Economy
ISSN: 2313-8181
Vol. 2, No. 1, 32-43, 2015
www.asianonlinejournals.com/index.php/Economy

An Econometric Investigation of the Determinants of Fossil Fuel Consumption: A Multivariate Approach for Ghana

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Abstract

The study examines the long run and short run determinants of fossil fuel consumption in Ghana for 1970-2011 period by using Autoregressive distributed lad model (ARDL). The bound test for cointegration produced no evidence of cointegration among the variables. There are no statistical significant long run and short run parameters for the fossil fuel consumption function for Ghana. The results suggest macro variables such as income, price, trade openness, investment, money supply, and government expenditure do not play observable role in fossil fuel consumption. As such, they could not be relied on as a policy tool to manage fossil fuel consumption. Future study should consider the issue of structural breaks and the direction of causality.

Keywords: Fossil fuel, Consumption determinants, Long run and short run elasticities, Cointegration link, Income, Price, ARDL bound approach, Stability test, Non structural break.

Contents

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1. Introduction

The examination of the determinants of energy consumption has been discussed widely in energy literature since energy is considered as one of the main engines of economic growth (Acaravci and Ozturk, 2012). The analysis took prominence in the literature following the empirical works of Kraft and Kraft (1978) for the United States. Fossil fuel consumption impact economic performance at both macro-level and the household level. Fossil fuel allows the households, firms and the government to run their activities such as transportation and powering of industrial machines for production. As the economy grows, fossil fuel usage also increases and this has necessitated the examination of factors that influence the consumption of fossil fuel in economies. This is important to avoid energy shortages in an economy such as Ghana, which has been experiencing energy shortages resulting in long queues at the filling stations. The examination of the determinants helps in assessing the trends and forecast of *fossil fuel* consumption, which is difficult to do (Doherty, 2012).

The empirical examination of the determinants of fossil fuel consumption has not produced consistent results in the literature. The discrepancies in the empirical findings are found in the works Han *et al.* (2000); Keii (2000); Gately and Huntington (2002); Wei (2002); Cooper (2003); Wolde-Rufael (2004); Griffin and Schulman (2005); Narayan and Wong (2009); Zou and Chau (2006); Dargay *et al.* (2007); Narayan and Smyth (2007); Skeer and Wang (2007); Hughes *et al.* (2008); Askari and Krichene (2010); Dargay and Gately (2010); Lee and Lee (2010); Faridul *et al.* (2011); Baumeister and Peersman (2012); Fawcett and Price (2012); and Schryder and Peersman (2012).

Various variables (Energy price, income, the share of heavy industry output in national income, population, financial development, exchange rate, interest rate, population growth, trade, and total traffic volume) have been reported in the literature to influence fossil fuel consumption.

The paper is based on microeconomic theory of demand and the concept of elasticity. The theory of demand suggests that other thing equal, the demand for a product is a function of the price of the product, the price of substitute product, technology and income (Mas-Colell *et al.*, 2007).

Governments embark on many forms of growth strategies. One of these strategies is the use of energy as an engine of growth and development (Kahsai *et al.*, 2010). Policy makers, managers, economists, and energy experts in an economy encourage energy conservation and the use of energy efficient sources in the face of limited energy supply, coupled with the fact that oil, and gas are imported with the limited foreign currency in economies which are not producers of energy. For example, the energy commission, 2010 report for Ghana indicated Ghana has installed capacity (1960MW) that comprises of hydro and thermal that is not sufficient for the current demand level. It is expected that fossil fuel demand will increase in future from 1.62 million tonnes (2005) to 2.49 million tonnes (2015) (Energy Commission, 2010). This called for the examination of the factors that affect fossil fuel consumption to help in energy demand management policy formulation.

The issue under investigation is to examine empirically the determinants of fossil fuel consumption. The paper contributes to the body of knowledge in literature, by empirically assessing the effect of financial development on fossil fuel consumption with inconsistent results. 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. The current paper adds to the literature in this area. The paper in addition, suggests a conceptual fossil fuel demand model for estimating demand for energy in small but open economy.

This paper contributes to theoretical knowledge as it seeks among other things to provide answers to research questions of *'what'; 'why' and 'how'* as indicated by Sutton and Staw (1995). Explanations are provided for *why* and how variables are linked and the significance of their relation. Reasons are also provided as to *why* other variables are not related or are not explanatory variables. From the review of the literature, 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. The findings have been mixed. 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. The findings provide policy guide for policies makers on energy demand management to ensure sufficient energy supply. Shahbaz *et al.* (2011) indicated that energy demand projections that do not consider variables such as financial sector development might produce inaccurate forecast that will work against any conservation policy in an economy. The findings serve as reference material for students and researchers in the area of energy economics who are 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 in Ghana in order to identify and determine policy options that can achieve sufficient energy consumption to spur economic growth. The study contributes to knowledge in energy sufficiency by determining factors influencing energy consumption over the 1970-2011 periods. In order to achieve the General objective, the researcher specifically: (b) Examine the unit root properties of the series variables (c) Estimate and analyse the determinants of fossil fuel energy consumption using Autoregressive distributed lag model (ARDL).

The paper is based on these research questions: (a) what is the nature of stationarity of the variables? (b) What is the nature of cointegration link among the variables? (c) What are the main determinants of fossil fuel consumption?

The main assumption behind the current paper is the claim that in Ghana *fossil fuel consumption is statistically influenced by macroeconomic variables (such income, price of energy, trade openness, investment, and government expenditure)*. Empirical data are used to test this claim.

This study is not without limitations. These limitations do not in any way invalidate the findings of the research. The study is based on secondary data. Hence, the study may suffer from error in variable. Any error in the data used might not been known by the researcher. Hence, the same data from various sources are compared for uniformity in the data set.

The review of literature is limited to only sources and references dealing with determinant of energy consumption, the role of financial development in energy consumption and economic growth, at aggregate and disaggregate levels as well as studies base on panel data.

These sources are reviewed since they are related to the focus of the current paper and provide enough information on all sections of the paper such as the statement of the problem, justification, research questions, assumption, theoretical framework, empirical framework, methodology, as well as the significance of the study.

The paper does not review articles on the problem of the financial sector energy sector and problems of economic growth, since this is not the focus of the paper and their inclusion will make them irrelevant.

The estimated model did not include variables such as education, democracy, and corruption. They are not included since the literature reviewed do not identify these variables and hence do not have theoretical and conceptual basis for inclusion.

The ordinary regression analysis (OLS) is not used since the series are not stationary and the use of such analysis method produces spurious regression results and produced invalid and unreliable results.

The issues of structural breaks are not considered in the current paper in the examination of the unit root properties of the series variables. The issue of the existence of nonlinearities in the energy demand model is not considered. Multivariate demand model is considered not bivariate energy demand model. The multivariate analysis is "important because changes in energy use are frequently countered by opposite movements in the employment of other factors, due to substitution, resulting in an insignificant overall impact on output" (Stern, 1998).

2. Methodology

The determinants of the fossil fuel demand model is performed by first examining the unit root properties of the series using the Augmented Dickey and Fuller (1979) (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 and Shin, 1999; Pesaran *et al.*, 2001).

2.1. Unit Root Test

The unit root test is conducted to determine whether the series in model are stationary or non-stationary in order to determine the order of integration. If the series are non-stationary they are made stationary through differencing before they are used in the estimation. This is done to avoid spurious results. The ADF test is based on the null (H_o) assumption that there is a unit root or the series are non-stationary in levels. The alternative hypothesis (H_1) states that the series are stationary or there is no unit root in the series. The critical values are compared with the calculated values at 5%, 1% and 10% levels of significant. The ADF test is as specified in equation (1).

$$\Delta z_t = \alpha_t + \beta_t \gamma_t + \rho z_{t-1} + \sum_{i=1}^{q} \partial \Delta z_{t-1} + \varepsilon_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where γ = time trend, Z= time series variable in the model, ε_t = error term or stochastic error term.

The KPSS test serves as a confirmatory test for the ADF test. The null assumption (H_o) of the KPSS is that, the series variables under investigation are stationary against the alternative assumption (H_1) that the series are non-stationary (Kwiatkowski *et al.*, 1992). Given that Y_t is the series variable under investigation, Kwiatkowski *et al.* (1992) specify an equation as shown in equation (2) to decompose the series into the sum of a deterministic trend (t), a random walk (r_t) and a stationary error (ε_t).

$$Y_t = \xi t + r_t + \varepsilon_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

The random walk is specified as in equation (3)

$$r_t = r_{t-1} + \mu_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Where μ_t is considered to be IID $(0, \sigma^2_\mu)$. The initial value of r_t which is r_0 is considered as the fixed and serves the role of an intercept in the model. The stationarity assumption is given as $\sigma^2_\mu = 0$. The series variable under investigation (Y_t) is trend stationary since the error term is stationary. In model (2), Kwiatkowski *et al.* (1992) set the coefficient $\xi=0$ where the null assumption that the series variable (Y_t) is stationary around a level (r_0) and not around a deterministic trend. This the authors considered as a special case. The test statistics under the KPSS is the Lagrange multiplier (LM) statistic under the assumption that $\sigma^2_\mu = 0$, given the assumption that μ_t is normally distributed and that the error term (ε_t) is IID $N(0, \sigma^2_\varepsilon)$. Kwiatkowski *et al.* (1992) specified a partial sum process of the residuals as in equation (4).

$$S_t = \sum_{i=1}^{t} e_i , \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

Where t= 1, 2, 3, …, T.

Following equation (4) the LM statistic is specified by Kwiatkowski *et al.* (1992) as in equation (5).

$$LM = \sum_{t=1}^{T} S_t^{\,2} / \hat{\sigma}^2_\varepsilon , \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (5)$$

In testing for stationarity in the levels of the series, Kwiatkowski *et al.* (1992) without considering the trend, e_t is considered as the residual from the regression of the series (Y) on an intercept only as shown in equation (6).

$$e_t = Y_t - \bar{Y} , \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (6)$$

2.2. The ARDL Model

The ARDL model is used in defining the long run link among the variables. The model is specified as in equation (7).

$$\Delta y_t = C_{0y} + C_{1y}t + b_1 y_{t-1} + b_2 z_{1,t-1} + b_3 z_{3,t-1} + ... + b_k z_{k,t-1} +$$

$$\sum_{i=1}^{m-1} \gamma_i \Delta y_{1,t-1} + \sum_{i=0}^{n-1} \alpha_{ik} \Delta z_{k,t-i} + e_{ty} ....(7)$$

Equation (7) is an unrestricted error-correction model (ECM). The variable '*y'* is regressed on variable '*z'*. Where 'z' is a vector, that is, Z_1, Z_2 …, Z_k (Belke and Polleit, 2006). The 'b's measures the long run effects, and γ and α's are the short run parameters which measures the short run effects. The *m* and *n* are the order of lags, *t* is the time trend. According to Belke and Polleit (2006) '*k*' is the number of "forcing variables in the model under estimation. The null assumption (Ho) states that there is no cointegration among the variables in the model against the alternative assumption (H_1) that the variables are cointegrated. That is, H_0: b_1=b_2-b_3= … =b_k =0 Against the alternative hypothesis H_1: Not H_0. The rejection /Acceptance of the H_0 is based on the Wald /F tests. The critical value provided by Pesaran *et al.* (2001) for the bound testing approach is used.

There are two set of variables for upper limit and lower limit, for series integrated of order one I, (1) and those integrated of order zero I (0). It must be noted that the upper limit values are for series integrated of order one, I(1) where the lower limit values are for series integrated of order zero, I(0). The computed value (Fob/Wald critical) values are compared with the upper and lower limit values for the bound test at various levels of significance such as 1%, 5% and 10%. In the interpretation of the results, if the computed F-statistics (Fob) lies between the upper limit and lower limits the results are considered as inconclusive, and one cannot talk about long run relationship or no long run relationship.

In the case where the F_{ob} is greater than the upper limit values, the $H_o$are not accepted which indicates significant cointegration relationship and statistical significant long run relationship. When the F_{ob} is less than the lower limit values of the bound, the H_o is accepted, which means that there is statistical significant cointegration relationship, and possible long run relationship.

In the estimation of the ARDL model, all the values in the model are used as dependent variables and the analysis is repeated. In the model in which cointegration relationship is identified, the model is estimated for the long run parameters or coefficients.

The lag selection is based on information such as Akaike (AIC), Schwarz information criteria (SIC). The number of regressions estimated in the ARDL model according to Pesaran *et al.* (2001) is given by $(n+1)^k$. where 'n' is the maximum number of lags use in the model and K is the number of series variables in the model under estimation.

In the ARDL model, aside the estimation of the long run coefficients, per the ARDL model, the error correction representation can also be estimated as in equation (8).

$$\Delta y_t = \sum_{i=1}^{p} \alpha_i \Delta y_{t-1} + \sum_{i=1}^{s} \beta_i \Delta x_{t-1} + \sum_{k=1}^{q} \beta_k \Delta z_{t-k} + \gamma ECM_{t-1} + e_t ....(8)$$

Equation (8) is used to estimate the short run relationship among the variables. The ARDL model estimated is assess for it goodness of fit using various diagnostic tests such as J-B Normality test, Breusch-Godfred LM test, ARCH LM test, White Heteroskedasticity test, Ramsey RESET. The stability of the model is tested using the cumulative sum of recursive residuals (CUSUM) and the cumulative sum of squares of recursive residuals (CUSUM sq). In the use of the two plots, CUSUM and CUSUMSQ, if the statistics stay within the critical bonds of 5% level of significance, the null hypothesis of all coefficients in the given regression are stable and cannot be rejected.

2.3. Empirical Model

The operation model used for estimating the fossil fuel consumption function is as specified in general form in equation (9), where FF= fossil fuel consumption; P= price; INV= investment; OPEN= trade openness; M2= money supply; Y= income and GE= government expenditure. The data for the estimation of the empirical model span from 1970-2011 due to the availability of up to date data for the period. Empirical data is taken from World Bank Database.

$$FF_t = f(P, INV, OPEN, M2, Y, GE)...........................(9)$$

3. Empirical Results, Discussions, and Analysis

3.1 Unit Root Properties Tests

3.1a. Time Series Plot in levels and First Differences of Variables

The Time Series plot results shown in Figure 1 to Figure 7 indicate the series are not stationary in levels and achieved stationarity by differencing (Figure 8 to Figure 13). Since the variables are unit root in levels, shock to the variables might have permanent effect and not transitory effects. This calls for scientific investigation of the nature of unit root using the KPSS model of unit root.

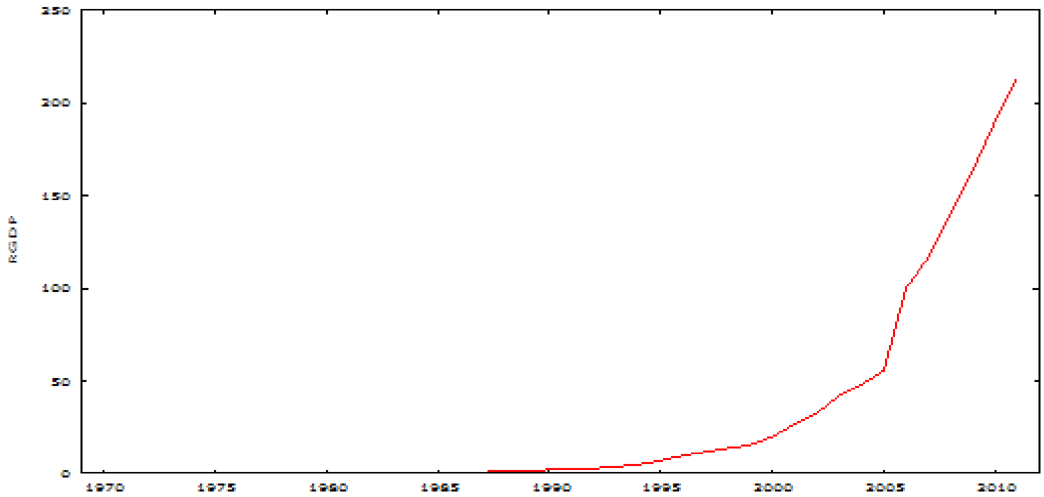

Figure-1. Time series Plot of Y in levels

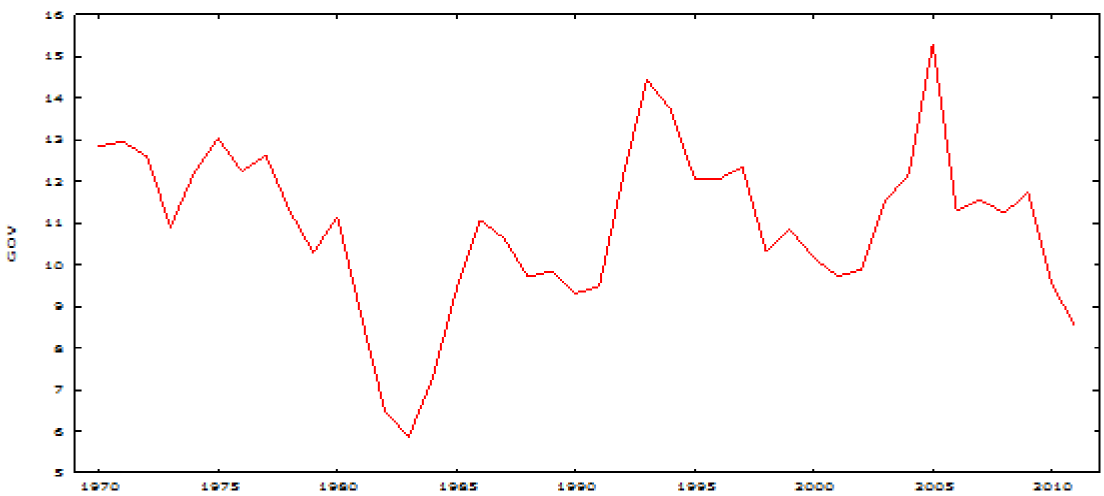

Figure-2. Time series Plot of GE in levels

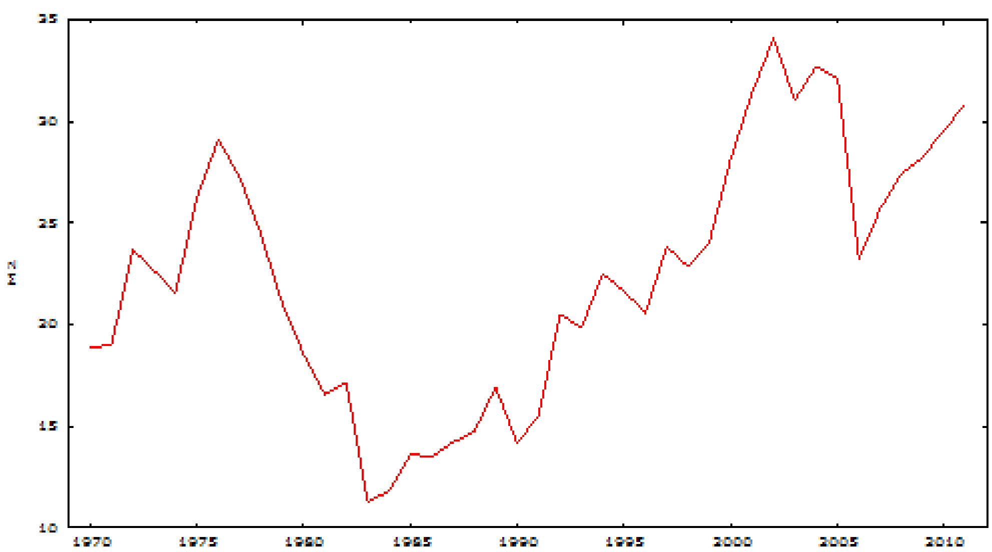

Figure-3. Time series Plot of M2 in levels

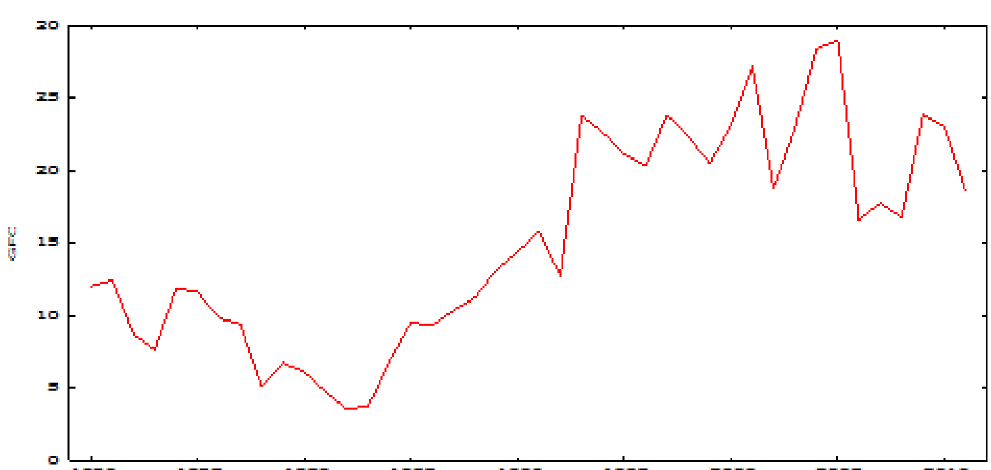

Figure-4. Time series Plot of INV in levels

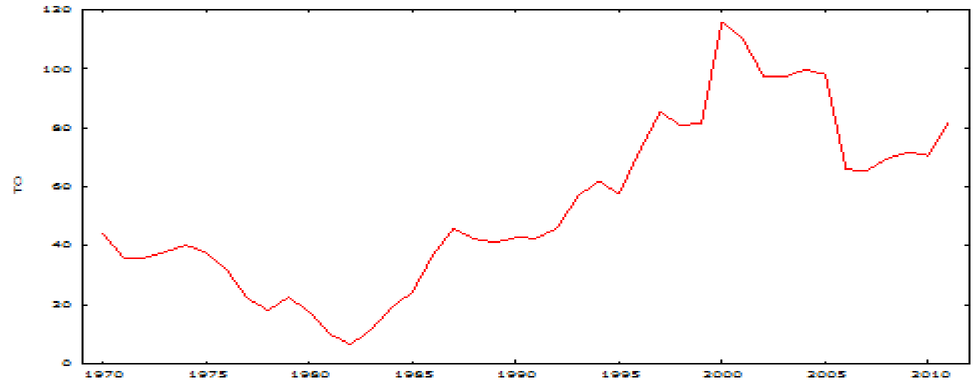

Figure-5. Time series Plot of OPEN in levels

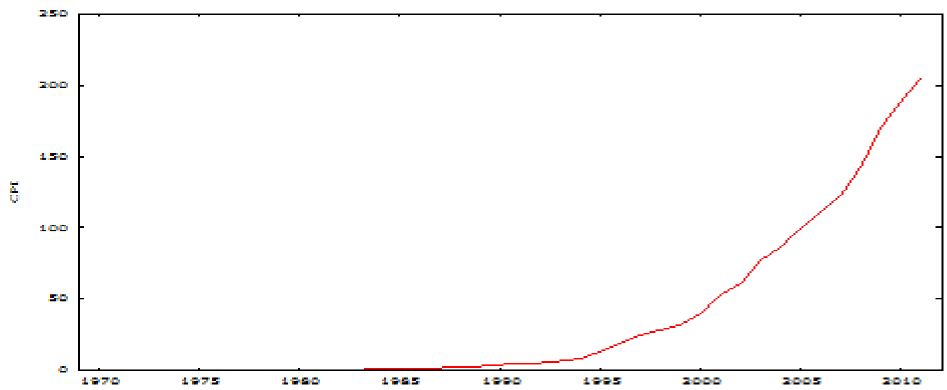

Figure-6. Time series Plots of IN in levels

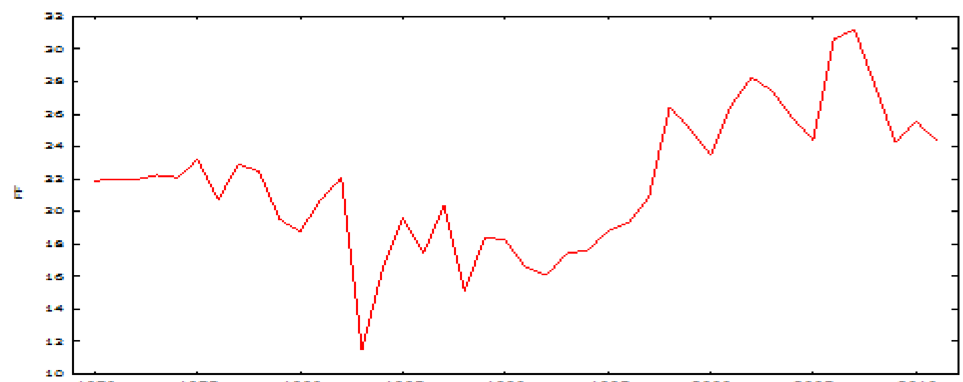

Figure-7. Time series Plot of Fossil fuel (FF) use in levels

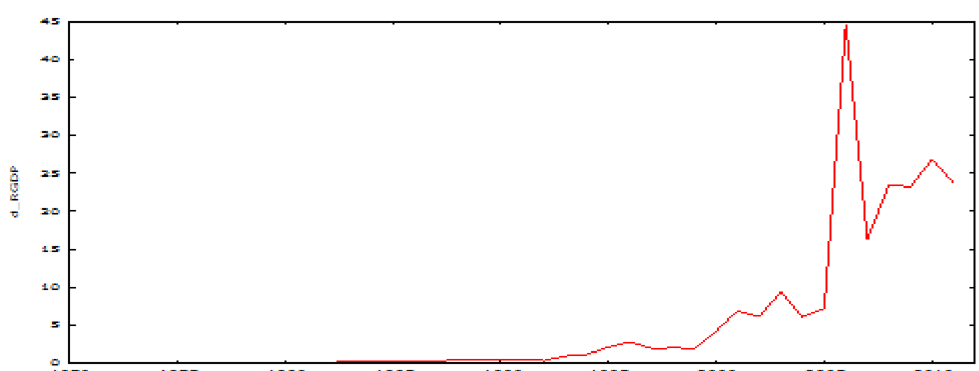

Figure-8. Time series Plot of Y in 1st difference

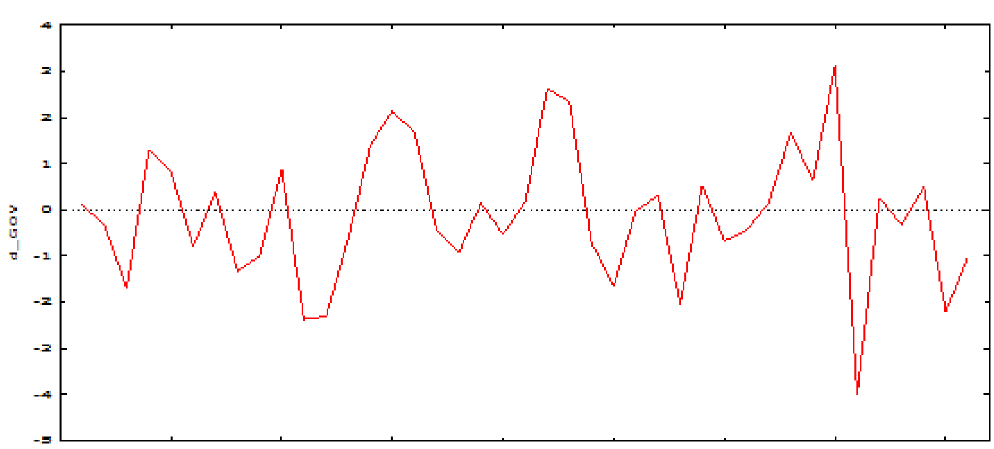

Figure-9. Time series Plot of GE in 1st difference

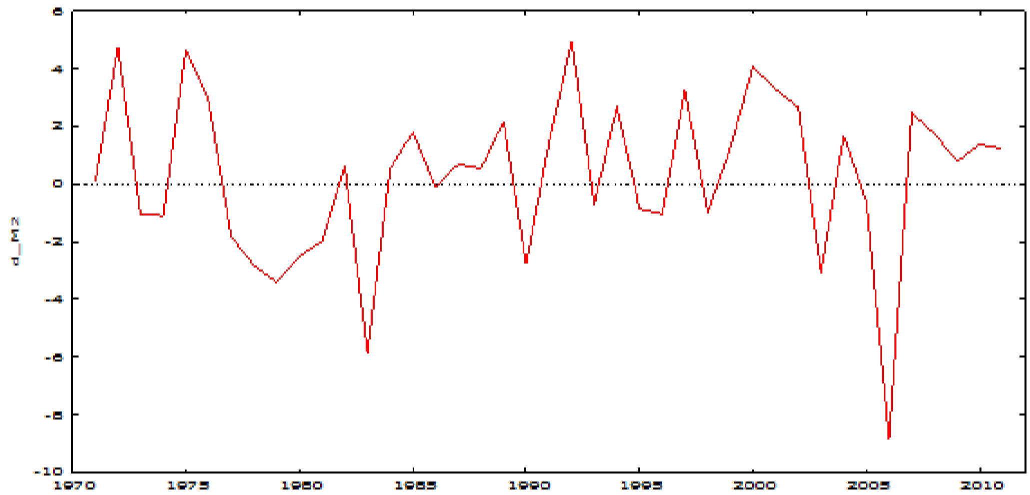

Figure-10. Time series Plot of M2 in 1st difference

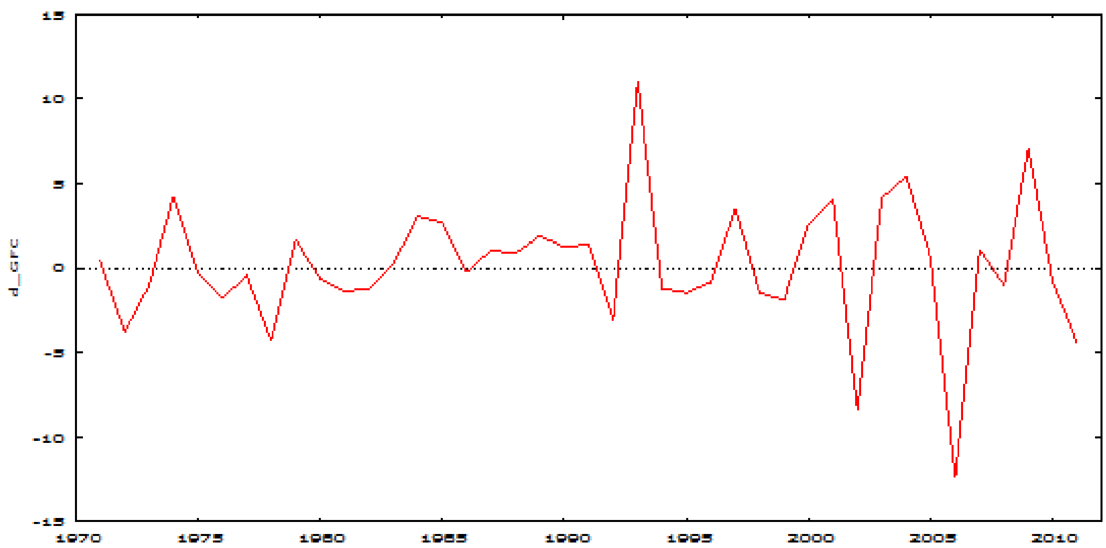

Figure-11. Time series Plot of INV in 1st difference

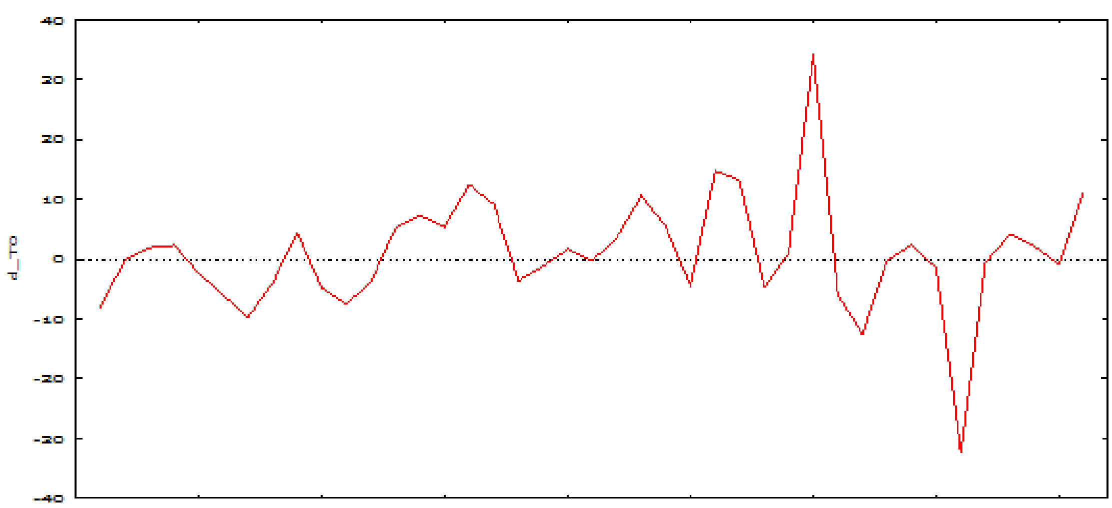

Figure-12. Time series Plot of OPEN in 1st difference

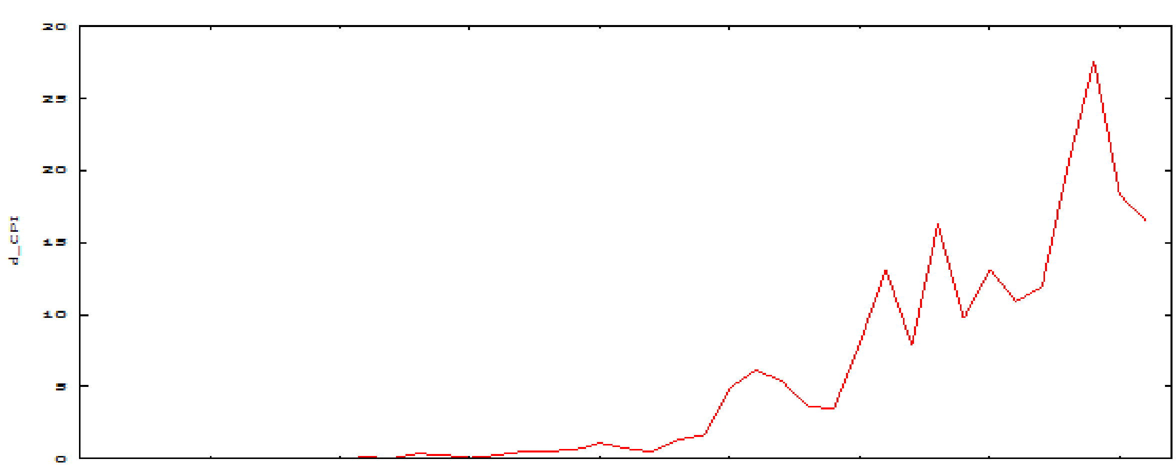

Figure-13. Time series Plot of IN in 1st difference

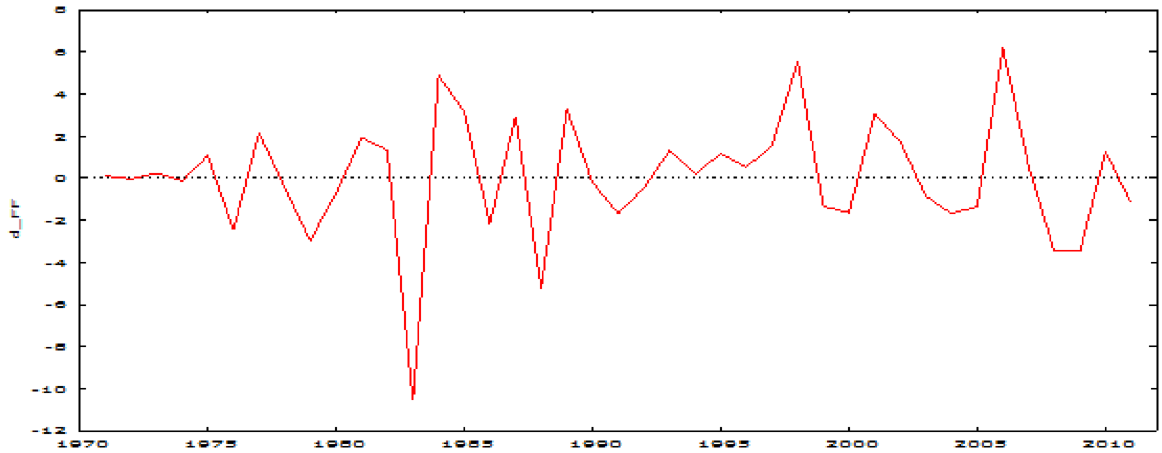

Figure-14. Time series Plot of FF Consumption in 1st difference

3.1b. ADF Test (Without Structural Break)

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**
Y	4.85154	1.000	Not stationary	1
Y-1st dif.	-2.08822	0.5519	Not stationary	1
GE	-2.46708	0.3419	Not stationary	1
GE-1st dif.	-5.84979	0.0001062***	Stationary	1
M2	-1.62565	0.7652	Not stationary	1
M2-1st dif.	-5.98178	7.189e-005***	Stationary	1
INV	-2.92979	0.1642	Not stationary	1
INV-1st dif.	-6.33633	1.653e-007***	Stationary	1
OPEN	-2.03577	0.5649	Not stationary	1
OPEN-1st dif.	-5.43876	0.0003485***	Stationary	1
IN	6.335	1.000	Not stationary	1
IN-1st dif.	-3.00133	0.1445	Not stationary	1
FF	-2.76126	0.2191	Not stationary	1
FF-1st dif.	-6.94919	3.485e-009***	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 was 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**
ΔlnY	-5.5524	0.0001***	Stationary	1
ΔlnGE	-5.07122	0.0009815***	Stationary	1
ΔlnM2	-6.27268	2.988e-005***	Stationary	1
ΔlnINV	-6.50775	1.438e-005***	Stationary	1
ΔlnOPEN	-4.67444	0.0007281***	Stationary	1
ΔlnIN	-4.7219	0.002565***	Stationary	1
Δln EC	-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

3.1c. 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 paper for confirmation of the stationarity properties of the series. The 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
Y	0.239611	n.a	Not stationary	3
Y-1st dif.	0.230848	n.a	Not stationary	3
GE	0.107255	n.a	Stationary	3
GE-1st dif.	0.0724631	n.a	Stationary	3
M2	0.192296	0.023	Stationary	3
M2-1st dif.	0.0694082	n.a	Stationary	3
INV	0.139794	0.067	Stationary	3
INV-1st dif.	0.147786	0.052	Stationary	3
OPEN	0.134766	0.076	Stationary	3
OPEN-1st dif.	0.121051	n.a	Stationary	3
IN	0.272644	n.a	Not stationary	3
IN-1st dif.	0.256955	n.a	Not stationary	3
FF	0.230714	n.a	Not stationary	3
FF-1st dif.	0.0993028	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
Δln Y	0.105237	Stationary	3
ΔlnGE	0.0711901	Stationary	3
ΔlnM2	0.0759265	Stationary	3
ΔlnINV	0.127304	Stationary	3
ΔlnOPEN	0.103818	Stationary	3
ΔlnIN	0.0902278	Stationary	3
ΔFF	0.0871667	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 Cointegration Link, Long Run, and Short Run Estimates

3.2a. The ARDL Bound Test

The results reported in Table 5 indicate insignificant cointegration between fossil fuel consumption (FF) and the series variables in all the 7 models since the F-statistics values are less than the critical values of the upper bounds at the 90%, 95% and 99% levels of significance which is an indication of no cointegration among the series variables. The null assumption of no cointegration is not rejected in all the models.

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/Y, OPEN, GE, IN, INV, M2)	na		Na			
2. F_{Y}(Y/FF, OPEN, GE, IN, INV, M2)	0.064066		Not Cointegrated			
3. F_{OPEN}(OPEN/FF, Y, GE, IN, INV, M2)	0.42434		Not Cointegrated			
4. F_{GE}(GE/FF, Y, OPEN, IN, INV, M2)	0.028877		Not Cointegrated			
5. F_{IN}(IN/FF, Y, OPEN, GE, INV, M2)	0.0024545		Not Cointegrated			
6. F_{INV}(INV/FF, Y, OPEN, GE, IN, M2)	1.0053		Not Cointegrated			
7. F_{M2}(M2/FF, Y, OPEN, GE, IN, INV)	1.6218		Not Cointegrated			

Source: Author's computation, 2013/2014: Note: critical values are obtained from Pesaran *et al.* (2001) and Narayan (2004).

3.2b. The Long-Run Parametric (Elasticities) Results of the ARDL Test

The long-run determinant of fossil fuel consumption was estimated with fossil fuel consumption is the dependent variable. The results as reported in Table 6 indicate that all the variables are not statistically significant determinants of fossil fuel consumption. In addition, the coefficients, which are essentially elasticity estimates, per the log run representation, are all inelastic.

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

Variable	Coefficient	Std. Error	T-ratio	P-value
Constant	1.3322	0.74748	1.7823	0.085*
Trend	0.033949	0.053678	.63244	0.532
lnY	-0.085712	0.33863	-.25311	0.802
lnOPEN	0.072535	0.11135	.65141	0.520
lnGE	0.032240	0.18972	.16993	0.866
lnIN	-0.0086259	0.17411	-.049543	0.961
lnINV	-0.14873	0.14833	-1.0027	0.324
lnM2	0.34292	0.26928	1.2735	0.212

Author's computation, 2013/2014: ARDL (0) selected based on Akaike Information Criterion.
Note: * denotes 10% significant level

3.2c. The Short-Run Elasticities of the 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 values of the short run coefficients are not different from that of the long run values since there is lack of cointegration link among the variables in the estimated model (See Table 5). The results indicate that all the variables are not statistically significant determinant of fossil fuel consumption in the short. The coefficient of -1.0000 indicates that, after 1 percent deviation or shock to the system, the long-run equilibrium relationship of fossil fuel consumption is quickly re-established at the rate of about 100% percent per annum. The value indicates a very stronger adjustment rate.

Table-7. Short-run representation of ARDL model. ARDL (0) selected based on Akaike Information Criterion. Dependent variable: ΔlnFF

Variable	Coefficient	Standard Error	T-Ratio	Prob. Values
Constant	1.3322	0.74748	1.7823	0.085*
Trend	0.033949	0.053678	0.63244	0.532
ΔlnFF	na	na	na	Na
ΔlnY	-0.085712	0.33863	-0.25311	0.802
ΔlnOPEN	0.072535	0.11135	0.65141	0.520
ΔlnGE	0.032240	0.18972	0.16993	0.866
ΔlnIN	-0.0086259	0.17411	-0.049543	0.961
ΔlnINV	-0.14873	0.14833	-1.0027	0.324
ΔlnM2	0.34292	0.26928	1.2735	0.213
ecm (-1)	-1.0000	0.000	Na	Na

ecm = LNFF-1.3322C-0.033949T + 0.085712LNY-0.072535LNOPEN-0.032240 LNGE + 0.0086259LNIN + 0.14873LNINV-0.34292LNM2……..(10)
R-Squared 0.65746 R-Bar-Squared 0.58011
S.E. of Regression 0.13656 F-stat. F(7, 31) 8.5001[0.000]
Mean of Dependent Variable 3.0602 S.D. of Dependent Variable 0.21075
Residual Sum of Squares 0.57813 Equation Log-likelihood 26.7858
Akaike Info. Criterion 18.7858 Schwarz Bayesian Criterion 12.1316
DW-statistic 1.7463

Source: Author's computation, 2013/2014.
Note: * denotes statistical significance at the 10% level

3.3. The Diagnostic and Stability Tests Results

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 model passed only the Heteroscadasticity test indicating the variances are constant over time. The R^2 (0.65746) and the adjusted R^2 (0.58011) in Table 7 are an indication of a very well behave model. The coefficient indicate approximately 65.75% 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)= .47329[.491]	F(1, 30)= .36854[.548]
B:Functional Form	CHSQ(1)= 1.9411[.164]	F(1, 30)= 1.5713[.220]
C:Normality	CHSQ(2)= 1.0777[.583]	Not applicable
D:Heteroscedasticity	CHSQ(1)= 1.1890[.276]	F(1, 37)= 1.1635[.288]

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.

Both stability tests (CUSUM and CUSUMSQ) as shown in Figure 15 and 16 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.

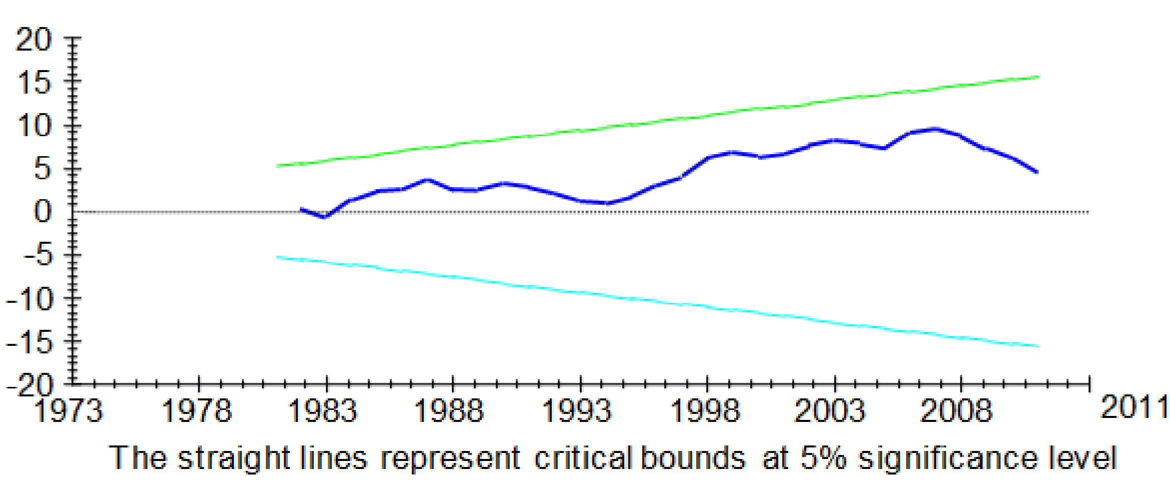

Figure 15. Plot of Cumulative sum of recursive residuals (CUSUM)

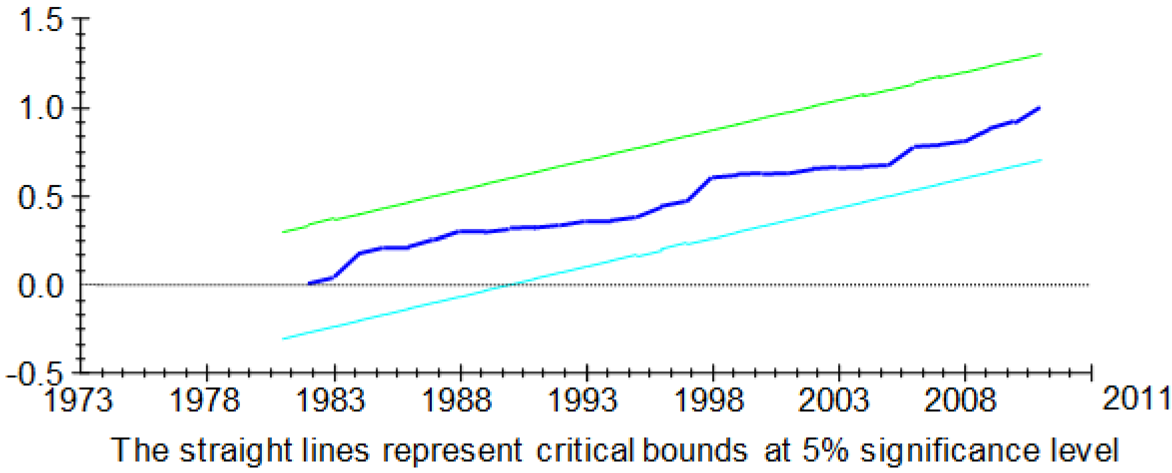

Figure-16. Plot of Cumulative sum of squares of recursive residuals (CUSUMSQ)

4. Conclusions

This paper investigated the long run and short run determinants of fossil fuel consumption in Ghana for 1970-2011 period, by using ARDL model. The results show that there is no long run and short-run determinant evidence for fossil fuel. Future changes in fossil fuel consumption could not be predicted using the variables in the model. The findings are not in line with the assumption underlying the paper. The findings are expected especially since the estimated model did not consider the issue of structural breaks over time.

The findings do not support orthodox microeconomic contention that price and income influence the demand for a product (Mas-Colell *et al.*, 2007). In addition, empirical findings reported by previous researchers (Hughes *et al.*, 2008; Askari and Krichene, 2010; Dargay and Gately, 2010; Lee and Lee, 2010; Faridul *et al.*, 2011; Baumeister and Peersman, 2012; Fawcett and Price, 2012; Narayan and Wong, 2012; Schryder and Peersman, 2012) are not supported. These researchers reported that variables such as energy price, income, financial development, trade, government expenditure, and investment have significant influence on fossil fuel consumption.

This is possibly the results of combining both micro and macro variables as regressors. The findings indicate the variables in the model could not be relied on as policy variables to manage fossil fuel consumption in the study area.

Future studies should consider the issue of causality and structural breaks since the current study did not consider these issues. Other issues such as population and exchange rate should be considered in future models. Nonlinear models should be considered in future modelling of the determinants of fossil fuel consumption.

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