An econometric investigation of the effect of financial development on aggregate, and disaggregate energy consumption: time series assessment for Ghana

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ABSTRACT

The paper has examined both long run and short run link between financial development and energy consumption in Ghana for 1970-2011 period using Autoregressive Distributed Lad Model. The ARDL test results produced significant evidence of cointegration among the variables. There are statistical significant long run and short run effects of financial development on energy consumption. The results seem to suggest that financial development is a key explanatory variable in energy consumption and as such, financial development could be relied on as a policy tool to manage energy consumption. Future research should account for the effect of structural effect and the issues of causality.

JEL classification: O13, P28, P48, Q40
Keywords: Financial Development, Fossil fuel consumption, Electricity consumption, Aggregate energy consumption, long run.

1 Introduction

Since the seminal work of Kraft and Kraft (1978) for the United States, the research works on the key explanatory variables in energy consumption has been prominent in the energy literature (Acaravci & Ozturk, 2012). Research on energy consumption is considered so important because energy is seen as an engine of economic growth in all economies (Kahsai, Nondo, Schaeffer, & Gebremedhin, 2010; Stern, 2004). Energy use increases as the economy grows, as such examining the factors that influence energy consumption is worth spend resources.

Previous work on the determinant of energy consumption neglected financial sector development in the literature (Sadorsky, 2010; Alam, 2006; Stern, 2000). Among the few literature that focused on the role of finance in energy consumption, there is no consensus on the effect of financial development on energy consumption and economic growth as well as the direction of causality among the variables. This according to researchers such as (Shahbaz et al., 2011) may results from the type of data used, period covered, the level of economic growth of the countries, the econometric estimation models.

Some studies that focus on the link between financial development and energy consumption are as follows Mehrara and Musai (2012); Faridul et al. (2011); Kakar, Khilji, and Khan (2011); Bartleet and Gounder (2010); Sadorsky (2010); Dan and Lijun (2009); and Huang et al. (2008); Mehrara and Musai (2012) indicates that availability of affordable loans to citizens allow them the opportunity to purchase items such as computers; televisions; mobiles; automobiles for use which cause energy consumption to increase in an economy. Faridul et al. (2011) states that financial sector "improves monetary transmission mechanism, boosts savings and investment and promotes economic growth and leads to increase demand for electricity use".

Kakar et al. (2011) reported of positive effect of finance on energy demand for Pakistan and indicated that increase in financial development is associated with increases in energy demand. Sadorsky (2010) explained that financial sector allows people to save (bank deposits) which when made available to people as loans leads to increase in consumption, investment and energy consumption. Dan and Lijun (2009) reported that financial development predicts energy consumption in China.

The issue under investigation is to examine empirically the effect of financial development on aggregate energy consumption, fossil fuel consumption, and electricity consumption. Previous empirical studies have produced mixed findings in the empirical literature (Shahbaz et al., 2011; Kakar et al., 2011). This according to researchers (Shahbaz et al., 2011) might results from the level of economic growth, the econometric estimation models, the type of data used, and the period covered. These issues motivate the current study.

The current paper adds to the literature in this area, by using bivariate model to examine the effect of financial development on aggregate energy, fossil fuel, and electricity consumption. The paper contributes to theoretical knowledge as it seeks among other things to provide answers to research questions of 'how', 'why', and 'what' (Sutton & Staw, 1995). Since, empirical findings have been mixed; the paper contributes to the literature (Shahbaz et al. (2011). On policy, the findings provide policy guide on energy demand management to ensure sufficient energy supply (Shabaz et al., 2011) to ensure the success of energy demand policies. The findings serve as reference material for students and researchers in the area of energy economics, interested in investigating energy demand in Small but Open economy, such as Ghana.

The general objective of the paper is to contribute empirically to the general body of knowledge and research work in the area of energy demand, by developing a model to examine the effect of financial development on aggregate and disaggregate energy consumption. The paper is based on the research question of what is the effect of financial development on aggregate and disaggregate energy consumption in the long run and short run? The main assumption behind the paper is that financial development has significant effect on aggregate and disaggregates energy consumption.

The limitations of the paper are: (a) the use of bivariate model, which does not allow for the examination of the effect of other factors on energy consumption (Stern, 1998). The model might suffer omitted variable bias since there is no control variable. The issues of structural breaks are not considered in the paper, in the examination of the unit root properties of the series variables. The data span 1970-2011 for Ghana. The rest of the paper looks at the methodology, results, and conclusions.

2 Econometric Methodology

2.1 Empirical Model and Data

A bivariate model specified as in equation (1) is used. There are only two variables in the bivariate demand for energy model. The dependent variables are the energy sources (Aggregate energy consumption; electricity consumption and fossil fuel consumption). The explanatory variable is financial development (proxied by Money Supply, M2).

$$M_{tj} = \sum_{i=1}^{1} \beta N_{1i} + \varepsilon_t \text{..........................}(1)$$

Where M and N represent the dependent variables (Aggregate energy consumption, Electricity Consumption and Fossil Fuel Consumption) and independent variables (M2) respectively. Where j=1 for Aggregate energy consumption; 2 for Electricity consumption and 3 for Fossil fuel consumption for the dependent variables (M). For the independent variables (N), i=1, for 1=M2. Data for the estimation of the model were taken from World Development Indicators (WDI-2012). The study period is from 1961-2013.

2.2 Econometric Estimation Methodology

The examination of the effect of financial development on energy consumption is performed by first examining the unit root properties of the series using the Augmented Dickey-Fuller (1981) (ADF) and the Kwiatkowski et al. (1992, KPSS). Second, the long run and the short-run links among the variables are examined using the ARDL model (Pesaran, & Shin, 1999; Pesaran, Shin, & Smith, 2001). For detail discussions on the ADF, KPSS, and the ARDL, refer to Yeboah and Ohene-Manu (2015).

3 Empirical Results

3.1 Unit Root Properties of the Variables

3.1.1: The ADF Test without Structural Breaks

The results on the ADF test for unit root test are reported in Table 1. 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 1 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
EC	-3.47054	0.04257**	Stationary	1
EC-1st dif.	-5.28079	0.0005454***	Stationary	1
FF	-2.76126	0.2191	Not stationary	1
FF-1st dif.	-6.94919	3.485e-009***	Stationary	1
AEC	-2.64205	0.265	Not stationary	1
AEC-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

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 2. These results indicate that the series exhibit unit root processes in levels.

Table 2 ADF stationarity test results with a constant and a time trend

Variables(1st dif.)	t-statistics	ADF/P-Value	Results	Lag length
ΔlnM2	-6.27268	2.988e-005***	Stationary	1
ΔlnEC	-5.43042	2.366e-005***	Stationary	1
ΔlnFF	-7.24778	4.627e-010***	Stationary	1
ΔlnAEC	-6.78405	6.467e-006***	Stationary	1

Source: Author's computation, 2013/2014: Note: *** denotes significance at 1% level

3.1.2 The KPSS Test without Structural Breaks

The KPSS test results are reported in Table 3 and Table 4. The series were examined in levels and in first difference (Table 3) as were as in their logarithm form (Table 4). The results in Table 3 indicate mixed results. Some series are unit root in levels but become stationary in first difference, indicating that they are integrated of order one, I(1). Series variables that are stationary at levels are integrated of other zero, I(0). The levels of significance are 1%; 5% and 10%. Some series are stationary at 10% but not at 1% and 5%. The results based on logarithm form indicate the series are stationary in first difference.

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
EC	0.0650454	n.a	Stationary	3
EC-1st dif.	0.0476522	n.a	Stationary	3
FF	0.230714	n.a	Not stationary	3
FF-1st dif.	0.0993028	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

Table 4. KPSS stationarity test results with a constant and a time trend

Variable	KPSS P-value	Results	Lag Length
ΔlnM2	0.0759265	Stationary	3
ΔlnEC	0.0451254	Stationary	3
ΔFF	0.0871667	Stationary	3
ΔlnAEC	0.064566	Stationary	3

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

3.2 The Examination of the Cointegration Link, Long Run, and Short Run Parameters

3.2.1 Cointegration

The results on the examination of cointegration link between financial development and the energy sources are reported in Table 5. The results show that there is significant cointegration link between aggregate energy consumption, and financial development; between fossil fuel consumption, and financial development; and between electricity consumption and financial development. The long run parameters are estimated and reported in Table 6.

Table 5. Test for cointegration relationship

Energy sources	90% I(0) I(1) 2.915 3.695	95% I(0) I(1) 3.538 4.428	99% I(0) I(1) 5.155 6.265	Decision
F_{AEC}(AEC/M2) F_{M2}(M2/AEC)	4.468** 21.121***			Cointegrated
F_{EC}(EC/M2) F_{M2}(M2/EC)	37.201*** 6.970***			Cointegrated
F_{FF}(FF/M2) F_{M2}(M2/FF)	3.429 12.247***			Cointegrated

Source: Author's computation, 2013/2014. Note: critical values are obtained from Pesaran et al., (2001) and Narayan, (2004). Note: *** and ** denote significant at 1% and 5% levels of significance

3.2.2 The Long-Run Elasticities of the ARDL Model

Table 6 reports the results of the long run parameters. The results show that financial development significantly influenced energy consumption. The results indicate that in the long run 1% increase in financial development leads to about 54.8% increase in electricity consumption; about 48.9% increase in fossil fuel consumption and about 16.2% increase in aggregate energy consumption. The values of the elasticities indicate inelastic demand for energy sources since the values are less than one in the long run. Money supply elasticity of electricity consumption is more elastic followed by that of fossil fuel consumption and then aggregate energy consumption.

Table 6. Estimated long-run Elasticity Coefficients
Regressor =lnM2

Regresands	Elasticities	Std Error	T-ratio	P-value
lnEC	0.548	0.187	2.937	0.006***
lnFF	0.489	0.109	4.475	0.000***
lnAEC	0.162	0.025	6.439	0.000***

Author's computation, 2013/2014: Note: *** denotes statistical significance at the 1%. ARDL (1) selected based on Akaike Information Criterion

3.2.3 The Short-Run Elasticities of the ARDL Model

Table 7 reports the results on the short run elasticities. The results indicate that in the short run, 1% increase in financial development (proxied by money supply) leads to about 33.2% increase in electricity consumption; about 35.6% increase in fossil fuel consumption and about 14.2% increase in aggregate energy consumption. The values indicate inelastic energy demand in relation to money supply in the short run. Money supply elasticity of fossil fuel demand is more elastic followed by that of electricity demand and then aggregate energy consumption in the short run. The values of the long run elasticities coefficients are larger than that of the short run values, which indicates that the money supply elasticities of energy demand, is more elastic in the long run than in the short run.

Table 7. Estimated Short-run Elasticity Coefficients
Regressor =ΔlnM2-$_1$

Regresands	Elasticities	Std Error	T-ratio	P-value
lnEC	0.332	0.126	2.640	0.012**
lnFF	0.356	0.102	3.499	0.001***
lnAEC	0.142	0.031	4.596	0.000***

Author's computation, 2013/2014: *** and ** denotes statistical significance at the 1% and 5% levels respectively. ARDL (1) selected based on Akaike Information Criterion

3.2.4 Results of Diagnostic and Stability Tests

Table 8 reports the results of the diagnostic tests of the short-run estimation to examine the reliability of the error correction model for the energy sources and financial development. The null assumptions of adequate specification, absence of heteroskedasticity, normally distribute error, and no serial correlation was investigated. Except the heteroscadasticity assumption in the electricity and fossil fuel models, the model passed the rest of the tests. The R^2 and the adjusted R^2 values in Table 8 are an indication of very well behaved model.

Table 8 Short-Run Diagnostic Tests of ARDL Model (AEC); EC; FF

Energy sources	A:Serial Correlation	B:Functional Form	C:Normality	D:Heteroscedasticity
AEC	LMV-CHSQ(1)= 0.211[0.646] FV-F(1, 32)= 0.178[0.675]	LMV-CHSQ(1)= 2.871[0.090] FV-F(1, 32)= 2.616[0.116]	LMV-CHSQ(2)= 2.319[0.314] Not applicable	LMV-CHSQ(1)= 0.837[0.360] FV-F(1, 36)= 0.811[0.374]
EC	LMV-CHSQ(1)= 0.333[0.564] FV-(1, 30)=0.284[0.597]	LMV-CHSQ(1)= 2.084[0.149] FV-(1, 30)= 1.863[0.182]	LMV-CHSQ(2)= 4.022[0.134] Not applicable	LMV-CHSQ(1)= 7.337[0.007] FV-(1, 37)=8.574[0.006***]
FF	LMV-CHSQ(1)= 0.004[0.951] FV-(1, 34)= 0.003[0.954]	LMV-CHSQ(1)= 0.555[0.456] FV-(1, 34)= 0 0.491[0.488]	LMV-CHSQ(2)= 1.836[0.399] Not applicable	LMV-CHSQ(1)= 3.521[0.061] FV-(1, 37)= 3.671[0.063*]

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
LMV=LM Version; FVM=F Version
R-Squared 0.651 R-Bar-Squared 0.609
R-Squared 0.834 R-Bar-Squared 0.814
R-Squared 0.652 R-Bar-Squared 0.622

Source: Author's computation, 2013/2014. Note: ***, and * denote significance at 1% and 10% levels respectively

The stability tests (CUSUM and CUSUMSQ) (Figure 1; Figure 2; Figure 3; Figure 4; Figure 5 and Figure 6) 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 of parameter instability are rejected in both tests.

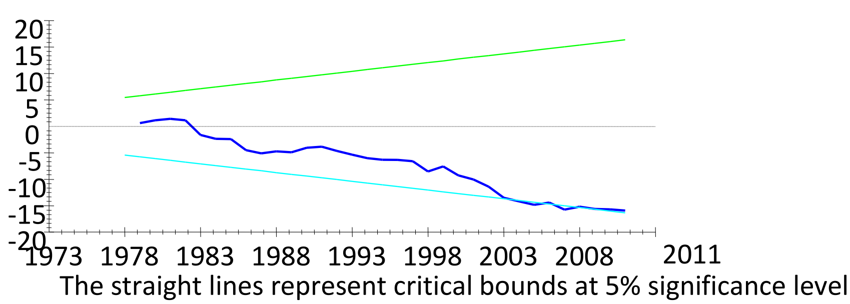

Figure 1: Plot of CUSUM (M2 on EC)

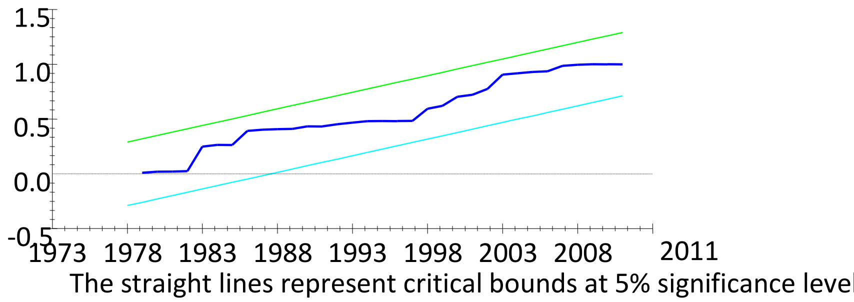

Figure 2: Plot of CUSUMSQ (M2 on EC)

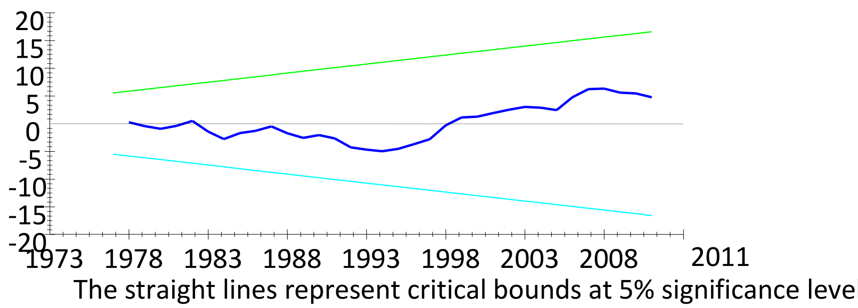

Figure 3: Plot of CUSUM (M2 on FF)

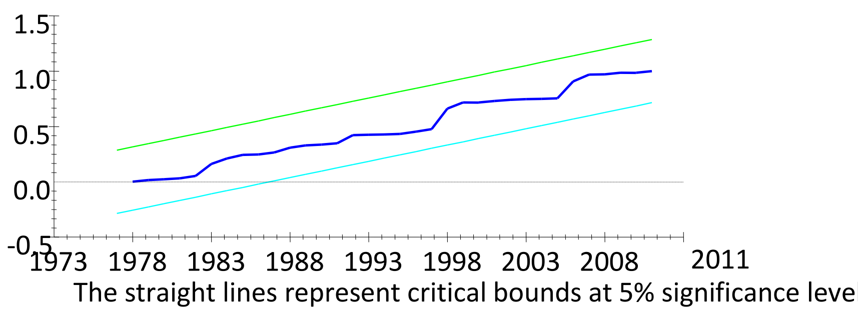

Figure 4: Plot of CUSUMSQ (M2 on FF)

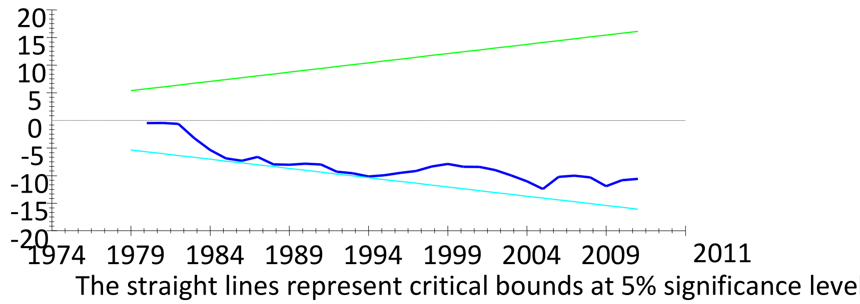

Figure 5: Plot of CUSUM (M2 on AEC)

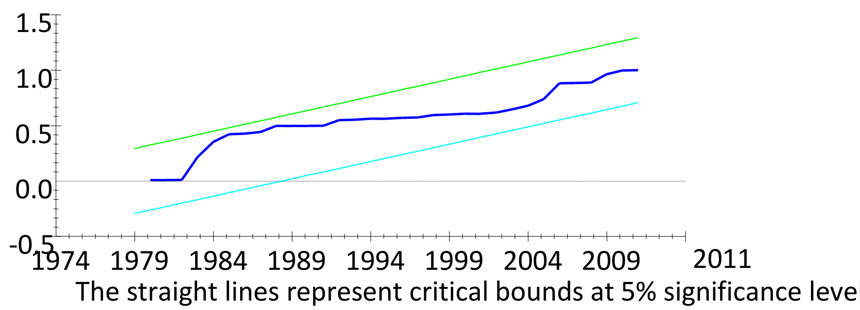

Figure 6: Plot of CUSUMSQ (M2 on AEC)

4 Conclusions

The paper investigates the long run and short-run effect of financial development on energy consumption. The results indicate that financial development has significant effect on energy consumption (electricity consumption, fossil fuel consumption, and aggregate energy consumption). The findings of positive effect of the financial development on energy consumption are in support of the findings of previous researchers (Faridul et al., 2011; Kakar et al., 2011; Bartleet & Gounder, 2010; Sadorsky, 2010; Dan & Lijun, 2009; Huang et al., 2008) who reported that financial development influence energy consumption. Kakar et al., (2011) reported of positive effect of finance on energy demand for Pakistan and concluded that increase in financial development is associated with increases in energy demand. The findings are inconsistent with that of Yeboah and Ohene-Manu (2015) who reported of positive but insignificant effect of financial development on fossil fuel consumption in a multivariate energy demand model.

The theoretical concepts that financial sector explain changes in disaggregate energy consumptions are supported in the short run and long run. Policy makers who are responsible for energy demand management can use financial development to reach the planned consumption levels needed. Future studies should consider the issue of causality and structural breaks since the current study did not consider these issues. Other variables such as population, income, price, and exchange rate should also be considered in future research. Nonlinear models should be considered in future modelling of the determinants of energy consumption.

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