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ABSTRACT

The study modelled the long run and short run link between financial development and aggregate energy consumption in Ghana for the period 1970 to 2011 using Autoregressive Distributed Lad Model (ARDL). The results produced significant evidence of cointegration between the variables. The results seem to suggest that financial development is a key explanatory variable in aggregate energy consumption. Financial development is recommended as a policy tool to manage energy consumption. Causality issues as well as the effect of structural breaks in modelling should be the subject of future research.

Key words: Financial development; Aggregate energy consumption; Long run
Jel codes: O13, P28, P48

1 INTRODUCTION

The empirical verification of the link between financial development and energy consumption dates back to the pioneering works of Kraft and Kraft (1978) for the United States (Acaravci & Ozturk, 2012). The importance of energy in the growth of an economy is well documented in the literature (Stern, 2004; Kahsai, Nondo, Schaeffer, & Gebremedhin, 2010).

According to researchers such as Stern (2000), Alam (2006), and Sadorsky (2010) earlier empirical works neglected the role of financial development in energy consumption. Researchers explain that economic growth is a function of financial development and that financial development allows for savings and investment which impact positively on growth and increase in energy use (Faridul et al. (2011). As citizens income level increase, they are able to purchase items whose operations are based on energy use (Mehrara & Musai (2012).

The empirical works that accounted for the role of financial development in energy consumption produced inconsistent results in the literature. The mixed findings have been attributed to many reasons such as the time of data used, the estimation method, and the level of income or growth (Shahbaz et al., 2011; Kakar et al., 2011).

The empirical findings of the role of financial development in energy consumption are found in the works of researchers such as and Huang et al. (2008); Dan and Lijun (2009); Bartleet and Gounder (2010); Sadorsky (2010); Faridul et al. (2011); Kakar, Khilji, and Khan (2011); Mehrara and Musai (2012); and Yeboah (2015). For example, Dan and Lijun (2009) indicated financial development explain changes in energy consumption in China in their study. Sadorsky (2010) reported that financial development increase energy consumption through increase in bank deposit, increase in loans to citizens, which results in increase in investment, and consumption. Kakar et al. (2011) study for Pakistan indicated that financial development is related positively with energy consumption.

Energy is a commodity, which is vital for the existence of modern life. Energy is expected to impact positively on economic performance directly at the macro-level and indirectly at the household level. Energy resources such as oil, gas, electricity, and wood-fuel, allow households, firms and the government to run their activities. At the household level, cooking, lighting, and washing is done with energy. At the firm level, machines are powered using energy. The Government uses various forms of energy for various activities such as lighting, and transportation.

The use of energy by all these entities come at a cost to the entities. Given the importance of energy to these entities, energy availability is a problem in many economies, and Ghana is no exception. Limited access to modern and affordable energy is an important contributor to the poverty levels in developing countries, particularly in sub-Saharan Africa and some parts of Asia.

Access to modern forms of energy is essential to overcome poverty, promote economic growth and employment opportunities, support the provision of social services, and, in general, promote sustainable human development. According to International Energy Agency (World Energy Outlook, 2012) the demand for energy will continue to grow strongly, increasing by one-third over the period to 2035 particularly due to the increased demand from economies such as China, India, and the Middle East.

There have been previous research works (Kraft & Kraft,1978; Akarca & Long, 1980; Yu & Hwang, 1984; Wolde-Rufael, 2004; Kahsai et al., 2010; Faridul, 2011) to identify the key determinants of energy demand but failed to achieve consistent findings on the link and channel of effect among the dependent and explanatory variable(s). Kraft and Kraft (1978) examined the effect of income on energy consumption and concluded that income determines energy consumption but failed to include other variables such as financial development. Following their work other researchers (Akarca and Long, 1980; Yu and Hwang, 1984; Abosedra & Baghestani, 1989) confirmed their findings but also failed to account for unit roots, and did not include financial development in their model. Another problem of previous studies is that the empirical findings are mixed and that few works exist in the literature.

Addressing these gaps is very important in order to fully understand the key determinants of energy consumption. Accurately estimating and analyzing the determinants of energy demand can also provide some information for governments as a basis of setting up appropriate policies related to environment such as pollution and energy taxes. Another issue is that developing countries suffer more than the developed countries from energy price increases. Volatile energy markets can distort the mid- and long-term development path of the industry, and even countries 'economy as a whole. The present study attempted to fill this gap by modelling energy demand in aggregate model.

The objective of the paper is to examine the link between financial development and aggregate energy consumption to contribute to the body of knowledge in the energy literature. The paper is based on the assumption that financial development influence aggregate energy consumption in the long run and short run. The research question underlying the paper is what is the long run and short run effect of financial development on aggregate energy consumption?

The current study did not take into account the issues of structural breaks in examining stationary properties. The rest of the study looks at the methodology, results, and conclusions. supply).

2 **ECONOMETRIC METHODOLOGY**

2.1 Estimation Method

Unit properties of the variables (financial development, and aggregate energy consumption) were examined using the Augmented Dickey-Fuller (ADF) unit root test procedure and the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) unit root tests. The assumption of the KPSS test is that there is non-unit root around a deterministic trend (trend-stationary) against the alternative assumption that the variables are unit root. The null assumption of the ADF test is that there is stationarity in the variables in levels whereas the alternative assumption is that the variables are not stationary in levels. The long run and short run relationship between financial development and aggregate energy consumption is tested using the ARDL method. Since there are enough literature on the KPSS, ADF, and the ARDL models, they are not reviewed in the current study. The ARDL model has the advantage of dealing with small data set and can be used whether the stationarity properties of the variables are known or unknown, although, none of the variables should be integrated of order two.

2.2 Data

The empirical study is based on annual secondary data on financial development (proxied by money supply), and aggregate energy consumption (proxied by total energy consumption) for Ghana for the period 1970 to 2011. Data was obtained from World Bank database. The sample size for the study is 54.

Table 1 Data Description, Proxies and Sources

Data Description	Source
Financial Development (M2) is proxied by Money Supply	World Bank World Development Indicator (WDI)
Aggregate Energy Consumption (TE) is proxied by Total Energy Consumption	World Bank World Development Indicator (WDI)

2.3 Conceptual Framework and the Empirical Model

The relationship between financial development and aggregate energy consumption is modelled for Ghana to determine whether financial development affect aggregate energy consumption in the long run and short run. The relationship between financial development and aggregate energy consumption is modelled in the current study in a bivariate model as indicated in equation (1). The dependent variable in the model is aggregate energy consumption (TE) whereas the independent variable is financial development (M2). The model is specified in log-linear form in equation (1).

$$\ln TE_t = \ln M2_t + e_t \text{..(1)}$$

3 EMPIRICAL RESULTS

3.1 The ADF Test without Structural Breaks

The results on the ADF test for unit root test are reported in Table 2. 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. The first difference of the series in linear form was not stationary. Taking the logarithm of the first difference of the series, and testing these with intercept, and trend makes the series stationary. That is, the null hypothesis of unit root is rejected. The results are reported in Table 2. These results indicate that the series exhibit unit root processes in levels.

Table 2 ADF stationarity test results with a constant and trend

Variables	t-statistics	ADF/P-Value	Results	Lag length
M2	-1.62565	0.7652	Not stationary	1
M2-1st dif.	-5.98178	7.189e-005***	Stationary	1
TE	-2.64205	0.265	Not stationary	1
TE-1st dif.	-6.77729	6.611e-006***	Stationary	1

Source: Author's computation, 2013/2014: Note: *** and ** denote significance at 1% and 5% levels of significance

3.3 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 study for confirmation of the stationarity properties of the series. The results are reported in Table 3. The series were examined in levels, and in first difference (Table 3). The series were not stationary levels. However, the variables attained stationarity on first difference. The variables are integrated of order one, I(1).

Table 3 KPSS stationarity test results with a constant and a time trend

Variables	t-statistics	P-Value	Results	Lag length
M2	0.192296	0.023	Stationary	3
M2-1st dif.	0.0694082	n.a	Stationary	3
AEC	0.157637	0.044	Stationary	3
AEC-1st dif.	0.0660478	n.a	Stationary	3

(Author's computation, 2013/2014): Critical values at 10%, 5% and 1% significant levels are 0.122 0.149 0.212 respectively

3.3 Results of Autoregressive Distributed Lag (ARDL) model/Bound Approach to Cointegration for Aggregate Energy Consumption (TE) and Financial Development (M2)

The results reported in Table 4 indicate significant cointegration between aggregate energy (TE) consumption and money supply (M2) since the calculated F-statistics of 21.1214 is greater than the critical values of the upper bounds at the 90%, 95% and 99% levels of significance in model 2. The calculated F-statistics of 4.4682 is greater than the critical values of the upper bounds at the 90% and 95% levels of significance in model 1. The null assumption of no cointegration is rejected in model 1 and 2. The results indicate that financial development is a long-run equilibrium variable that explains aggregate energy consumption during the period under discussion.

Table 4 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
	Computed F -Stats		**Decision**			
1. F_{TE}(TE/M2)	4.4682**		Cointegrated			
2. F_{M2}(M2/TE)	21.1214***		Cointegrated			

Source: Author's computation, 2013: Note: critical values are obtained from Pesaran et al. (2001) and Narayan, (2004)

3.4 Results of Long-Run Elasticities of ARDL Model

The long-run determinant of aggregate energy consumption was estimated using the model in which aggregate energy consumption is the dependent variable. The results are reported in Table 5. The results indicate that financial development statistically and significantly determines aggregate energy consumption in the long run since the coefficient value of 0.1616 is significant at 1% level. The coefficient of financial development does have expected a priori theoretical sign of positive. The results shows that 1% increase in financial development leads to about 16.16% increase in aggregate energy consumption.

Table 5 Estimated long-run coefficients. Dependent variable is LNTE

Variable	Coefficient	Std. Error	T-ratio	P-value
Constant	5.3711	0.070277	76.4269	0.000***
Trend	0.0028319	0.6824e-3	4.1497	0.000***
lnM2	0.16159	0.025097	6.4387	0.000***

Author's computation, 2013: ARDL (2) selected based on Akaike Information Criterion. NB: *** denotes significance at 1% level

3.5 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 6. The results on the nature of the short run coefficients (0.14197) are not different from that of the long-run coefficients. Money consumer (M2) is significant determinant of aggregate energy consumption in the short run at 1% level. One percent increase in money supply leads to about 14.19% 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 -0.8786 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 87.86% percent per annum. The value indicate stronger adjustment rate.

Table 6 Short-run representation of ARDL model. ARDL (2) selected based on Akaike Information Criterion. Dependent variable: ΔlnTE

Variable	Coefficient	Standard Error	T-Ratio	Prob. Values
Constant	4.7188	0.87243	5.4088	0.000***
Trend	0.0024880	0.7447e-3	3.3409	0.000***
$\Delta lnTE_{-1}$	0.20951	0.14006	1.4959	0.144
ΔlnM2	0.14197	0.030891	4.5958	0.000***
ecm (-1)	-0.87856	0.15997	-5.4919	0.000***
ecm = LNTE-5.3711C -0.0028319T -0.16159LNM2……….(5.18)				
R-Squared	0.8340	R-Bar-Squared	0.8139	
S.E. of Regression	0.0345	F-stat. F(4, 33)	41.4513[0.000***]	
Mean of Dependent Variable	5.9348	S.D. of Dependent Variable	0.0800	
Residual Sum of Squares	0.0394	Equation Log-likelihood	76.6550	
Akaike Info. Criterion	71.6550	Schwarz Bayesian Criterion	67.5611	
DW-statistic	2.0651			

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

3.6 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 7. 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 (0.7663) and the adjusted R^2 (0.7457) in Table 6 are an indication of a very well behave model. The coefficient indicate approximately 76.63% of the variations in aggregate energy consumption are attributed to the explanatory variable.

Table 7 Short-Run Diagnostic Tests of ARDL Model

Test Statistics	LM Version	F Version
A:Serial Correlation	CHSQ(1)= 0.21127[0.646]	F(1, 32)= 0.17890[0.675]
B:Functional Form	CHSQ(1)= 2.8719[0.090]	F(1, 32)= 2.6161[0.116]
C:Normality	CHSQ(2)= 2.3195[0.314]	Not applicable
D:Heteroscedasticity	CHSQ(1)= 0.83719[0.360]	F(1, 36)= 0.81100[0.374]

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. 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.

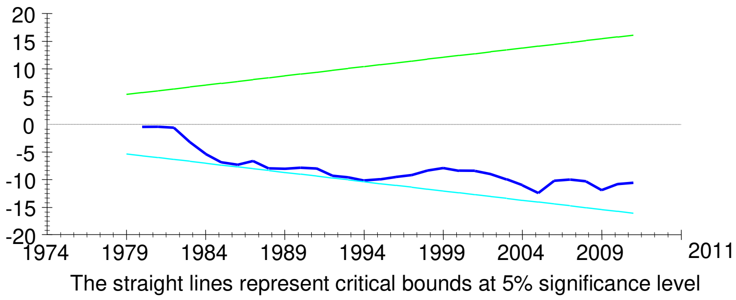

Figure 1: Plot of Cumulative sum of recursive residuals

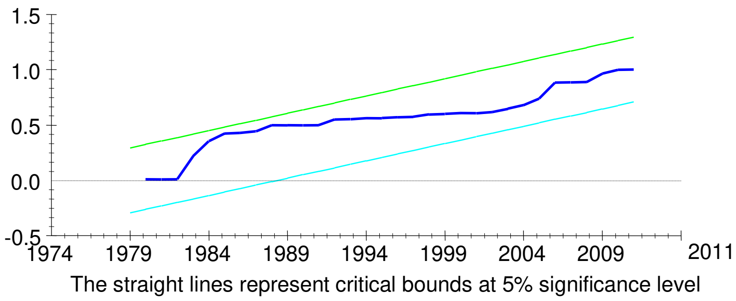

Figure 2: Plot of Cumulative sum of squares of recursive residuals

4 CONCLUSIONS AND POLICY IMPLICATIONS

The present study has examined the financial development-aggregate energy consumption nexus using the ARDL method for Ghana for the period 1970 to 2011. The results suggest stable long run and short run relationship between financial development and aggregate energy consumption. The findings are in support of the previous findings of researchers such Huang et al. (2008); Dan and Lijun (2009); Bartleet and Gounder (2010); Sadorsky (2010); Faridul et al. (2011); and Muhammad (2011), who reported that financial development influences energy consumption. The theoretical concepts that, financial development explains changes in aggregate energy consumptions are supported in the short run and long run.

The findings of the study seems to suggest that financial development is a policy variable that explains the consumption of aggregate energy consumption in the long run and short run that policy makers can rely on to manage energy consumption.

Future studies should consider the current topic in a multivariate modelling of the effect of financial development on aggregate energy consumption by considering other variables such as investment, government expenditure, growth, price, and energy price. In addition, causality issues and structural break issues should be taken into account in future studies.

REFRENCES

Abosedra, S., & Baghestani, H. (1989). New evidence on the causal relationship between United States Energy Consumption and Gross National Product. *Journal of Energy and Development*, 14(5), 285-292.

Acaravci, A., & Ozturk, I. (2012). Electricity Consumption and Economic Growth Nexus: A Multivariate Analysis for Turkey. *Amfiteatru Economic*, 14(31), 246-257.

Alam, M. S. (2006). Economic Growth with Energy, *MPRA Paper*, No. 1260.

Bartleet, M., Gounder, R. (2010). Energy Consumption and Economic Growth in New Zealand: Results of Trivariate and Multivariate Models. *Energy Policy*, 38(7), 3505-3517.

Dan. Y., & Lijun, Z. (2009). Financial Development and Energy Consumption: An Empirical Research Based on Guangdong Province. Paper presented at International Conference on Information Management, Innovation Management, and Industrial Engineering, 2009, ICIII, 3, 102- 105.

Dickey, D. A., & Fuller, W. A. (1979). "Distribution of the Estimators for Autoregressive Time Series with a Unit Root". *Journal of the American Statistical Association*, 74(366), 427-431.

Dickey, D. A., & Fuller, W. A. (1981). Likelihood Ratio Statistics For Autoregressive Time Series With A Unit Root. *Econometrica*, 49(4), 1057-1072.

Faridul, I., Muhammad, S., & Mahmudul, A. (2011). Financial Development and Energy Consumption Nexus in Malaysia: A Multivariate Time Series Analysis. *Munich Personal RePEc Archive*, 1-29. Online at http://mpra.ub.uni-muenchen.de/28403/ MPRA Paper No. 28403.

Huang, B., Hwang, N., & Yang, C. W. (2008). Causal Relationship between Energy Consumption and GDP Growth Revisited: a Dynamic Panel Data Approach. *Ecological Economics*, 6(7), 41-54.

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, H. M., & Shin, Y. 1(999). Autoregressive Distributed Lag Modelling Approach to Cointegration Analysis. in: S. Storm, ed. 1999. Econometrics and Economic Theory in the 20th 10 Century: The Ragnar Frisch Centennial Symposium. Cambridge: Cambridge University Press. Ch. 11.

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.

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, D. I. (2000). A Multivariate Cointegration Analysis of the Role of Energy in the U.S. Macroeconomy. Energy Economics 22(2), 267-283.

Stern, D. (2004). The Rise and Fall of the Environmental Kuznets Curve. *World Development*, 32(8), 1419-1439.

Wolde-Rufael, Y. (2004). Disaggregated energy consumption and GDP, the experience of Shangai 1952-1999. *Energy Economics* 26(1), 69-75.

World Energy Outlook, 2012

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