Bivariate modelling of the financial development-fossil fuel consumption nexus in Ghana

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ABSTRACT
The present paper modelled the relationship between financial developments and fossil fuel energy consumption in Ghana for the period 1970-2011 by applying Autoregressive Distributed Lad Model (ARDL). The findings of the paper on the cointegration test indicate significant evidence of cointegration between fossil fuel consumption and financial development. The findings seem to suggest that financial development is an explanatory variable in fossil fuel consumption management in achieving sustainable oil energy consumption for economic growth. The direction of causality between the two variables should be examined in future studies as well as multivariate analysis and structural breaks.

Key words: Fossil fuel consumption, financial development; long run; short run
Jel codes: O13, O16, P28, P34, Q42, Q43

1 INTRODUCTION
The work of Kraft and Kraft (1972) on the determinants of energy consumption has continued to spur interest in the energy literature on the key explanatory variables in examining the factors that influence energy consumption. Fossil fuel plays very important role in all levels of the economy (household, firms, and government) in various activities that are performed. Previous theoretical and empirical literature neglected explicitly the role of finance in the energy demand modelling. This according to other researchers does not fully addresses this issue resulting in the problem of omitted variable in the econometric modelling of energy demand. The recent studies to account for the role of finance in energy demand has also produced inconsistent findings, which calls for, further empirical study.

Whereas some studies reported of positive link between fossil fuel and finance, others have reported of negative relationship between fossil fuel and finance. However, other studies have indicated insignificant link between fossil fuel and finance (Odusanya, Osisanwo, Tijani, 2016). For example, Sadorsky (2010) used different indicators of financial development in twenty-two emerging economies for the period 1990-2006. The findings of the study indicated that financial development has positive effect on energy demand.

In a similar study by Shahbaz et al. (2010) indicated a significant and positive effect of financial development on energy consumption in Pakistan, with bidirectional casual relation between financial development and energy consumption. Islam et al. (2013) study for Malaysia indicated positive effect of financial development on energy consumption, with unidirectional.

Chitioui (2012) examined the link between financial development and energy consumption in Tunisia was significant and reported of a positive relationship between energy consumption and financial development for the period under discussion.

In Tunisia, Shahbaz and Lean (2012) investigated the link between financial development and energy consumption and reported that energy consumption positively influences energy consumption in both long run and short run.

Çoban and Topcu (2013) investigated the link between financial development and energy consumption for the European Union for the period 1990 to 2011. The findings of the study indicated significant positive relationship between financial development and energy consumptions. The proxies for financial development (bank or stock variable) did not influence the empirical findings.

For the period 1967 to 2010, Safaynikou and Shadmehri (2014) examined the link between financial development and energy consumption for Iran by employing the ARDL model and reported of significant positive effect of financial development on energy consumption.

Ali et al. (2015) study for Nigeria on the role of economic growth and financial development in fossil fuel consumption and reported that there exist a significant negative effect of financial development on fossil fuel consumption in both long run and short run.

Chang (2015) extended the work of Sadorsky (2010) to examine the nonlinear influence of financial development (proxied by various measures of both bank and stock markets) and income on energy consumption for the period 1999 to 2008 for both high and low income countries. The findings of the results indicated significant effect of finance on energy consumption in all the countries in the study.

Siddique and Majeed (2015) examined the relationship between financial development and energy consumption in South Asian countries of India, Nepal, Pakistan, Sri Lanka and Bangladesh and reported that there existed significant long-run relationship between energy consumption and financial development. However, there was no significant short run relationship between energy consumption and financial development.

Odusanya et al. (2016) re-examined the relationship between financial development and energy consumption in Nigeria for the period 1971 to 2014 by employing the ARDL method. The findings of the study indicated significant positive relationship between financial development and energy consumption.

The empirical review of the effect of financial development indicates mixed findings in the literature and the present study fills in the gap in the literature. The aim of the paper is to model and investigate the influence of financial development on fossil fuel consumption for Ghana in order to contribute to the energy literature. The research question underlying the present paper is; what is the effect of financial development on fossil fuel consumption in both short run and long run? The assumption underlying the current study is that, financial development has significant effect on fossil fuel consumption in the short run and long run.

Financial development is proxied by money supply and no other variables such as bank deposit or stock market variables. The limitations of the study are that of the estimation methods such as the Augmented Dickey-Fuller (ADF), Kwiatkowski-Phillips-Schmidt-Shin (KPSS), and the ARDL methods, as well as the demerits of secondary data used. The rest of the present paper deals with the methodology (section 2), the empirical results (section 3), and conclusions (section 4).

2 METHODOLOGY

2.1 Estimation Method

The stationarity properties of the variables in the study (financial development, and fossil fuel consumption) were examined by employing the Augmented Dickey-Fuller (ADF) unit root test and the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) unit root test. The null assumption of the KPSS test is that there is stationarity around a deterministic trend (trend-stationary) against the alternative assumption that the variables are non-stationary. The null assumption of the ADF test is that the data set are stationary in levels whereas the alternative assumption is that the data set are not stationary in levels. The long run and short run link between financial development and fossil fuel consumption was investigated using the ARDL cointegration method developed by Pesaran and Shin (1998) and Pesaran, Shin, and Smith (2001). The ARDL model has the advantage of been suitable for small data set and it is suitable whether the stationarity properties are known or unknown of the variables.

2.2 Data

The data for the empirical assessment of the link between financial development and fossil fuel consumption is based on annual secondary data for Ghana for the period 1970 to 2011. The source of the data is the 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)
Fossil Fuel Consumption (FF)	World Bank World Development Indicator (WDI)

2.3 Conceptual Framework

The effect of financial development and fossil fuel consumption is modelled for Ghana to determine the effect of financial development on fossil fuel consumption in the long run and short run in other to test the theoretical proposition that finance play important role in energy consumption. The relationship between financial development and fossil fuel consumption was modelled in the present study in a bivariate model as specified in equation (1). The dependent variable in the model is fossil fuel consumption (FF) whereas the independent variable in the model is financial development (M2). The model is as specified in log-linear form in equation (1).

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

3. EMPIRICAL RESULTS

3.1 Descriptive Statistics

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 of the summary statistics of the variables as shown in Table 2 indicate that fossil fuel consumption falls as low as 11.529GWh and as high as 31.205GWh. Of the series variables the most volatile is financial development variable (0.278) followed by fossil fuel (0.195). The range of the coefficient of skewness is between positive one (1) and negative one (-1). The results are shown in Table 2. All the series variables are positively skewed but are less skewed. The coefficient values of the kurtosis of the series variables M2 (-0.972), and FF (-0.199) are less than zero (0) which indicates more flat-topped distribution.

Table 2 Summary Statistics, using the Observations 1970-2011

Vars.	Mean	Min	Max	SD	CV	SK	KUR
FF	21.797	11.529	31.205	4.257	0.195	0.097	0.867
M2	22.446	11.305	34.108	6.239	0.278	0.033	-0.972

Source: Author's computation, 2013/2014. SK=Skewness; KUR. =Kurtosis; CV=Coefficient of Variation; Min. Minimum; Max. =Maximum; SD=Standard Deviation

3.2 The ADF Test Results

The results on the ADF test for unit root test are reported in Table 3. 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 variables. The first difference of the variables attained stationarity.

Table 3 ADF stationarity test results with a constant and trend

Variables	t-statistics	ADF/P-Value	Results	Lag length
M2	-1.6257	0.7652	Not stationary	1
M2-1st dif.	-5.9818	7.189e-005***	Stationary	1
FF	-2.7613	0.2191	Not stationary	1
FF-1st dif.	-6.9492	3.485e-009***	Stationary	1

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

3.3 The KPSS Test Results

The KPSS test is based on the null assumption (H_o) that the series variables under investigation are stationary (series are not unit root) against the alternative hypothesis (H_1) 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 after the ADF test is used. The results are reported in Table 4. The variables were examined in levels in linear form. The series were stationary in the first difference of the linear form and not in levels.

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

Variables	t-statistics	Results	Lag length
M2	0.1923	Stationary	3
M2-1st dif.	0.0694	Stationary	3
FF	0.2307	Not stationary	3
FF-1st dif.	0.0993	Stationary	3

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

3.4 Results of Autoregressive Distributed Lag (ARDL) Model/Bound Approach to Cointegration for Fossil Fuel consumption (FF) and Financial Development (M2)

The results of the cointegration test are shown in Table 5. The results reported in Table 5 indicate significant cointegration between fossil fuel consumption (FF) and financial development variables (M2) since the calculated F-statistics of 12.2467 is greater than the critical values of the upper bounds at the 90%; 95% and 99% levels of significance in model 2 with financial development as the dependent variable. The null assumption of no cointegration is rejected in model 2. The results indicate stable long-run equilibrium relationship between financial development and fossil fuel consumption. In model 1 with fossil fuel consumption as the dependent variable, the calculated F-statistics of 3.4292 is less than the critical values of the upper bounds at the 90%; 95% and 99% levels of significance. This indicates no significant cointegration between the series variables.

Table 5 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_{FF}(FF/M2)	3.4292		Not Cointegrated			
2.F_{M2}(M2/FF)	12.2467***		Cointegrated			

Source: Author's computation, 2013/2014: Note: critical values are obtained from Pesaran et al., (2001) and Narayan, (2004): NB *** denotes significance at 1% level

3.5 Results of Long-Run Elasticities of ARDL Model

The long-run determinant of fossil fuel consumption was estimated using the model in which fuel consumption is the dependent variable. The results are reported in Table 6. The results indicate that financial development (M2) statistically significantly determines fossil fuel consumption in the long run since the coefficient value of 0.4889 is significant at 1% level. The coefficient of financial development has expected a priori theoretical sign that is positive. The results shows that 1% increase in financial development leads to about 48.89% increase in fossil fuel consumption.

Table 6 Estimated long-run coefficients. Dependent variable is LNFF

Variable	Coefficient	Std. Error	T-ratio	P-value
Constant	1.4843	0.3098	4.7919	0.000***
Trend	0.0032	0.0029	1.1031	0.278
lnM2	0.4889	0.1093	4.4748	0.000***

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

3.6 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 7. The results on the nature of the short run coefficients (0.3561) are different from that of the long-run coefficients. Financial development is significant determinant of fossil fuel consumption in the short run at 1% level. One percent increase in financial development variable leads to about 35.61% increase in fossil fuel 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 theoretically expected sign that is negative. The coefficient of -0.7285 indicates that, after 1% deviation or shock to the system, the long-run equilibrium relationship of fossil fuel consumption is quickly re-established at the rate of about 72.851% percent per annum. The value indicate stronger adjustment rate.

Table 7 Short-run representation of ARDL model. ARDL (1) selected based on Akaike Information Criterion. Dependent variable: ΔlnFF

Variable	**Coefficient**	**Standard Error**	**T-Ratio**	**Prob. Values**
Constant	1.0814	0.3298	3.2793	0.002***
Trend	0.0023	0.0022	1.0799	0.288
ΔlnM2	0.3561	0.1018	3.4995	0.001***
ecm (-1)	-0.7285	0.1466	-4.9690	0.000***
ecm = LNFF -1.4843C -0.0032119T-0.48885LNM2…...(2)				
R-Squared	0.6522	R-Bar-Squared	0.62235	
S.E. of Regression	0.1295	F-stat. F(3, 35)	21.8744[.000]	
Mean of Dependent Variable	3.0602	S.D. of Dependent Variable	0.2108	
Residual Sum of Squares	0.5871	Equation Log-likelihood	26.4869	
Akaike Info. Criterion	22.4869	Schwarz Bayesian Criterion	19.1597	
DW-statistic	1.9907	Durbin's h-statistic	0.0724[.942]	

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

3.7 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 8. 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 (0.6522) and the adjusted R^2 (0.6224) in Table 8 are indication of a very well behave model. The coefficient indicate approximately 65.22% of the variations in fossil fuel consumption are attributed to the explanatory variable.

Table 8 Short-Run Diagnostic Tests of ARDL Model

Test Statistics	LM Version	F Version
A:Serial Correlation	CHSQ(1)= .0039[0.9510]	F(1, 34)= .0034[0.9540]
B:Functional Form	CHSQ(1)= .5555[0.4560]	F(1, 34)= .4913[0.4880]
C:Normality	CHSQ(2)= 1.8360[0.3990]	Not applicable
D:Heteroscedasticity	CHSQ(1)= 3.5207[0.0610]	F(1, 37)= 3.6717[0.0630]
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, 2013/2014.

The stability of the long-run estimates was determined by employing the cumulative sum (CUSUM) and cumulative sum of squares (CUSUMSQ) procedures. This was determined using the residuals of the error-correction model indicated by equation (2). The CUSUM test of stability determines the methodological arrangements of the estimates and its null hypothesis states the coefficients are stable. The null assumption is rejected when the CUSUM surpasses the given critical boundaries that demonstrate unstable nature of the estimates. The CUSUMSQ determines the stability of the variance. Both tests as indicated 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.

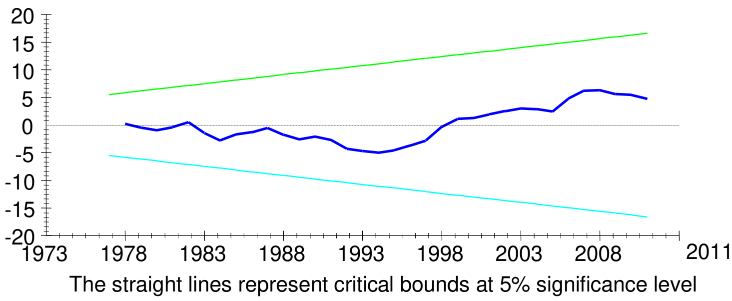

Figure 1: Plot of Cumulative sum of recursive residuals

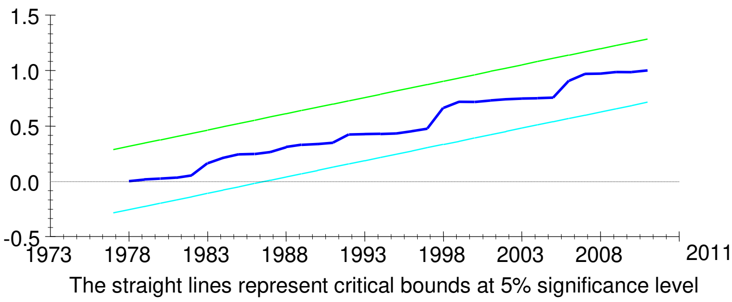

Figure 2: Plot of Cumulative sum of squares of recursive residuals

4 CONCLUSIONS AND POLICY IMPLICATIONS

The main aim of the paper is to model the effect of financial development on fossil fuel consumption for Ghana for the period 1970 to 2011 using annual secondary data by employing the ARDL method development by Pesaran and Shin (1998) and Pesaran et al. (2001).

The results overwhelmingly show financial development significantly and positively influences fossil fuel energy consumption for the period under discussion. The results here are consistent with previous studies (Sadorsky, 2010; Shahbaz et al., 2010; Islam et al., 2011; Chitioui, 2012; Shahbaz & Lean, 2012; Çoban and Topcu, 2013; Safaynikou & Shadmehri, 2014; Chang, 2015; Siddique & Majeed, 2015; Odusanya et al., 2016) that determined that financial development positively influences energy consumption.

The results are not consistent with those of Ali et al. (2015) study for Nigeria who reported of significant negative effect of financial development on fossil fuel consumption in both long run and short run, and that of Siddique and Majeed (2015) who reported of no significant short run relationship between energy consumption and financial development for South Asian countries of India, Nepal, Pakistan, Sri Lanka and Bangladesh.

The findings seem to suggest that financial development is an important policy tool to manage energy consumption in other to achieve sustainable energy consumption for a sustainable economic growth. Future studies should consider issues such as structural breaks and direction of causality to enable inform policy discussions. Multivariate studies should be considered also in future studies since the current study is based on bivariate analysis. This will allow the inclusion of other explanatory variables.

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