An econometric modelling of government activities-total energy demand nexus for Ghana

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ABSTRACT

The paper modelled both long run and short run effects of government activities on total energy demand in Ghana for the period 1970 to 2011 using Autoregressive Distributed Lag Model (ARDL). The results of the findings indicate significant evidence of cointegration between government activities and total energy demand. The results show that government activities are key explanatory variable in total energy demand. Government activities are recommended as a policy tool to manage energy demand. Further study is worth considering in the area of causality and structural breaks in unit root.

Key words: Government activities; total energy demand; Long run
Jel codes: O13, P28, P48, Q41, Q42, Q43, Q48

1 INTRODUCTION

The pioneering works of Kraft and Kraft (1978) on the factors that influence energy demand for the United States continues to stir interest in the energy literature due to the important role energy plays in the economic growth and development of an economy such as Ghana. The importance of energy in an economy such as Ghana is well researched by researchers such as Stern (2004), and Nondo, Schaeffer, and Gebremedhin (2010). Among the importance are washing, cooking, lighting, powering of machines, transportation, poverty reduction, promotion of economic growth and development, and the creation of employment.

Many factors have been identified in the empirical examination of the determinants of energy demand (Kraft & Kraft,1978; Akarca & Long, 1980; Yu & Hwang, 1984; Wolde-Rufael, 2004; Kahsai et al., 2010; Faridul, 2011; Kakar, Khilji, & Khan, 2011; Shahbaz et al., 2011; Mehrara & Musai, 2012), yet very important factors such as government activities have been neglected in the study with only few known popular studies been that of Glasure (2002), and Bukhari, Sillah, and Al-Sheikh (2012), and Eze (2017).

According to the findings of these works government activities are cointegrated with energy consumption and government activities impact positively on energy demand in the short run and long run. The current paper is in line with that of Glasure (2002), and Bukhari et al. (2012), however, the paper deviate from that of Eze (2017) by examining the effect of government expenditures on total energy consumption whereas the study of Eze (2017) examined the effect of energy consumption (oil and, electricity, and gas) on government expenditures.

Aside the fact that important factors such as government activities have been neglected in earlier model of energy demand, previous studies have also produced mixed results whereas others also failed to account for unit root properties of the variables in the model estimated.

Recent record of government expenditure in Ghana indicated a decreased in expenditure from 495.56GHS Million to 4604.08 GHS Million in June in 2017. Government Spending in Ghana averaged 3237.06 GHS Million from 2012 until 2017, and reached a high value of 26277.16 GHS Million in February of 2014 and recorded a low value of 836.07 GHS Million in February of 2012. In nominal terms, government expenditures continue to increase over the years in Ghana, and this increase according to empirical studies is expected to have a positive effect on economic growth, and energy consumption (Eze, 2017).

The current study fills this gap by modelling total energy demand as a function of government activities. Addressing the gap is important in that information is provided for policy makers to rely on in formulating appropriate policies to control energy demand, air pollution, and the introduction of appropriate energy taxes in managing energy consumption. That also helps policy makers to achieve sustainable development in the face of volatile energy market.

The objective of the present paper is to investigate the effect of government activities on total energy demand to contribute to knowledge in the energy literature. The assumption underlying the paper is that government activities significantly influence total energy demand in both long run and short run. The paper is based on the research question: what is the long run and short run effect of government activities on total energy demand?

The present paper did not focus on structural breaks in unit root and the direction of causality. The rest of the paper looks at the research method, empirical results, and conclusions.

2 METHODOLOGY

2.1 Estimation Method

The stationarity properties of the variables (government activities, and total energy demand) were investigated by employing the Augmented Dickey-Fuller (ADF) stationarity test and the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) stationarity tests. The KPSS test is based on the assumption that there is non-unit root around a deterministic trend against the alternative assumption that the variables under investigation are unit root. On the other hand, the ADF test is based on the null assumption that there is stationarity in the variables under investigation in levels with the alternative assumption that the variables are not stationary in levels.

In examining both the long run, and short run link between government activities, and total energy demand, the ARDL method was employed. There are extensive theoretical literature on the KPSS, ADF, and the ARDL models, hence, they are not reviewed in the current study (e.g. see Dickey, & Fuller, 1979; Kwiatkowski, Phillips, Schmidt, & Shin, 1992; Pesaran, & Shin, 1999). The ARDL model has many advantages such as dealing with small data set, and whether the stationarity properties of the variables under investigation are known or unknown, if only the variables are not integrated of order two, I(2).

2.2 Data

The empirical study of the link between government activities and aggregate energy demand is based on annual secondary data for Ghana for the period 1970 to 2011, with a sample size of 54. The source of the data is the World Bank database. Table 1 looks at the data description, proxies, and sources.

Table 1 Data Description, Proxies and Sources

Data Description	Source
Government Activities (GOV) is proxied by Government Expenditure	World Bank World Development Indicator (WDI)
Aggregate Energy demand (TE) is proxied by Total Energy Consumption	World Bank World Development Indicator (WDI)

2.3 Conceptual Framework and the Empirical Model

The link between government activities and aggregate energy consumption is modelled in the current study to determine the effect of government activities on aggregate energy demand in the long run, and short run, in a bivariate model as reported in equation (1). The dependent variable in the model is aggregate energy demand (TE), with government activities as the explanatory variable, in a log-linear model.

$$\ln TE_t = \ln GOV_t + e_t \text{..}(1)$$

3 EMPIRICAL RESULTS

3.1 Analysis of Descriptive Statistics

3.1.1. Results of Central tendencies and Dispersion

The results of the summary statistics of the variables are shown in Table 2. The mean measures the central tendency of the series variables and the values indicate a good fit. The volatility of the series variables are measured by the coefficient of variation. The nature of the distribution of the series is measured using the coefficient of skewness. The series distributions are normal and asymmetric. The types of the skewness are positive and negative. The range of the coefficient of skewness is between positive one (1) and negative one (-1). The results are shown in Table 2.

The results of the summary statistics of the variables as shown in Table 2 indicate that total energy demand falls as low as 304.95GWh and rise as high as 433.12GWh whereas government activities falls as low as 5.861 dollars and rise as high as 15.308 dollars. Among the series variables, the least volatile series variable is total energy (0.079) followed by government expenditure (0.177). In a positive distribution, the asymmetric tail moves towards the right. In a negative skewness, the asymmetric tail moves to the left direction. Hildebrand (1986) stated that an absolute value of coefficient of skewness greater than 0.2 indicates greater skewness. The results as shown in Table 2 indicate the variables are negatively skewed.

The nature of the peakness of the series variables were measured using the coefficient of kurtosis proposed by Pearson, 1905 (Zenga & Fiori, 2009). There are three forms of the nature of peakness. They are platykurtic (more flat-topped distribution- $\gamma<0$); leptokurtic (less flat-topped distribution-$\gamma>0$) and leptokurtic (equally flat-topped distribution- $\gamma=0$). A higher coefficient value of kurtosis is an indication of more extreme observation or the distribution is more single-peaked. The results of the values of the coefficients of kurtosis as shown in Table 2 indicate. The coefficient value of the kurtosis of TE (-0.383) is less than zero (0) which indicates more flat-topped distribution. The coefficient value of the kurtosis of GOV ($ 0.495) is less than unity (1) which indicates more flat-topped distribution.

Table 2 Summary Statistics, using the Observations 1970-2011

Var	Mean	Min.	Max.	S.D	CV.	SK.	KUR.
TE	376.720	304.950	433.120	30.022	0.079	-0.140	-0.383
GOV	10.967	5.861	15.308	1.945	0.177	-0.439	0.495

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

Multi-collinearity among the series variables was tested using the correlation matrix. The results are reported in Table 3. The results as reported in Table 3 shows that total energy demand (TE) exhibit significant positive correlation with GE. Overall, the magnitudes of the correlation coefficients 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	TE	GOV
TE	1.000	
GOV	0.188	1.000

Source: Author's computation, 2013

3.2 The ADF Unit Root Test results without Structural Breaks

The scientific investigation of the nature of unit root using the ADF, and the KPSS model of unit root is dealt with in this section.

3.2.1 The ADF Test without Structural Breaks

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. The null hypothesis of unit root was 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
GOV	-2.4671	0.3419	Not stationary	1
GOV-1st dif.	-5.8498	0.0001***	Stationary	1
TE	-2.6421	0.265	Not stationary	1
TE-1st dif.	-6.7773	0.0000***	Stationary	1

Source: Author's computation, 2013: Note: *** denotes significance at 1% level of significance

Taking the logarithm of the first difference of the series and testing these with intercept and trend makes series stationary. That is, the null hypothesis of unit root is rejected. The results are reported in Table 5. These results indicate that the series exhibit unit root processes in levels.

Table 5 ADF stationarity test results with a constant and a time trend

Variables(1st dif.)	t-statistics	ADF/P-Value	Results	Lag length
ΔlnGOV	-5.0712	0.0009***	Stationary	1
ΔlnTE	-6.7841	0.0000***	Stationary	1

Source: Author's computation, 2013: NB: *** denotes significance at 1% level

3.2.3 The KPSS Test without Structural Breaks

The KPSS test is based on the null assumption (Ho) that the series variables under investigation are stationary (series are not unit root) against the alternative hypothesis (H1) that the series are not stationary (series are unit root). The KPSS is a reversed test for unit root. It is used in the current thesis for confirmation of the stationarity properties of the series. The results are reported in Table 6 and Table7. The series were examined in levels and in first difference (Table 6) as were as in their logarithm form (Table 7). The results in Table 6 do not indicate mixed results. The series are not unit root in levels, and in first difference, indicating that they are integrated of order zero, I(0), and order, one, I(1). The levels of significance are 1%; 5% and 10%. The results based on logarithm form indicate the series are stationary in first difference also.

Table 6 KPSS stationarity test results with a constant and a time trend

Variables	t-statistics	P-Value	Results	Lag length
GOV	0.1073	n.a	Stationary	3
GOV-1st dif.	0.0725	n.a	Stationary	3
TE	0.1576	0.044	Stationary	3
TE-1st dif.	0.0660	n.a	Stationary	3

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

Table 7 KPSS stationarity test results with a constant and a time trend

Variable	KPSS P-value	Results	Lag Length
ΔlnGOV	0.0712	Stationary	3
ΔlnTE	0.0646	Stationary	3

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

3.3.1. Results of Autoregressive Distributed Lag (ARDL) model/Bound Approach to Cointegration for Total Energy Demand (TE) and Government Activities (GOV)

The results in Table 8 shows significant cointegration relationship between total energy demand and government activities in model 1 with total energy demand as the dependent variable since the calculated F-statistics of 26.4179 is greater than the critical values of the upper bounds at the 90%, 95% and 99% levels of significance. The results reported in Table 8 indicate significant cointegration between total energy (TE) demand and government activities (GOV) since the calculated F-statistics of 8.3113 is greater than the critical values of the upper bounds at the 90% and 95% levels of significance in model 2 with government activities as the dependent variable. The results indicate that government activities are a long-run equilibrium variable that explains total energy demand during the period under discussion.

Table 8 Test for cointegration relationship

Critical bounds of the F -statistic: intercept and trend						
	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
Models	**Computed F -Stats**		**Decision**			
1. F_{TE}(TE/GOV)	26.4179***		Cointegrated			
2. F_{GOV}(GOV/TE)	5.1387**		Cointegrated			

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

3.3.2 RESULTS OF LONG-RUN ELASTICITIES OF ARDL MODEL

The long-run determinant of total energy demand was estimated using the model in which total energy demand is the dependent variable. The results are reported in Table 9. The results indicate that government activities (GOV) statistically significantly determine total energy demand in the long run since the coefficient value of 0.2074 is significant at 10% level. The coefficient of government activities does have expected a priori theoretical sign of positive. The results shows that 1% increase in government activities leads to about 20.74% increase in total energy demand.

Table 9 Estimated long-run coefficients. Dependent variable is LNTE

Variable	Coefficient	Std. Error	T-ratio	P-value
Constant	5.3301	0.2482	21.4780	0.000***
Trend	0.0052	0.0016	3.2194	0.003***
lnGOV	0.2075	0.1056	1.9647	0.058*

Source: Author's computation, 2013: ARDL (1) selected based on Akaike Information Criterion. Note: *** and * denote significance at 1% and 10% levels

3.3.3 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 10. The results on the nature of the short run coefficients (0.0781) are different from that of the long-run coefficients. Government expenditure is significant determinant of aggregate energy consumption in the short run at 5% level. One percent increase in government expenditure leads to about 7.8% increase in aggregate energy 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 is statistically significant and does have the theoretical expected sign which is negative. The coefficient of -0.3764 indicates that, after 1 percent deviation or shock to the system, the long-run equilibrium relationship of aggregate energy consumption is quickly re-established at the rate of about 37.63% percent per annum. The value indicate stronger adjustment rate.

Table 10 Short-run representation of ARDL model. ARDL (1) selected based on Akaike Information Criterion. Dependent variable: ΔlnTE

Variable	**Coefficient**	**Standard Error**	T-Ratio	Prob. Values
Constant	2.0059	0.6993	2.8684	0.007***
Trend	0.0019	0.8357E-3	2.3525	0.025**
ΔlnGOV	0.0781	0.0344	2.2669	0.030**
ecm (-1)	-0.3763	0.1213	-3.1015	0.004***

ecm = LNTE -5.3301C -0.0052T -0.2075LNGO……………………………(1)

R-Squared 0.7629	R-Bar-Squared 0.74200
S.E. of Regression 0.0407	F-stat. F(3, 34) 36.4703[0.000]
Mean of Dependent Variable 5.9348	S.D. of Dependent Variable 0.0801
Residual Sum of Squares 0.0562	Equation Log-likelihood 69.8822
Akaike Info. Criterion 65.8822	Schwarz Bayesian Criterion 62.6071
DW-statistic 2.1760	Durbin's h-statistic -.81752[0.414]

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

3.3.4. 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 11. 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 (0.7629) and the adjusted R^2 (0.7420) in Table 10 are an indication of a very well behave model. The coefficient indicate approximately 76.29% of the variations in aggregate energy consumption are attributed to the explanatory variable.

Table 11 Short-Run Diagnostic Tests of ARDL Model

Test Statistics	LM Version	F Version
A:Serial Correlation	CHSQ(1)= 0.9539[0.329	F(1, 33)= 0.8497[0.363]
B:Functional Form	CHSQ(1)= 0.3935[0.530]	F(1, 33)= 0.3453[0.561]
C:Normality	CHSQ(2)= 24.4977[0.000]	Not applicable
D:Heteroscedasticity	CHSQ(1)= 0.1625[0.687]	F(1, 36)= 0.1546[0.696]
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 (1). 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 CUSUMSQ 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.

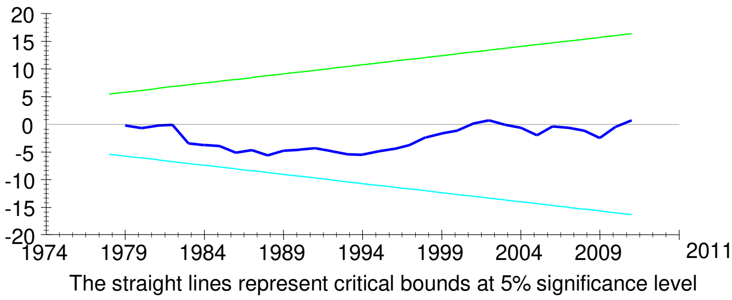

Figure 1: Plot of Cumulative sum of recursive residuals

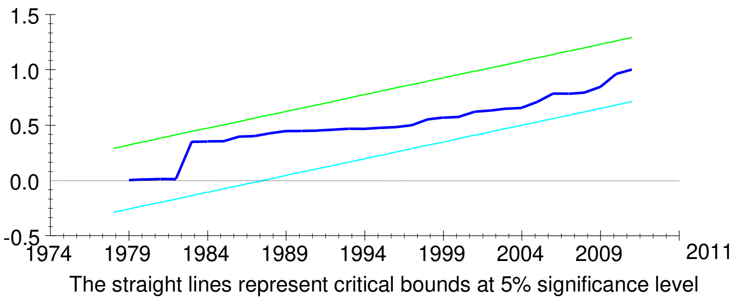

Figure 2: Plot of Cumulative sum of squares of recursive residuals

4. CONCLUSIONS

The current paper investigated the government activities-total energy demand nexus by employing the ARDL modelling method for Ghana for the period 1970 to 2011 using secondary data. The results suggest stable long run and short run link between government activities and total energy demand.

The findings of the study support the findings of previous studies by researchers such as Eze (2017) who reported of stable long run nexus between energy demand and government expenditure. The estimates of the long run elasticities in the current study are not in line with that of Eze (2017) which produced negative link between oil demand and government expenditure. However, the findings support the long run estimates of the link between electricity demand and gas demand and government expenditure, which are positive.

Bukhari, Sillah and Al-Sheikh (2012) who reported that increased oil consumption is found to be induced by per capita government expenditures in all GCC countries except for UAE, and Glasure (2002) who reported of cointegration link between energy demand and government activities with government activities causing energy demand. Government activity is expected to play an influential role in energy demand especially the oil products and electricity. Hence, increase in government activities is expected to lead to increase in energy demand.

The theoretical framework on the link between government activities and total energy demand are supported in both short run, and long run. The findings of the research seems to suggest that government activities is a policy variable in the explanation of the demand of total energy demand in the long run, and short run. Policy makers can rely on government activities to manage total energy consumption.

Further research should consider modelling the topic under investigation in a multivariate analysis by including other variables such as investment, financial development, income, and energy price. The current study did not consider the issue of causality and structural break in unit root, hence further studies in this direction is worth undertaking.

REFERENCES

Akarca, A. T., Long, T. V. (1980). On the relationship between energy and GNP: a re-examination. *J. Energy and Develop*. 5(2), 326-331.

Bukhari, M.S. S., & Hamad, M. H. Al-S. (2012). Income, Price, and Government Expenditure Elasticities of Oil in the Gulf Cooperation Council Countries. *International Journal of Energy Economics and Policy*, 2(4), 333-341.

Dickey, D. A., & Fuller, W. A. (1981). Likelihood ratio statistics for autoregressive time series with a unit root. *Econometrica,* 49(4), 1057-1072.

Eza, L. A. (2017). Government expenditure and energy consumption in Nigeria. Unpublished MSc. Thesis.

Faridul, I., Muhammad, S., & Mahmudul, A. (2011). Financial development and energy consumption nexus in Malaysia: A multivariate time series analysis. *Munich Personal RePEc Archive (MPRA),* 28403, 1-28.

Glasure, Y. U. (2002). Energy and national income in Korea: further evidence on the role of omitted variables. Energy Economics, 24(4), 355-365.

Hildebrand, D. K. (1986). *Statistical thinking for behavioral scientists*. Boston: Duxbury.

Kakar, Z. K., Khilji, B. A., & Khan, M. J. (2011). Financial Development and Energy Consumption: Empirical Evidence from Pakistan. *International Journal of Trade, Economics, and Finance*, 2(6), 469-471.

Kahsai, M. S., Nondo, C., Schaeffer, P. V., & Gebremedhin, T. G. (2010). "Does Level of Income Matter in the Energy Consumption and GDP Nexus: Evidence from Sub-Saharan African Countries". *Research Paper*#7, Research Institute, West Virginia University.

Kraft, J., & Kraft, A. (1978). On the Relationship between Energy and GNP. *Journal of Energy and Development*, 3(2), 401-403.

Kwiatkowski, D., Phillips, P. C. B., Schmidt, P., & Shin, Y., (1992). Testing the Null Hypothesis of Stationarity against the Alternative of a Unit Root: How sure are we that Economic Time Series have a Unit Root? *Journal of Econometrics*, 54(1-3), 159-178.

Mehrara, M., & Musai, M. (2012). Energy Consumption, Financial Development, and Economic Growth: An ARDL Approach for the Case of Iran. *International Journal of Business and Behavioral Sciences*, 2(6), 92-99.

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.

Pearson, K. (1905). Das Fehlergesetz und seine Verallgemeinerungen durch Fechner und Pearson. A Rejoinder. *Biometrika*, 4(1/2), 169-212.

Shahbaz, M., Tang, C. F., & Shahbaz S. M. (2011). Electricity Consumption and Economic Growth Nexus in Portugal Using Cointegration and Causality Approaches. *Energy Policy*, 39(6), 3529-3536.

Stern, I. D. (2004). Energy and Economic Growth. *Encyclopedia of Energy*, 2(00147), 1-51.

Wolde-Rufael, Y. (2005). Energy demand and economic growth: the African experience. Journal of Policy Modelling, 27(8), 891-903.

Yu, E. S., Hwang, B. K. (1984). The relationship between energy and GNP: further results. *Energy Economics*, 6(3), 186-190.

Zenga, M., & Fiori, A. M. (2009). Karl Pearson and the Origin of Kurtosis. *International Statistical Review*, 77(1), 40-50.