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Disaggregated Energy Consumption and Economic Growth in Ghana

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ABSTRACT: This study has examined the causality between disaggregated energy consumption (electricity and fossil consumption) and overall growth, agricultural and manufacturing growth in Ghana's economy over the period 1971-2007. By employing the Augmented Dickey Fuller test all variables were found to be integrated of the order one and the Johansen test showed the presence of cointegration between the variables. The granger causality test for the study indicated a unidirectional causality from overall growth to electricity and fossil consumption; a unidirectional causality from agriculture to electricity consumption both in the short and long run; and a feedback relationship between manufacturing and electricity consumption. Energy seem not be an essential factor of production in the agricultural sector but important in the manufacturing sector therefore, it is recommended that efforts be geared towards ensuring a high supply of energy to the manufacturing sector in order to keep up its contribution to the economy.

Keywords: Energy consumption; Economic growth; Cointegration; Granger causality; Ghana
JEL Classification: C3, O4, Q43

1. Introduction

The impact of energy consumption on economic growth has attracted the interests of economists and policy makers in recent times. According to Erbaykal (2008), the petroleum crisis in 1970s displayed the importance of energy as a production factor. Since then, energy comes up as a production factor in addition to labor and capital. After the seminal work by Kraft and Kraft (1978), a number of studies have been done in the area of energy and growth by examining the causality between them but with mixed results. Earlier studies focused on the total energy consumption and total Gross Domestic Product (GDP) growth with a few focusing on the relationship between the disaggregated energy and growth in various countries. However, these studies have concentrated largely outside Africa with very little known in Ghana. Again, the few studies on Ghana have focused on electricity and aggregate growth but with mixed results. Meanwhile apart from electricity, fossil energy is an important component in the country's energy consumption. The importance of fossil energy can be acknowledged by the huge amount of money spent to import crude oil and how an increase in petroleum price and LPG shortage affect the smooth operation of many businesses in the country. For instance information from the Bank of Ghana is that the country spent about $1.72 billion to import crude oil, gas and oil products between January and July 2011 resulting in a 45.4% annual growth of merchandise imports of the country within the period to an amount of $8.6 billion. By incorporating fossil energy the paper seeks to examine the causal relationship between disaggregated energy (electricity and fossil) and total GDP growth, industrial growth and agricultural growth in the Ghanaian contest. The rest of the paper is organized as follows: Section two reviews some empirical literature; Section three deals with methodological issues; Section four is analysis of results and section five concludes with recommendation.

2. Review of Empirical literature

Following the literature, any study on the causality between energy and growth has revealed one or more results out of four possible outcomes (See Ozturk, 2010 for detailed survey of literature on energy-growth nexus). These are the unidirectional causality from energy to growth; unidirectional causality from growth to energy; feedback relationship between energy consumption and growth; and no causality. In the light of this, Soytas and Sari (2007) have explained that the variation in empirical findings could be due to different economic structure of particular countries being studied and also to the fact that different economies have different consumption pattern and various sources of energy.

Kraft and Kraft (1978) study on the USA economy for the period 1947-1974 saw a unidirectional causality relation from GNP to energy consumption. According to Jumbe (2004) the result of the Kraft and Kraft study gave an indication that the low level of energy dependence enabled the USA to pursue energy conservation policies which had no adverse effects on income (Khan and Ahmed, 2009). However, this result was not corroborated in the study by Akarca and Long (1980) which used the same data set for the period 1947–1972 but found no relationship between the two variables. They argued that Kraft and Kraft's (1978) work could suffer from temporal time period instability. In other North American countries Francis et al. (2007) over the period 1971-2002 found bidirectional causality between energy and growth in the short run for Haiti, Jamaica, and Trinidad and Tobago. In the long run however, no evidence of a relationship was found for Haiti and Jamaica; but there was a feedback relationship for Trinidad and Tobago. Lorde et al. (2010) investigated the relationship between electricity consumption and economic growth in the Barbados economy utilizing a neo-classical one-sector aggregate production model. The empirical results was that electrical energy consumption by the non-residential sector acts as a driver of economic growth in the long run and a unidirectional causality from electricity consumption by the non-residential sector to real GDP.

In Europe, Erol and Yu (1987) carried out a study for six industrialized countries including England, France, Italy, Germany and Canada for the period 1952-1982 with the results of their study giving a unidirectional causality from energy consumption to GDP for Canada; unidirectional causality from GDP to energy consumption for Germany and Italy; and no causality for France and England.

Masih and Masih (1997) in their study realized bidirectional causality between energy consumption and real income in Korea and Taiwan. Also Yang (2000) investigating the causal relationship between energy and GDP with Taiwan data for the period 1954–1997, found bidirectional causality between total energy consumption and GDP. Aqeel and Butt (2001) using Hsiao's Granger causality test established one way causality from economic growth to total energy consumption and petroleum consumption for Pakistan. Their results however, showed no causality between the gas sector and economic growth. Morimoto and Hope (2004) found bidirectional causality between electricity consumption and economic growth in Sri Lanka during the period 1960–1998. In Vietnam Binh (2011) showed that there is a strong unidirectional causality running from growth to energy consumption. The author used the cointegration and granger approach for the period of 1976-2010.

In his study on 17 African Countries Wolde-Rufael (2006), observed a unidirectional causality running from growth to electricity consumption in Cameroon, Ghana, Nigeria, Senegal, Zambia and Zimbabwe; unidirectional causality from electricity to growth for six other countries and no causality for the rest. More so, Akinlo (2008) observed bidirectional relationship between energy consumption and economic growth for Gambia, Ghana and Senegal; causality from growth to energy consumption in Sudan and Zimbabwe and no causality in Cameroon and Cote D'Ivoire.

3. Data and Methodology

The granger causality test is used in the study to examine the relationship between growth and energy in Ghana. The country study covers the period of 1971 to 2007 by relying on secondary data from the World Bank's Development Indicator 2010. The data utilized are electricity consumption and fossil fuel consumption as components of disaggregated energy use. The fossil fuel is made of coal, oil, petroleum and natural gas. The growth variables are the overall GDP growth, agricultural growth and manufacturing growth. We begin our analysis by looking at the stationarity of the variables and proceed to test for the presence of cointegrating vectors.

Stationarity/Unit Root

Time series data are often found to be non stationary in their levels and thus produce spurious results when used for regression analysis. Where time series data are found to be non stationary the method of differencing approach is applied to the series until they become stationary. In carrying out the unit root or stationary test the Augmented Dickey Fuller (ADF) test is employed. The variables are of the order 1, that is $I(1)$ if they are stationary at first difference and of the order 0 denoted as $I(0)$ if they are stationary in levels.

Cointegration

To determine the causal relationship between energy and growth, there is also the need to test for cointegration. Cointegration means that even though individual variables may be non stationary in levels, a linear combination of two or more of such series is stationary. This occurrence suggests the existence of a long run relationship or equilibrium between the variables (Gujarati and Sangeetha, 2007). For the purpose of this study, the Johansen trace test is used to test for the existence of cointegartion and the number of cointegrating vectors. The presence of cointegrating vector is a sufficient condition to estimate a Vector Error correction Model (VECM).

Granger Causality

Economists have been interested in examining whether one variable can help forecast another economic variable and to achieve this, the granger causality test has been developed. To test for causality, in the Granger sense, involves using *F*-tests to investigate whether lagged information on say economic growth provides any statistically significant information about energy consumption in the presence of lagged energy consumption. If it is found to be significant then economic growth does granger cause energy consumption and when it is insignificant there is no causality. To implement a test of granger causality we use the autoregressive specification of a multivariate vector auto regression. According to Granger's theorem when the variables are cointegrated, the simple granger causality is augmented with the Error Correction Term (ECT), derived from the residuals of the appropriate co integration relationship to test for causality. Thus we estimate a VECM for the Granger causality test for our problem at hand. The VECM representation is as follows:

$$\Delta lnY_t = c_0 + \sum_{i=1}^{k} \beta_i \Delta lnY_{t-i} + \sum_{i=1}^{k} \alpha_i \Delta lnE_{t-i} + \sum_{i=1}^{k} \gamma_i \Delta lnF_{t-i} + \rho_i ECT_{t-1} + \mu_t \quad (1)$$

$$\Delta lnE_t = c_0 + \sum_{i=1}^{k} \lambda_i \Delta lnE_{t-i} + \sum_{i=1}^{k} \varphi_i \Delta lnY_{t-i} + \sum_{i=1}^{k} \nu_i \Delta lnF_{t-i} + \rho_i ECT_{t-1} + \mathcal{E}_t \quad (2)$$

$$\Delta lnF_t = c_0 + \sum_{i=1}^{k} e_i \Delta lnF_{t-i} + \sum_{i=1}^{k} \pi_i \Delta lnE_{t-i} + \sum_{i=1}^{k} x_i \Delta lnY_{t-i} + \rho_i ECT_{t-1} + \mu_t \quad (3)$$

where *Y* is overall growth, *E* is electricity consumption, *F* is fossil consumption , and ρi is the adjustment coefficient. ECT_{t-1} expresses the error correction term of growth equation, Δ indicates first difference operator, μ_t and ε_t are mutually uncorrelated white noise errors, while *t* denotes the time period. In equation (1), the energy variables granger causes growth if their coefficients and ρi are significantly different from zero. In equations (2) and (3), growth granger causes energy if the coefficient of growth and ρi are significantly different from zero. *F*-statistic is used to test the joint null hypothesis that the coefficients are equal to zero, and *t*-test is employed to estimate the significance of the error coefficient. It is important to note that a significant error coefficient indicates causality in the long run. However in all, the regressions may lead to one or more of the following four scenarios:

1. Unidirectional causality from energy to growth,
2. Unidirectional causality from growth to energy,
3. Bilateral causality between energy and growth and
4. Independence. In this case there is no granger causality.

4. Results and Analysis

Unit root

The standard ADF test was used to test for stationarity of the variables. In carrying out this test, the null hypothesis is that the series contains unit root and the alternate is that the series has no unit root. Table 1 shows the ADF test statistics of the series for the unit root. The results indicate that all the variables are integrated of the order 1. That is the variables in their levels were not stationary at both 1% and 5% significant levels as a result they were differenced once and the resultant variables were stationary. The variables *lnY, lnE, lnF, lnM, and lnA s*tands respectively for the logs of overall growth, electricity consumption, fossil consumption, manufacturing growth and agricultural growth while the *D* in front of each variable represents the difference of that variable.

Table 1. ADF Test for Unit Root

variable	t-statistic	1% critical value	5% critical value	Prob*
lnE	-1.676593	-3.639407	-2.951125	0.4337
lnF	-2.089633	-3.626784	-2.945842	0.2498
lnY	0.269745	-3.67017	-2.963972	0.9726
lnA	0.404808	-3.626784	-2.945842	0.9804
lnM	-0.153049	-3.632902	-2.948404	0.9354
DlnE	-5.618846	-3.639407	-2.951125	0.0000
DlnF	-6.830964	-3.639407	-2.951125	0.0000
DlnY	-4.195207	-3.632902	-2.948404	0.0023
DlnA	-6.620963	-3.632902	-2.948404	0.0000
DlnM	-4.067652	-3.632902	-2.948404	0.0032

*MacKinnon (1996) one-sided p-values

Cointegration

Table 2 below shows the Johansen test results for possible cointegration among the variables. The results from the table points to at least one cointegrating vector between GDP growth *(lnY)* and the energy variables *(lnE and lnF)* at 1% level of significance. Again cointegration exists between agricultural growth *(lnA)* and all the energy variables at 1% level of significance, and also between manufacturing growth *(lM)*, and the energy variables at 5% significant level. Thus the results suggest a long run relationship between both total growth and the energy variables and also between the disaggregated growth and energy variables.

Table 2. Johansen Trace Test Results for Cointegration

variable	Ho: number of CE(s)	Eigenvalue	Trace Statistic	0.05 critical value	Prob.**
lnY, lnE and lnF	None *	0.723428	63.18866	42.91525	0.0002
	At most 1	0.346238	20.77427	25.87211	0.1892
	At most 2	0.184954	6.748862	12.51798	0.3714
lnA, lnE and lnF	None *	0.855582	83.53369	42.91525	0.0000
	At most 1	0.382757	19.67720	25.87211	0.2427
	At most 2	0.107551	3.754938	12.51798	0.7772
lnM, lnE and lnF	None *	0.442984	30.24098	29.79707	0.0444
	At most 1	0.298153	11.51582	15.47211	0.1817
	At most 2	0.005812	0.186527	3.81798	0.6690
* denotes rejection of the hypothesis at the 0.05 level					
**MacKinnon-Haug-Michelis (1999) p-values					

Granger Causality

Tables 3, 4 and 5 provide the results for the granger causality test. The Akaike Information and Schwartz Information Criterion were used in determining the lag length selection. The results from Table 3 point to a unidirectional causality from overall growth to electricity consumption in the short run, and fossil consumption in both the short run and long run. The long run causality from growth to fossil consumption is confirmed by the significant t- test on the lagged ECT. This seems to support the work of Wolde-Rufael (2006) and Twerefo et al., (2008) that found a positive unidirectional causality running from growth to energy consumption in Ghana but contradicts Akinlo's (2008) bidirectional causality in Ghana. The results from this study may be attributed to the fact that energy like any normal commodity positively depends on income. Therefore as the economy grows demand for electricity and fossil for residential and non residential uses is likely also to increase. The fact that energy does not granger cause growth may be attributed to the results from the relationship between energy and the agriculture growth and this will be explained shortly.

Table 3. Causality test between overall growth and disaggregated energy

Equation		Short run		Long-run
	DlnY	*DlnE*	*DlnF*	ECT_{t-1}
	F - statistics			t - statistic
DlnY	-	0.19529	0.56058	-3.04877***
DlnE	4.30549**	-	2.44197	0.91197
DlnF	2.99374*	0.4302	-	-2.13747**

***,**, * indicates significant at 1%, 5%, and 10% levels, respectively

Again when growth is disaggregated, there is unidirectional causality from agricultural growth to electricity consumption both in the short and long run but no relationship between fossil and agricultural growth (Table 4). The argument for such results may be that the agricultural sector which is the largest sector employs majority of the Ghanaian labour force, therefore a growth in the sector leading to an increase in workers' wages and salary can cause consumption of electricity increase.

Table 4. Causality test between agricultural growth and disaggregated energy

Equation		Short run		Long-run
	DlnA	*DlnE*	*DlnF*	ECT_{t-1}
	F - statistics			t – statistic
DlnA	-	0.34561	0.22814	-0.40873
DlnE	4.79816**	-	4.37190**	1.44645*
DlnF	2.4837	0.44153	-	-1.34704*

***, **, * indicates significant at 1%, 5%, and 10% levels, respectively.

The first two causality results suggest that there is no established causality from energy to overall growth and agricultural growth in the Ghanaian economy. One can therefore say that any shortage in electricity or fossil supply may not adversely affect GDP growth or cause a fall in the GDP because per this study, the agrarian economy does not receive any causality from energy. This may not be strange because the Ghanaian agricultural sector for a long time has been the largest contributor to the nation's growth contributing an average of 39.4% between 2002 and 2007 as against 32.9% from the service sector and 27.7% from the industrial sector (ISSER, 2008) but the sector is less responsive to energy (Adom, 2011). A prominent feature of agriculture in Ghana is the small-holder farmers dominating the system with few large scale farming which is mainly for the industrial crops, such as cocoa, oil palm, rubber, and pineapples. Most of the small scale farmers still rely on rudimentary tools and crude farming methods like the slash and burn which of course will have nothing to do with electricity and fossil fuel. Therefore since fossil and electricity energy do not granger cause growth in the Ghana's dominant sector (agriculture) it is not surprise that energy does not granger cause overall growth in the economy.

However, from Table 5 there is a unidirectional causality from manufacturing to fossil consumption in the short and the long run, and bidirectional causality between manufacturing and electricity consumption in both runs. The manufacturing sector in Ghana made up of textiles and garment, cement, iron and steel products, food processing and beverages and wood and paper products require electricity for smooth operation. The extent that in 2006/2007 the electricity power rationing in the country cost the manufacturing sector a negative growth rate of 2.3% (ISSER, 2008) implies that electricity means a lot to this sector. Also growth in the manufacturing sector may cause consumption of electricity to increase because the sector depends on electricity and thus a growth in the sector would call for more electricity for production. The unidirectional causality from manufacturing to fossil consumption can be attributed to the fact that some manufacturing depends to some extent on oil, petroleum and natural gas therefore changes in the sector's growth would affect fossil consumption.

Table 5. Causality test between manufacturing growth and disaggregated energy

Equation		Short run		Long-run
	DlnM	*DlnE*	*DlnF*	ECT_{t-1}
	F - statistics			t – statistic
DlnM	-	4.03103**	0.57989	-1.74689**
DlnE	7.56837***	-	2.45256	1.57929*
DlnF	4.43101**	0.41809	-	1.33912*

***, **, * indicates significant at 1%, 5%, and 10% levels, respectively

5. Conclusion

This study has examined the causality between disaggregated energy consumption and growth in the Ghanaian economy for the period 1971-2007. The energy variables were electricity and fossil consumption while the overall GDP growth, agriculture growth and manufacturing growth were used for growth. The appropriate test showed that all the variables were integrated of order one and the presence of cointegration among all the growth and the energy variables. As a result the simple granger causality test was augmented with the long run part that is the lagged of ECT. The empirical findings indicated that electricity consumption and fossil consumption do not granger cause overall growth but aggregate growth granger cause electricity consumption and fossil consumption. When growth is disaggregated, we found unidirectional causality from agriculture to electricity consumption both in the short and long run. Also, there was bidirectional causality between manufacturing and electricity consumption but a unidirectional causality from manufacturing to fossil consumption in the short and the long run.

Thus even though electricity and fossil consumption seem not be an essential factor of production in the Ghanaian agricultural sector and the overall growth they are important for the manufacturing sector. Therefore, the policy recommendation is that efforts should be geared towards ensuring a high supply of energy to the manufacturing sector in order to sustain its contribution to the economy.

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