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INFLUENCE OF ELECTRICITY CONSUMPTION ON ECONOMIC GROWTH IN GHANA

AN ECONOMETRIC APPROACH

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Abstract

Aims of the study were to critically examine the extent to which electricity consumption influences economic growth in Ghana and also determine, if it is electricity consumption that causes economic growth in Ghana or otherwise. The study employed Augmented Dickey-Fuller test, Cointegration test, Vector Error Correction Model and Granger Causality test. The study revealed that, in the long term, a hundred percent increase in electricity power consumption will cause real gross domestic product per capita to increase by approximately fifty-two percent. However, in the short run, electricity consumption negatively affects real gross domestic product per capita. The study again revealed that unidirectional causality run from electricity consumption to economic growth meaning that any policy actions taken to affect the smooth consumption of electricity in Ghana will definitely affect her gross domestic product per capita. Therefore, the current load shedding policy due to low supply of electricity will definitely affect the Ghanaian economy negatively, that is lower production levels, high inflation, and high rates of unemployment and lower standard of living. Therefore, the government of Ghana should invest massively into electricity infrastructure and conservation measures to meet the needs of the various sectors of the Ghanaian economy.

Keywords: Electricity Consumption, the Extent, Economic Growth, Ghana

INTRODUCTION

Aims of this study are to critically examine the extent to which electricity consumption affect economic growth in Ghana and also determine, if the current electricity power rationing policy is good for Ghana or not. Production is traditionally affected by land, labour, and capital according to the classical economists. Currently, there are other intermediate inputs that can equally affect production which economic growth theories have not yet considered (Vlahinic´-Dizdarevic´ et al., 2010). Energy is one of such inputs. Energy is a key input in economic activity stretching from household level to industrial level more especially in developing countries like Ghana (Adhikari et al., 2013). In Ghana, energy is the backbone for all sectors especially services, manufacturing even agric because of storage. Energy provision can affect an economy either positively or negatively. For instance, changes in real energy prices have a direct influence on economic output and growth. That is, higher real energy prices increased the greater cost of doing business, leading to a negative effect on economic growth and vice versa in the short-run. The main question that pops into the mind of the researchers is, to what extent does electricity consumption influence economic growth in Ghana? The relationship between electricity consumption and economic growth has been extensively investigated in other economies including Ghana (Kraft and Kraft, 1978; Akarca and Long, 1980; Shahbaz et al., 2011; Farhani et al., 2012; Bildirici et al., 2012; Mahmoudinia et al., 2013), but only few works have been done on Ghana (Kwakwa, 2012; Adom, 2011; Akinlo, 2008; Wolde-Rufael, 2006). The works done on Ghana only focused on the causal relationship between electricity consumption and economic growth. They failed to critically examine the extent to which electricity consumption impacts or influences economic growth of the Ghanaian economy. In other words, if electricity consumption increases or decreases by a certain margin, to what extent will it increase or decrease Ghana's GDP growth? This is not yet known in the electricity consumption and economic growth literature in Ghana. This calls for further investigation between electricity consumption and economic growth in Ghana. Therefore, the aim of this study is to critically examine the extent to which electricity consumption influences economic growth in Ghana.

Electricity Consumption in Ghana

Ghana's energy sector is classified into two main categories; power and petroleum. The vision for the energy sector is to ensure availability of energy services and its universal access for export by 2020. Traditionally, the sources of energy in Ghana are electricity, fossil fuels and biomass (The State of the Ghanaian Economy, various issues, Energy Commission, 2006). Electricity is one of the major sources of Ghana's energy consumption boosting economic growth significantly in Ghana apart from other input resources such as time, tools, materials, money, human resource and information. The reason is that in this modern times of Ghana no electricity supply, means no production (Ghana Statistical Service, 2010).

In 1984, the total electricity generated in Ghana was 1.8 billion kilowatt-hours. This figure grew steadily, more than doubling in 1986, reaching 5.8 billion kilowatt-hours in 1990. Ghana has generated an average of about 7 billion kilowatts (kWh) of electricity annually since 1995, with about 14 percent imported. Total domestic energy production increased from 5.9 million kWh in 2003 to slightly above 6 million kWh, domestic consumption grew faster from 5.9 million kWh in 2003 to 6.7 million kWh in 2004 (see Table 1). In 2004, Ghana generated about 6 million kilowatts (kWh) of electricity, a little increase of about 2.35 percent on 2003 but more than 20 percent below the peak of 2002. Against a production increase of only 2.35 percent, Ghana was forced to import about 878,408 kWh of electricity in 2004 from La Cote D'Ivoire.

Table 1: Selected Indicators of Power Generation and Consumption, Ghana, (kWh)

Indicators	2002	2003	2004	2005
Total Domestic Production	7,295,530	5,900,362	6,012,774	6,787,907
Total Imports	1,145,651	940,232	878,408	814,616
Total Sales	8,028,281	6,462,036	6,886,497	7,311,398
Total Domestic Consumption	7,416,447	5,858,076	6,014,630	6,673,103
Total Transmission Losses	368,127	333,172	205,227	248,440

Source: The State of the Ghanaian Economy, various issues

On the other hand, the annual growth of electricity consumption in Ghana is estimated to be about 12 percent. The bulk of power generated in Ghana, particularly by the Volta River Authority (VRA), continued to be purchased by the Electricity Company of Ghana (ECG) and Northern Electricity Department (NED) for onward distribution to domestic consumers as well as to certain industrial establishments (see Table 2). In 2004, ECG purchased 4.8 million kWh (about 72 percent of power sold in Ghana) for onward transmission to other consumers. Between 2003 and 2004, the proportionate share of ECG in total electricity consumption shot up from 53.9 percent to 72.14 percent, underscoring the increasing demand for electric power in Ghana. Also, power purchases by the NED has been rising rapidly, its relative share of total electricity power sales growing from 4.77 percent in 2002 to 7.1 percent in 2004, and its absolute consumption also rising from 0.383 million kWh to 0.473 million kWh over the same period. These increments in the consumption of electricity might be due to high population growth, rural electrification and expansion in industries in Ghana. The major domestic consumers of electricity, buying power directly from VRA in 2005, include ECG, Anglogold Ashanti and Gold Fields Ghana, Volta Aluminium Company (VALCO), Akosombo Textiles Limited (ATL), Diamond Cement, and Aluworks. VRA sold aboult 72.6 percent of the power it generated in 2005 to ECG and 7.1 percent to the Northern Electricity Deparment (NED) during the year. VALCO, which used to be the single largest electricity purchaser, accounted for only 0.2 percent of consumption in 2005. Akosombo Township, Aluworks, the Communaute Electrique du Benin, SONABEL and Ghana Free Zones Board together accounted for about 20 percent of total energy consumption.

Table 2: Major Consumers of Electric Power in Ghana, 2002 – 2004 (in mWh)

Total Energy Consumption				
Sector	**2002**	**2003**	**2004**	**2005**
Electricity Company of Ghana	4,326,377	4,505,377	4,819,691	4,818,055,100
Northern Electricity Department	382,780	425,821	472,647	472,638,226
Akosombo Township	27,144	31,651	40,571	34,499,920
Aluworks limited	15,152	14,397	12,241	12,241,128
Akosombo Textiles	27,573	27,513	23,791	23,790,480
Mines	562,082	572,998	599,121	598,812,764
Volta Aluminium Company	2,062,680	250,262	10,249	10,248,552
Communaute Electrique du Benin	611,428	601,978	662,004	662,004,053
SONABEL		1,885	3,022	3,021,510
Compagnie Ivoirienne d'Electricite	406		1,614	
Ghana Free Zones Board	9,682	4,403	4,732	4,732,240
Diamond Cement		25,552	31,589	
Total	**8,025,304**	**6,461,837**	**6,681,272**	**6,640,043,973**

Source: The State of the Ghanaian Economy, various issues.

Also, about 52 percent of Ghana's population lives in cities where energy consumption is sufficiently higher than rural areas. The electricity distribution infrastructure is extensive and provides access to about 66 percent of Ghana's population with a large proportion in urban areas. For domestic use, urban areas accounts for 88 percent of residential electricity use while rural domestic use accounts for the remaining 12 percent. The use of electricity by urban residents usually includes lighting, ironing, refrigeration, air conditioning, television, radio, etc, however, the use electricity for domestic cooking is very negligible (Energy Commission, 2006). Electricity consumption is also dominant in the industrial and service sectors, accounting for about 65.6 percent of modern energy used in the two sectors of the Ghanaian economy. In

2010, the industrial, residential and commercial (non-residential) sectors accounted for 46 percent, 40 percent and 14 percent, respectively, of the total electricity end-use in Ghana.

The annual growth of national demand for power is estimated at 10 – 14 percent and the inability to fulfill this demand has been a major constrained on industrial, domestic productivity and growth. The energy sector of Ghana is hardly hit by supply side of the sector undermining accessibility, affordability and reliability of energy supply. About 70 percent of Ghana's electricity is generated from two hydro-electric dams, low level of water inflows into the hydro-electric dams have resulted in severe electricity crises. In 1998, 2002, 2006, and 2012, Ghana experienced drought-related electricity crises. This resulted in an extensive load shedding programme to cut down and manage the demand load of the country since energy production was less than energy demand which is still the case in Ghana. This has led to shut down of some companies and industries in Ghana which in the long run has affected the country's GDP growth. Hence, Ghana has adopted rationing to resolve her electricity consumption crises. Is this electricity conservation policy measure healthy for Ghana's economic expansion? In other words, is Ghana less electricity consumption dependent or more electricity consumption dependent country?

LITERATURE REVIEW

Energy consumption plays a very significant role in economic growth and socio-economic development in both developed and developing economies (World Bank Report, 2007; Isma'il et al., 2012; Mallick, 2009; Vlahinic´-Dizdarevic´ et al., 2010; Baek et al., 2011; Atif et al. 2010; Masuduzzaman, 2013). Its role is well recognized in the energy economic growth nexus literature. From literature it is observed that unidirectional causality run from economic growth to energy consumption; this implies that a country is not entirely dependent on electricity for its economic growth, and that energy conservation policies will have little or no adverse effects on the economic growth of that country. On the other hand, if unidirectional causality runs from energy consumption to economic growth, it means that economic growth is dependent on electricity consumption, and a decrease in electricity consumption will likely restrain economic growth (that is unemployment, budget deficit, low income, etc) and that the country should employ additional resources in subsidizing energy prices and securing long term and stable energy sources for its economy. There is also bidirectional causality between energy consumption and economic growth, which implies that energy and economic growth complement each other. That is increases in economic growth raised electricity consumption and increasing electricity consumption increases economic growth. These hypotheses have been tested in many energy consumption and economic growth literature. The direction of causality between energy consumption and economic growth varies from country to country, the reasons might be due to different economic structure of particular countries being studied; different economies have different consumption pattern and various sources of energy and also the kind of methodology used for the study. Some of such findings are illustrated below.

Akomolafe et al. (2014) examined the relationship between electricity consumption and economic growth for the period 1990 to 2011. The study employed Augmented Dickey Fuller test and Philip Perrron unit roots test; Johansen test for cointegration, vector error correction and Granger Causality test. The results of the study showed unidirectional causality from electricity consumption to real gross domestic product.

Bayer (2014) examined the relationship between economic growth and electricity power consumption in emerging countries during the period 1970 to 2011. The study made use of Pedroni, Kao and Johansen co-integration tests and Granger causality tests. The findings demonstrated that electricity consumption has a positive impact on the economic growth in the whole panel and electricity has the largest impact on economic growth in Hungary, while it had the smallest impact in Indonesia. The Granger causality test demonstrated that there was bidirectional causality between economic growth and electricity consumption. The study suggested that emerging countries should diversify energy supply and increase the share of renewable energy sources in energy consumption by considering their highly dependence on electricity.

Pathan et al. (2014) examined the causality between energy consumption and economic growth in Pakistan over the period of 1991 to 2006. The study employed Granger causality and unit root test. The study found that electric power consumption Granger-causes GDP growth.
Shaari et al. (2013) investigated the relationship among population, energy consumption and economic growth in Malaysia for the period 1991 to 2011 using unit root test, cointegration test and Granger causality test. The results showed that population has an effect on energy consumption and energy consumption contributes to economic growth in Malaysia.

Hossain (2013) examined the dynamic causal relationships between energy consumption and economic growth using time series data from 1972 to 2010 of Bangladesh. The study made use of unit root test, cointegration test and Vector Error Correction Model (VEC). The study found a unidirectional causality from economic growth to energy consumption.

Adhikari et al. (2013) investigated the long-run relationship between energy consumption and economic growth for 80 developing countries during the period 1990 to 2009. The 80 countries were divided into upper middle income countries, lower middle income countries, and low income countries. They employed panel unit root tests, panel co-integration test and dynamic ordinary least squares estimator. The empirical result revealed strong relation running from energy consumption to economic growth for upper middle income countries and lower middle income countries, and a strong relation running from economic growth to energy consumption for low income countries.

Akinwale et al. (2013) examined the causal relationship between electricity consumption and economic growth in Nigeria for the period 1970 to 2005. The paper adopted the methods of Augmented Dicky Fuller test, Vector Auto Regressive (VAR) and Error Correction Model (ECM) to test the causality between real GDP and electricity consumption. The result showed that there is a unidirectional causality from real GDP to electricity consumption without a feedback effect.

Mehrara et al. (2012) examined the causal relationship between electricity consumption and GDP in a panel of 11 selected oil exporting countries by using panel unit root tests and panel cointegration analysis. The results showed a strong unidirectional causality from oil revenues and economic growth to electricity consumption in the oil exporting countries with no feedback effect from electricity to GDP for oil dependent countries. Oil revenues had significant effects on GDP in the short-run. This implied that oil and GDP drove the electricity and not vice versa.

Shaari et al. (2012) examined the relationship between energy consumptions and economic growth. The study used the method of unit root tests, Johansen cointegration test and Granger causality model. The result indicated that oil and coal consumptions do not Granger cause economic growth and vice versa. The study found causality runs from economic growth to electricity consumption. A unidirectional relationship existed between gas and economic growth, with causality running from electricity use to economic growth in Malaysia.

Ahmad et al. (2012) investigated the relationship between energy consumption and economic growth of Pakistan. A time series data was used for the period 1973 – 2006. The study employed unit root test (Augmented dickey Fuller test), Granger Causality test and Ordinary Least Squares test. The results of Granger causality test showed unidirectional causality running from GDP to energy consumption. Also, the results of ordinary least squares test showed positive relation between GDP and energy consumption in Pakistan.

Kakar et al. (2011) explored the nature of the relationship between economic growth and total energy consumption for Pakistan for the period 1980 to 2009. The study employed unit root test, Johansen cointegration test, vector error correction model, and Granger causality test. The study indicated that unidirectional causality exists between economic growth and total energy consumption, and that the direction of causality runs from energy consumption to economic growth and any energy shock may affect the long run economic development of Pakistan.

Orhewere et al. (2011) investigated the causality between GDP and each of the basic subcomponents of energy consumption in Nigeria. The study aimed at finding out whether different sources of energy have varying impact on economic growth of Nigeria. The study found non-stationary and cointegrated series for both economic growth and energy variables in Nigeria; for the 1970 – 2005 periods. Using a vector error correction based Granger causality test, the study found a unidirectional causality from electricity consumption to GDP both in the short-run and long-run. The study also found that unidirectional causality run from gas consumption to GDP in the short-run and bidirectional causality between the variable in the long-run. No causality was found in either direction between oil consumption and GDP. The study indicated that a policy to reduce energy consumption aimed at reducing emission will have negative impact on the GDP in Nigeria.

Apergis et al. (2010) examined the relationship between nuclear energy consumption and economic growth for sixteen countries within a multivariate panel framework over the period 1980 to 2005. The study employed panel cointegration test and panel vector error correction model. The study revealed a long-run equilibrium relationship between real GDP, nuclear energy consumption, real gross fixed capital formation, and the labour force with the respective coefficients positive and statistically significant. The results of the panel vector error correction model found bidirectional causality between nuclear energy consumption and economic growth in the short-run while unidirectional causality run from nuclear energy consumption to economic growth in the long run.

Odhiambo (2010) examined the dynamic causal relationship between electricity consumption and economic growth in Kenya during the period 1972 to 2006. The study used cointegration and error – correction models to determine the causal link between electricity consumption and economic growth in Kenya. The found a distinct unidirectional causal flow from electricity consumption to economic growth in Kenya. In addition, the study found that both economic growth and electricity consumption Granger cause labour force participation in Kenya. The study concluded that electricity consumption is a panacea for economic growth in Kenya and any enery conservation policies should be treated with extreme caution.

Acaravci (2010) investigated the causal relationship between energy consumption and economic growth with structural breaks for period of 1986 to 2005 by using cointegration and vector error-correction models for Turkish economy. The results indicated that electricity consumption per capita weakly and strongly causes real per capita in both short-run and long-run. The study also found no causal evidence from real GDP per capita to electricity consumption per capita. The study concluded that electricity consumption plays a key role in

Turkey's economic growth and therefore, policies to manage the supply of electricity are required to ensure that the electricity is sufficient to support Turkey's economic growth.

Noor et al. (2010) investigated the causal relationship between energy consumption and economic growth for five South Asian countries over period 1971 – 2006. The study applied panel unit root test, cointegration test, fully modified ordinary least squares estimates and Granger causality test. The results indicated that a unidirectional causality is found from GDP per capita to energy consumption in the short-run.

Olusegun Odularu et al. (2009) investigated the relationship between energy consumption and economic growth in Nigeria from the period 1970 to 2005. The energy sources used to test for this relationship were crude oil, electricity and coal. The study employed the method of cointegration. The results derived infer that there exists a positive relationship between current period energy consumption and economic growth and coal also had the same positive relationship. A negative relationship was noted for lagged values of energy consumption and economic growth. The implication of the study is that increased energy consumption is a strong determinant of economic growth in Nigeria.

Hye et al. (2008) determined the direction of causality between energy consumption and economic growth, using annual data from 1971 to 2007. The study employed the bounds testing approach to cointegration and an augmented form of the Granger causality test to identify the direction of the relationship between variables both in the short run and long run. The study found bidirectional causality between economic growth and energy consumption in the short-run while in the long-run unidirectional causality run from economic growth to energy consumption.

Aktas et al. (2008) examined the short-run and long-run causal relationship between oil consumption and economic growth in Turkey. The study employed Granger causality test. The study found that there exist bidirectional Granger causality between oil consumption and economic growth in the short run and long run.

Akinlo (2008) observed bidirectional relationship between energy consumption and economic growth for Gambia, Ghana and Senegal and causality run from economic growth to energy consumption in Sudan and Zimbabwe and no causality in Cameroon and Cote D'Ivoire.

Also Wolde-Rufael (2006) examined the causal relationship between electricity consumption and growth for 17 African countries. The study found unidirectional causality running from electricity consumption to economic growth in Cameroon, Ghana, Nigeria, and Senegal, Zambia and Zimbabwe and no causality for the rest.

Kwakwa (2012) examined the causality between the disaggregated energy consumption and economic growth in Ghana for the period 1971 to 2007. The study employed unit root test, cointegration test and Granger causality test. The empirical results found that electricity consumption and fossil consumption do not Granger causes overall economic growth while aggregate growth Granger cause electricity consumption and fossil consumption. When growth was disaggregated, the study found unidirectional causality from agriculture to electricity consumption both in the short run and long run. Also, bidirectional causality was found between manufacturing and electricity consumption but a unidirectional causality from manufacturing to fossil consumption in the short run and long run. The study recommended that efforts should be geared towards ensuring a high supply of energy to the manufacturing sector in order to sustain its contribution to the economy. The study did not determine the extent of electricity consumption on economic growth.

Adom (2011) determined the causality between electricity consumption and economic growth from the period 1971 to 2008. The study employed unit root test, ARDL Bounds Cointegration Analysis and Toda and Yomamoto Granger Causality Test. The study revealed that data on Ghana supports the Growth-led-electricity hypothesis. The results implied that electricity conservation measures are a viable option for Ghana. The study failed to determine the extent to which energy consumption influence economic growth in Ghana.

Based on the empirical evidences above, there are mixed findings from one study to another for individual countries and regions. For Ghana, the extent to which electricity consumption influences economic growth is not clearly established. As a result, this study aims at: (1) determine the extent to which electricity consumption influences economic growth in Ghana; and (2) determine if the current load shedding policy measure is good for the growth process of Ghana.

METHODOLOGY

The study presented a production function taking energy (electricity consumption) as an input along with the traditional inputs which are labour and capital. In this production function real gross domestic product is a function of labour, capital and electricity consumption. The study assumed that Z_t denotes the vector of the variables of interest. Therefore, the dynamics of Z_t was represented in a vector error correction model, VECM, of the form as:

$$\Delta Z_t = \nu + \Pi Z_{t-1} + \sum_{i=1}^{p-1} \Phi_i \Delta Z_{t-i} + \varepsilon_t$$

Where;

Δ was the difference operator,

$\prod$ was $\alpha\beta$ is a 3x3 matrix,

α was the speed of the adjustment parameter and indicated how much of the disequilibrium was being corrected and it ranged between -1 and 0.

β was a matrix of cointegration vectors among the variables under consideration,

Φ_i were the short-run coefficients,

ε_t was a 3x1 vector of structural disturbances assumed to be a white noise process

p was the optimal lag length,

and Z_t was a vector of the variables defined as follows:

RGDP was real gross domestic product measured as real growth domestic product per capita.

K was Capital measured as gross fixed capital formation.

L was labour is measured as total level of employment.

EPCPC was electricity consumption measured as electricity consumption per capita.

Economic theory requires that the partial derivatives of the explanatory variables of real gross domestic product satisfy certain conditions; labour, capital and energy, a priori, were expected to be positive. The stationarity of the variables were checked using Augmented-Dickey-Fuller tests. After establishing that the variables were integrated of the same order and then, the Johansen Cointegration test was carried out to find out if there exist a long run relationship among the variables or not. The idea of the cointegration test was to determine whether these non-stationary variables were cointegrated or not. This study applied the Johansen Cointegration Maximum Likelihood Method of Cointegration developed by Johansen (1988) to determine the number of cointegrating vectors. The maximum Eigen value test was applied. If this test had shown that the variables were not cointegrated, then, the vector autoregressive, VAR, model would have been estimated; otherwise, the vector error correction model (VECM) will be estimated. The data for the variables of interest were sourced from the World Development Indicators, 2013.

RESULTS AND DISCUSSION

The summary statistics of all variables of interest used in this study are shown in table 3 below. From table 3, the logarithm of real gross domestic product per capita (LNRGDPPC), labour (L), capital (K) and electricity consumption (EPCPC) are approximately normal since their kurtoses are about three. Therefore, these variables were used in the estimation of the model. The model estimated had its dependent variable in logarithm form while the independent variables were not in logarithm form.

Table 3: Descriptive Statistics of Variable under Consideration

	GDPPC	LOG(GDPPC)	L	LOG(L)	K	LOG(K)	EPCPC	LOG(EPCPC)
Mean	568.7010	6.185933	7103828.	15.68456	2.09E+09	20.92836	302.7482	5.676009
Median	402.5770	5.997886	7201638.	15.78982	1.37E+09	21.03514	313.6418	5.748252
Maximum	1604.893	7.380812	10846580	16.19936	7.65E+09	22.75807	425.9200	6.054252
Minimum	264.6927	5.578570	491214.9	13.10464	1.43E+08	18.77507	93.48751	4.537828
Std. Dev.	387.0640	0.518765	2301924.	0.545939	2.22E+09	1.103464	72.14757	0.301508
Skewness	1.648907	1.293067	-0.561509	-3.295479	1.468053	-0.132263	-0.865846	-1.958914
Kurtosis	4.232897	3.201854	3.334943	16.27057	3.926210	2.384955	3.916672	7.651913
Jarque-Bera	17.04397	9.252149	1.888364	301.8796	13.03305	0.616350	5.278690	50.86081
Probability	0.000199	0.009793	0.388998	0.000000	0.001479	0.734787	0.071408	0.000000
Sum	18767.13	204.1358	2.34E+08	517.5903	6.91E+10	690.6357	9990.691	187.3083
Sum Sq. Dev.	4794194.	8.611748	1.70E+14	9.537566	1.57E+20	38.96428	166568.7	2.909032
Observations	33	33	33	33	33	33	33	33

The results of the Augmented Dickey-Fuller (ADF) test for log of real gross domestic product per capita (lnRGDPPC), labour (L), capital (K) and electricity consumption (EPCPC) are shown in table 4 below. From table 4, all the variables in their first difference were stationary at 5 percent level of significance. Therefore, all the variables log of real gross domestic product per capita (lnRGDPPC), labour (L), capital (K) and electricity consumption (EPCPC) are integrated at first order, I(1). As a result, the Johansen's cointegration approach was used to determine the number of cointegrating equation(s).

Table 4: The results of Augmented Dickey-Fuller test (ADF) for unit root

	None			Constant			Constant and Trend		
Variable	Level	1st diff.	Conclusion	Level	1st diff.	Conclusion	Level	1st diff.	Conclusion
	t-obs	t-obs		t-obs	t-obs		t-obs	t-obs	
lngdppc	1.4519	-4.2087	I(1)	0.5838	-4.3964	I(1)	-0.8942	-4.7065	I(1)
p-value	0.9606	0.0001		0.9870	0.0016		0.9445	0.0036	
k	4.3300	-1.7908		2.6713	-4.0401	I(1)	-2.9693	-5.0035	I(1)
p-value	1	0.0700		1	0.0039		0.1591	0.0017	
l	1.5389	0.2826		2.1205	-9.4483	I(1)	-2.6394	-8.0884	I(1)
p-value	0.9659	0.7601		0.9998	0		0.2674	0	
epcpc	-0.8788	-4.5134	I(1)	-2.7582	-4.4451	I(1)	-2.6799	-4.4571	I(1)
p-value	0.3276	0.0001		0.0757	0.0014		0.2509	0.0066	

VAR was used to determine the optimal lag length for the Johansen cointegration test which was based on the Schwarz information criterion (SC) as shown in table 5. From table 5, the optimal lag length based on SC is one. Using the selected optimal lag length, the likelihood ratio test which depends on the maximum Eigen values of the stochastic matrix of the Johansen (1991) procedure is used.

Table 5: VAR Lag Order Selection Criteria

VAR Lag Order Selection Criteria
Endogenous variables: LNGDPPC K L EPCPC
Exogenous variables: C
Date: 06/11/14 Time: 08:34
Sample: 1980 2012
Included observations: 30

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-1306.656	NA	1.04e+33	87.37705	87.56388	87.43682
1	-1227.804	131.4191	1.60e+31	83.18696	84.12109*	83.48579
2	-1208.938	26.41292*	1.41e+31	82.99587	84.67730	83.53377
3	-1188.346	23.33714	1.23e+31*	82.68976*	85.11850	83.46673*

** indicates lag order selected by the criterion*
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

Table 6 below shows the results for the cointegrating test for the variables under consideration. From table 6, the Maximum Eigenvalue statistics show that there is one cointegrating vectors at 5 percent level of significance. The null hypothesis of zero cointegrating vector is rejected against the alternative hypothesis of at least one cointegrating vector. Therefore, it is concluded that there is only one cointegrating vector specified in the model.

This implies that there are both long run and short run relationship among the variables being considered. As a result the long run relationship and vector error correction model (VECM) were estimated.

Table 6: Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.593128	27.87699	27.58434	0.0459
At most 1	0.423132	17.05442	21.13162	0.1694
At most 2	0.147635	4.951969	14.26460	0.7479
At most 3	0.007106	0.221069	3.841466	0.6382

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

The long-run relationships among the variables are shown in table 7 below. The result from the table shows that in the long-run all the variables of interest turned out to be statistically significant since the absolute values of the t-statistics are greater than two. From the table, there is a positive relationship between capital stock and RGDP per capita. This implies that if capital stock increases, RGDP per capita will definitely increase as well, the reverse is true ceteris paribus. Specifically, if Ghana decides to increase her capital stock by 1 percent, then her RGDP per capita will increase by 0.5768 percent. However, if Ghana decides to decrease her capital stock by 1 percent, then her RGDP per capita will also decrease by 0.5768 percent, all other things being equal. The effect of capital stock on economic growth is inelastic since the value of the effect is less than one (1). This means that a greater increase in capital stock will lead to a smaller change in RGDP per capita. The effect of capital stock on RGDP per capita is statistically significant at the 5 percent significance level. This means that acquisition of capital stock is crucial to Ghana's economic growth and development agenda.

Based on economic principles, experiences and observations, it is established that there is a positive relationship between labour force and economic growth. However, from the results obtained in this study, the positive linkage between labour force and economic growth was not achieved; rather a negative relationship was obtained. That is, a 1 percent increase in the Ghana's labour force will cause RGDP per capita of Ghana to decrease by 0.9945 percent; the opposite is also true, ceteris paribus. This means that labour productivity is very low in Ghana which might result from the kind of training labour receives from Ghana's educational institutions, and also due to some unacceptable labour attitude towards work. Based on the findings, this study concludes that Ghana does not have the needed labour force to push her economic growth and development agenda forward. The effect of labour force on RGDP per capita in Ghana is inelastic since the magnitude of the effect is less than one (1). This indicates that a greater increase in Ghana's labour force will lead to a smaller decrease in her RGDP per capita value, ceteris paribus. The effect is statistically significant at the 5 percent significance level. This implies that labour force participation is very important when it comes to the economic progress of Ghana.

In general, it is expected that there will be a positive relationship between electricity consumption and economic growth. From the findings, a 1 percent increase in electricity consumption in Ghana will cause her RGDP per capita to increase by 0.5201 percent. Alternatively, a 100 percent increase in electricity consumption will cause RGDP per capita to increase by 52.01 percent; the reverse is also true, ceteris paribus. The degree of the effect between electricity consumption and economic growth in Ghana is less than unity (inelastic). This illustrates that a greater increase in electricity consumption will lead a smaller increase in RGDP per capita. However, this effect is statistically significant at the 5 percent significance level indicating that electricity consumption is one of the very significant determinants of economic growth in Ghana and therefore, should be looked at critically.

Table 7: The long-run relationships among the variables

Variables	**K**	**L**	**EPCPC**	**Remarks**
Coefficients	2.76E-10	-1.40E-07	0.001718	Statistically significant
Standard error	2.90E-11	2.60E-08	0.00052	Statistically significant
t-statistics	9.52E+00	5.38E+00	3.30E+00	Statistically significant
Elasticity	0.5768	-0.9945	0.5201	< 1 (inelastic)

where $*\text{Elasticity} = \left(\frac{\text{dY}}{\text{dX}}\cdot\frac{\text{X}}{\text{Y}}\right) = \beta_i X$ *, (since the model is log- linear) X is the mean of K, L and EPCPC as shown in table 7 above and* β_i *is the respective coefficients.*

The short run dynamics among the variables were explored by vector error correction model (VECM). Error correction model allows the introduction of previous disequilibrium as independent variables in the dynamic behaviour of existing variables. Table 8 presents the short run dynamic relationship and the set of short run coefficients in the vector error correction model. VECM associates the changes in real gross domestic product per capita to the change with the other lagged variables and the disturbance term of lagged periods. The coefficient of the speed of adjustment is negative but not significant at 5 percent level of significance. This shows that there is about 17.99 percentage point adjustment taking place each year towards the long run periods. From table 8, the past year's real gross domestic product per capita impacted positively but not statistically significant. Specifically, a percentage increase in the past year's real gross domestic product per capita caused the current real gross domestic product per capita to increase by 0.303732 percent. This indicates that previous higher records of Ghana's RGDP per capita are crucial in determining the current value of Ghana's RGDP per capita, ceteris paribus.

The past year's capital stock had a positive and significant impact on the current real gross domestic product per capita and the impact is inelastic. Therefore, a percentage point increase in the past year's capital stock leads to less than percentage point increase in current real gross domestic product per capita, ceteris paribus. Also, the past year's labour had a positive but not significant impact on the current real gross domestic product per capita and the impact is elastic. Therefore, a percentage point increase in the past year's labour leads to more than percentage point increase in current real gross domestic product per capita. Finally, the past year's electricity consumption per capita had a negative but not significant impact on the current real gross domestic product per capita in the short run and the impact is inelastic. This means that a percentage point increase in the past year's electricity consumption per capita leads to less than percentage point decrease in current real gross domestic product per capita, ceteris paribus. This exhibits that electricity utilization in Ghana has not been smooth due to inadequate supply of electricity leading to load shedding which has affected economic activities badly. That is lower production levels; higher rates of unemployment, increment in the general price level as a result of finding other sources of energy consumption, and finally low GDP per capita value.

Table 8: The Result of Error Correction Model for Short Run Dynamics

Variables	**Coefficient**	**Standard error**	**t-**	**Elasticit**
CointEq1	-0.17985	(0.17089)	[-1.05245]	
D(LNRGDPPC (-1))	0.303732	(0.23528)	[1.29093]	0.303732
D(K(-1))	1.54E-10	(7.7E-11)	[1.99890]	0.001094
D(L(-1))	4.23E-08	(3.0E-08)	[1.41165]	88.407
D(EPCPC(-1))	-0.00061	(0.00056)	[-1.08948]	-0.18468
C	-0.01347	(0.03743)	[-0.35995]	
R-squared	0.230661	Log likelihood	15.11924	
Adj. R-squared	0.076793	Akaike AIC	-0.58834	
Sum sq. resids	0.684323	Schwarz SC	-0.31079	
S.E. equation	0.165448	Mean dependent	0.046491	
F-statistic	1.499083	S.D. dependent	0.172191	

Table 9 shows the results of Granger causality test for the variables under consideration. Results show that there is unidirectional causality between capital stock and gross domestic product per capita, capital stock and labour, at 5 percent level of significant. At 10 percent level of significant, there is unilateral directional causality between labour and gross domestic product per capita, electricity consumption per capita and gross domestic product per capita. The unidirectional causality running from electricity consumption per capita to economic growth indicates that any policy actions that smoothing or interrupt the consumption of electricity in Ghana will affect Ghana's economic growth either positively or negatively. Also, there is no unilateral directional causality between real gross domestic product per capita and capital stock, gross domestic product per capita and labour, gross domestic product per capita and electricity consumption, labour and capital stock; neither electricity consumption per capita and capital stock nor capital stock and electricity consumption.

Table 9: The Results of Granger Causality Test

Pairwise Granger Causality Tests
Date: 06/11/14 Time: 08:42
Sample: 1980 2012
Lags: 1

Null Hypothesis:	Obs	F-Statistic	Prob.
K does not Granger Cause LNRGDPPC	32	6.19914	0.0188
LNRGDPPC does not Granger Cause K		1.63757	0.2108
L does not Granger Cause LNRGDPPC	32	3.00294	0.0937
LNRGDPPC does not Granger Cause L		2.00015	0.1679
EPCPC does not Granger Cause LNRGDPPC	32	2.91726	0.0983
LNRGDPPC does not Granger Cause EPCPC		0.41853	0.5228
L does not Granger Cause K	32	0.91850	0.3458
K does not Granger Cause L		4.64798	0.0395
EPCPC does not Granger Cause K	32	1.93844	0.1744
K does not Granger Cause EPCPC		0.69400	0.4116
EPCPC does not Granger Cause L	32	0.07305	0.7889
L does not Granger Cause EPCPC		0.25211	0.6194

CONCLUSION

The aims of the study were to critically examine the extent to which electricity consumption per capita influences economic growth in Ghana and also determine if it is electricity consumption per capita that causes economic growth in Ghana or otherwise. The study employed Augmented Dickey-Fuller test, Cointegration test, Vector Error Correction Model and Granger Causality test.

The study revealed that, in the long term, a 1 percent increase in electricity power consumption will cause GDP per capita to increase by 0.5201 percent. However, in the short run, electricity consumption per capita negatively affects GDP per capita.

The study again revealed that unidirectional causality run from electricity consumption per capita to economic growth meaning that any policy actions taken to affect the smooth consumption of electricity in Ghana will definitely affect her GDP per capita growth. Therefore, the current load shedding policy due to low supply of electricity will definitely affect the Ghanaian economy negatively (i.e. lower production levels, high inflation, high rates unemployment and lower standard of living).

In future, the extent to which other kinds of energy affect economic growth in Ghana shall be investigated by disaggregating economic growth.

POLICY RECOMMENDATIONS

The study identified that the Ghanaian economy depends strongly and heavily on electricity consumption per capita and, therefore, the current electricity policy of load shedding due to inadequate electricity supply will affect the Ghanaian economic negatively (i.e. lower production levels, high inflation, high rates unemployment and lower standard of living). Therefore the following policies are suggested:

1. The Citizens of Ghana should be educated to use the limited electricity supply wisely.
2. The prepaid metering system should be extended to public institutions, private institutions and the remaining households of the country. This will further ensure wise usage of the limited electricity supply, reduce or prevent illegal connections drastically and ensure 100 percent revenue collection for the power providers.
3. Industries should invest in machinery that uses other sources of energy other than hydroelectric power. This will call for research and development of such new technology that will not rely on hydroelectric power generation.
4. The government should invest heavily in electricity infrastructure; this will ensure that there is enough energy to meet the needs of the agricultural, manufacturing and services sectors of the Ghanaian economy.
5. Households, industries and government should find new ways of investing in energy conservation methods so as to ensure sustainability now and in the future.

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