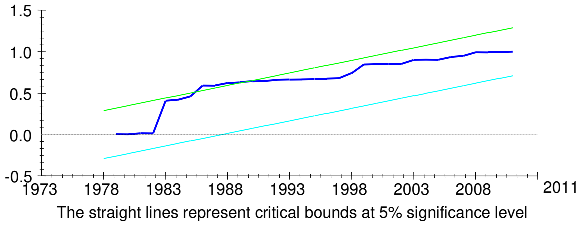

Figure 2: Plot of Cumulative sum of squares of recursive residuals

4. CONCLUDING REMARKS

This current paper examines the investment-electricity consumption nexus for Ghana from 1970 to 2011. The nexus was analysed using first the ADF and KPSS unit root tests and secondly, the ARDL bound testing method of estimation. All unit root test results suggest that there is stationarity. The key research findings are (a) there is cointegration link between investment and electricity consumption; (b) there is stable short run link between investment and electricity consumption; and (c) there is stable long run nexus between investment and electricity consumption.

The positive effect of investment on electricity consumption are in support of previous works such as Tang (2009) for Malaysia; Sadorsky (2010) for 22 developing countries; Bento (2011) for Portugal; Zheng et al. (2011) for United States and China; Zaman et al. (2012) for Pakistan; Omri and Kahouli (2014) for 69 high-income countries, middle-income and low-income; Leitão (2015) for Portugal.

The findings are inconsistent with some previous studies that reported of significant negative and neutral effect of investment on electricity consumption. For example, Bento (2011) studied for Portugal; and Sbia et al. (2014) study for UAE. Lee (2013) reported of a neutral link between investment and electricity consumption for G20 countries. Similar, Alam (2013) reported that whereas in Pakistan investment influences electricity consumption, in India, electricity consumption influences investment.

The empirical finding of a stable long run link between investment and electricity consumption of the study provides useful tool to energy policy makers in the management of electricity consumption in economies with serious energy consumption gap, such as Ghana. Further studies in multivariate modelling and causality analysis are worth research effort to determine whether the current findings would be replicated.

REFERENCES

Alam, A. (2013). "Electric power consumption, foreign direct investment and economic growth: A comparative study of India and Pakistan". *World journal of science, technology and sustainable development*, 10(1), 55-65.

Altinay, G., & Karagol, E. (2005). Electricity consumption and economic growth: Evidence from Turkey. *Energy Economics*, 27(6), 849-856.

Antweiler, W., Brian, R., Copeland, M., & Taylor, S. (2001). Is free trade good for the environment? *The American Economic Review*, 91(4), 877-908.

Bekhet, H. A., Othman, N. S., (2011). Causality analysis among electricity consumption, consumer expenditure, GDP and foreign direct investment FDI: Case study of Malaysia. *Journal of economics and international finance*, 3(4), 228-235.

Bento, J. P. (2011). Energy savings via foreign direct investment? Empirical evidence from Portugal. *Working Paper* No. 2011/24, Maastricht School of Management.

Bhargava, A. (1986). On the theory of testing for unit roots in observed time series. *Review of economic studies*, 53(3), 369-384.

Bildirici, E. M., Bakirtas, T., & Kayikci, F. (2012). Economic growth and electricity consumption: Auto regressive distributed lag analysis. *J. energy South. Afr.*, 23(4), 29-45.

Brown, R. L, Durbin, J., & Evans, J. M. (1975). Techniques for testing the consistency of regression relations over time. *J Roy Stat Soc*, 37(2), 149-92.

Chang, T., Fang, W., & Wen, L. F. (2001). Energy consumption, employment, output and temporal causality: evidence from Taiwan based on cointegration and error-correction modelling techniques. *Applied economics*, 33(8), 1045-1056.

Chima, C. M. (2007). Intensity of energy use in the U.S.A: 1949-2003. *Journal of business & economics research*, 5(11), 17-30.

Clerici, C., Taylor, M. S., & Taylor (2016). Dumsor in 2016: How electricity outages affect Ghana. https://interactive.aljazeera.com/aje/2016/ghana-electricity-outage.../index.html

De Vita, G., Endressen, K., & Hunt, L. C. (2006). An empirical analysis of energy demand in Namibia. *Energy policy*, 34(18), 3447-3463.

Dickey, D. A., & Fuller, W. A. (1979). Distribution of the estimators for autoregressive time series with a unit root. *Journal of the American statistical society*, 75(366), 427-431.

Dickey, S. D. A. (1984). Testing for unit roots in autoregressive-moving average models of unknown order. *Biometrika*, 71(3), 599-607.

Dritsaki, C., & Dritsaki, M. (2014). CO2 emissions, energy consumption, financial development and economic growth: A multivariate cointegration and causality analysis for Greece. *World applied sciences journal*, 32(2), 309-321.

Dube, S. (2009). "Foreign direct Investment and electricity consumption on economic growth: Evidence from South Africa." (Economia Internazionale). *International economics*, 62(2), 175-200.

Ekpo, U., Chuku, C., & Effiong, E. (2011). The dynamics of electricity demand and consumption in Nigeria: application of the bounds testing approach. *Current research journal of economic theory*, 3(2), 43-52.

Energypedia (2018). Ghana energy situation. https://energypedia.info/wiki/Ghana_Energy_Situation

Fatai, K., Oxley, L., & Scrimgeour, F. G. (2004). Modelling the causal relationship between energy consumption and GDP in New Zealand, Australia, India, Indonesia, The Philippines and Thailand. *Mathematics and Computers in Simulation*, 64(3), 431-445.

Ferguson, R., Wilkinson, W., & Hill, R. (2000). Electricity use and economic development. *Energy policy*, 28(13), 923-934.

Greene, W. (2002). *Time series Models*. P. 608-662 in Econometric Analysis, 5th edition. Prentice hall, upper Saddle Rive, NJ.

Hai, S. (2009). Analysis of the model of FDI impacting on the energy consumption intensity in China. *Technology and innovation management*, 30(2), 180-184.

Hatemi, A., & Irandoust, M. (2005). Energy consumption and economic growth in Sweden: A leveraged bootstrap approach, 1965-2000. *International journal of applied econometrics and quantitative studies,* 2(4), 87-98.

Hubler, M. (2009). "Energy saving technology diffusion via FDI and Trade: a CGE Mo del of China, working papers No.1479, Kiel institute for the World economy.

Kasperowicz, R. (2014). "Electricity consumption and economic growth: Evidence from Poland". *Journal of international studies*, 7(1), 46-57.

Kumi, T. (2017). "The electricity situation in Ghana: Challenges and opportunities." CGD policy paper. Washington, DC: Center for global development. https://www.cgdev.org/publication/electricity-situation-ghana-challenges-and-opportunities.

Kwiatkowski, D., Phillips, P., Schmidt, P., & Shin, Y. (1992). "Testing the null hypothesis of stationarity against the alternatives of a unit root: How sure are we that economic time series have a unit root?" *Journal of econometrics*, 54, 159-178.

Lee, C. C., & Chang, C. P. (2007). "Energy consumption and GDP revisited: a panel analysis of developed and developing countries". *Energy economics*, 29(6), 1206-1223.

Lee, W. J. (2013). The contribution of foreign direct investment to clean energy use, carbon emissions and economic growth. *Energy policy*, 55(4), 483-489.

Leitão, C. N. (2015). Energy consumption and foreign direct investment: A Panel data analysis for Portugal. *International journal of energy economics and policy*, 5(1), 138-147.

Lorde, T., Waithe, K., & Francis, B. (2018). The importance of electrical energy for economic growth in Barbados. *Energy economics*, 32(6), 1411-1420.

Lorde, T., Kimberly, W., & Brain, F. (2010).The importance of electrical energy for economic growth in Barbados. *Energy economics*, 32, 1411-1420.

Mielnik, O., & Goldemberg, J. (2002). 'Foreign direct investment and decoupling between energy and gross domestic product in developing countries'. *Energy policy*, 30(2), 87-89.

Miller, S. M., & Russek, F. S. (1991). "Cointegration, Error-Correction Models: The Temporary Causality between Government Taxes and Spending". *Southern economic journal,* 57, 221-229.

Oh, W., & Lee, K. (2004). Energy consumption and economic growth in Korea: testing the causality relation. *Journal of Policy Modelling*, 26(8-9), 973-981.

Omri, A., & Kahouli, B. (2014), Causal relationships between energy consumption, foreign direct investment and economic growth: Fresh evidence from dynamic simultaneous-equations models. *Energy Policy*, 67(3), 913-922

Omri, A. (2013). CO2 emissions, energy consumption and economic growth nexus in MENA countries: Evidence from simultaneous equations models. *Energy economics*, 40(3), 657-664.

Pesaran, M., & Shin, Y. (1999). An autoregressive distributed lag modelling approach to cointegrated analysis. In: Strom, S. (Ed.), econometrics and economic theory in the 20th century: The Ragnar Frisch Centennial Symposium. Cambridge university press, Cambridge, MA.

Pesaran, M. H., Shin, Y., & Smith, R. J. (2001). Bounds testing approaches to the analysis of level relationships. *Journal of applied econometrics*, 16(3), 289-326.

Sadorsky, P. (2010). The impact of financial development on energy consumption in emerging economies. *Energy policy*, 38(5), 2528-2535.

Sbia, R., Shahbaz, M., & Hamdi, H. (2014). A contribution of foreign direct investment, clean energy, trade openness, carbon emissions and economic growth to energy demand in UAE. *Economic modelling*, 3(3), 191-197.

Soytas, U., & Sari, R. (2003). Energy consumption and GDP: causality relationship in G-7 and emerging markets. *Energy economics*, 25(1), 33-37.

Stern, D. I. (1993). Energy use and economic growth in the USA: a multivariate approach. *Ener. econ*. 15(2), 137-150.

Stern, D. I. (2000). “A multivariate cointegration analysis of the role of energy in the U.S. macro-economy.” *Energy economics*, 22(2), 267-283.

Tang, C. F. (2009). "Electricity consumption, income, foreign direct investment, and population in Malaysia: New evidence from multivariate framework analysis". *Journal of economic studies*, 36(4), 371-382.

Tano, A. Y. (2015). The power crisis in Ghana: Analysis of the causal factors from the from the perspectives of public officials. https://www.graphic.com.gh › Features › Opinion.

Ubani, O. (2013). Determinants of the dynamics of electricity consumption in Nigeria. *OPEC energy review*, 37(2), 149-161.

Wolde-Rufael, Y. (2006). Electricity consumption and economic growth: A Time series experience for 17 African countries. *Energy policy*, 34(10), 1106-1114.

Yoo, S. H. (2005). Electricity consumption and economic growth: evidence from Korea. *Energy policy*, 33(12), 1627-1632.

Xiaoli, S., Junfeng, S., & Xuefei, S. (2007). Empirical of industry distribution of FDI impact on China’s energy consumption analysis. *Finance & trade economics,* 3, 117-121.

Zaman, K., Khan, M. M., Ahmad, M., & Rustam, R. (2012). “Determinants of electricity consumption function in Pakistan: Old wine in a new bottle”. *Energy policy*, 50(3), 623-634.

Zheng, Y., Qi, J., Chen, X. (2011). The effect of increasing exports on industrial energy intensity in China. *Energy policy*, 39(11), 2688-2698.

Ziramba, E. (2008). The demand for residential electricity in South Africa. *Energy policy*, 36(9), 3460-3466