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Causal Relationship between Energy Consumption and GDP in Bangladesh

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Abstract

Causal relationship between energy consumption and GDP for Bangladesh is studied in this paper using a multivariate analysis consisting of GDP, energy, capital, and labour for the period 1976 - 2008. This is different from the bivariate analysis, which many researchers used before. It is found that GDP and energy are cointegrated and causality in the sense of Granger is unidirectional running from energy consumption to GDP growth.

Keywords: *Granger causality; Energy use; GDP; Bangladesh*

1. Introduction

The empirical evidence on the relationship between energy consumption and economic growth remains ambiguous. Although considerable work has been done on this topic using the concept of Granger causality, the findings still remain widely divergent. The objective of this paper is to add further empirical evidence using data of Bangladesh, a developing economy.

Studies in this area generally used the bivariate approach, which includes only the two variables whose causality is studied. A recent development has seen use of the multivariate approach that is expected to shed a more accurate light on the issue.

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The multivariate approach includes variables other than those, but related to the variables, whose causality is studied. For example, when causality between energy and GDP growth is studied, labour and capital are also included in the analysis.

Stern (1993, 2000) studied causality between energy and GDP using a multivariate Granger causality method for the USA. The variables he considered were energy, GDP, capital and labour. Masih and Masih (1997, 1998) and Asafu – Adjaye (2000) included price in their trivariate models. Oh and Lee (2004) studied causal relationship between energy consumption and GDP in Korea using the multivariate approach that included GDP, energy, capital, and labour. Our paper proceeds along the line adopted by Oh and Lee.

Lee and Chang (2008) studied the causal relationship between energy consumption and real GDP within a multivariate framework that included capital stock and labor input for 16 Asian countries during the 1971-2002 period. It is found that although economic growth and energy consumption lack short-run causality, there is long-run unidirectional causality running from energy consumption to economic growth. This means that reducing energy consumption does not adversely affect GDP in the short run but would in the long run. Thus, these countries should adopt a more vigorous energy policy.

Erbaykal (2008) investigated the relationship between energy consumption and economic growth using oil and electricity consumption for the 1970-2003 period in Turkey. He employed the Bounds test approach by Pesaran at al (2001) for cointegration relationship. Co-integration test results showed that in the short run both oil consumption and electricity consumption have positive and statistically significant effect on economic growth. However, in the long run oil consumption has positive effect on economic growth while electricity consumption has negative effect. But in long run the electricity and oil consumption coefficients are statistically insignificant. Therefore, he concluded that both electricity and oil have short run effect on economic growth.

Omotor (2008) investigated the causal relationship between energy consumption and economic growth in Nigeria. He disaggregated energy consumption into coal, electricity and oil consumption. He applied Hsiao's Granger causality version and found bidirectional causality, that is, that energy consumption led economic growth and vice versa.

There are some aspects of this study that requires a special mention. Earlier studies mostly involved developed economies, while our study is on a developing economy that has seen considerable and steady increase in the use of energy. It is necessary to see in which way our results agree with, or differ from, those obtained for the developed countries.

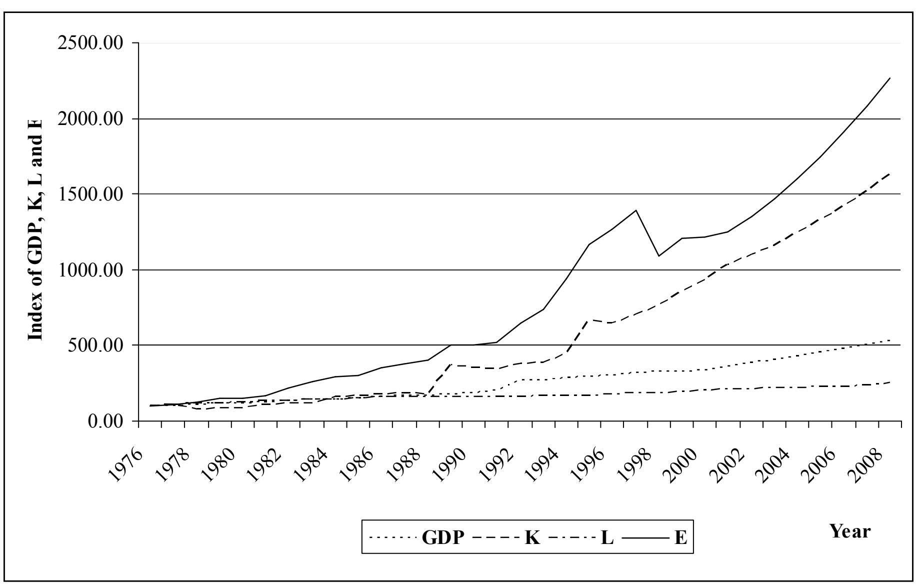
There is one important aspect of cointegration and causality that is very pertinent to this study. This refers to the use of vector autoregressive (VAR) and vector error correction model (VECM). The VAR model essentially suggests a short run relationship between the variables as first differencing removes much of the long run relation. These shortcomings can be avoided if the VECM model is used. This is done in this paper.

2. Variable definitions and data sources

We use annual time series data of real GDP, energy, capital, and labour of Bangladesh for the period 1976 to 2008. These were obtained from various issues of the Statistical Yearbook of Bangladesh, which is a publication of the Bangladesh Bureau of Statistics.

It is seen in Figure 1 that all four variables remained static till 1981, after which energy began to grow at a faster rate. After 1988, except labour, which grew slowly, all three variables grew faster except for the years 1994-1997 when some downswings were observed. Of all the variables, energy showed the highest growth.

Figure 1 : Index of real GDP (GDP), Capital (K), Labour (L), and Energy (E) from 1976 to 2008



3. Empirical Study

Our empirical study contains unit root tests, cointegration tests, and Granger causality tests. These are detailed below.

Unit root tests

The augmented Dickey-Fuller test (ADF) is used to examine existence of unit roots and determine the order of integration of the variables. The tests are done both with and without a time trend. Akaike method is used to choose the optimal lag length, which is found to be 3 for all variables. It can be seen from Table 1 that presence of a unit root can not be rejected for levels and first differences for all variables at the 5% significance level. However, for second difference the problem of unit root vanishes for all variables. Hence we only report the statistic for the level and the second difference of the variables.

Table 1 : Augmented Dickey-Fuller Unit Root Test

Variable	Lags	With a time trend		Without a time trend	
		Test statistics	Critical values	Test statistics	Critical values
GDP	1	-.93743	-3.5796	2.0412	-2.9706
K	1	-.99814	-3.5796	2.7532	-2.9706
L	1	-1.3105	-3.5796	1.3014	-2.9706
E	1	.10004	-3.5796	1.8077	-2.9706
$\Delta^2 GDP$	1	-5.3669	-3.5943	-5.4790	-2.9798
$\Delta^2 K$	1	-6.7378	-3.5943	-6.8879	-2.9798
$\Delta^2 L$	1	-3.7971	-3.5943	-3.6554	-2.9798
$\Delta^2 E$	1	-4.9366	-3.5943	-5.0206	-2.9798

Note: GDP, real GDP; K, capital; L, labour; E, energy; Δ^2Second difference operator. Critical values (5%) are from MacKinnon (1991). First difference values are not reported as stationarity could not be achieved then.

Cointegration tests

The maximum likelihood estimation method of Johansen and Juselius (1990) is used to test for cointegration. Gonzalo (1994) provided Monte Carlo evidence that Johansen-Juselius method performed better than others according to different criteria.

We first consider a VAR model given by

$$Z_t = \delta + \Pi_1 Z_{t-1} + ... + \Pi_k Z_{t-k} + \varepsilon_t, \quad t = 1,2,\ldots,T \qquad (1)$$

The corresponding VECM is written as:

$$\Delta Z_t = \delta + \Gamma_1 \Delta Z_{t-1} + ... + \Gamma_{k-1} \Delta Z_{t-k+1} + \Pi \Delta Z_{t-1} + \varepsilon_t \qquad (2)$$

where $Z = [GDP \quad K \quad L \quad E]$, $\Gamma_i = -1 + \Pi_1 + ... + \Pi_i$, $i = 1,...,k-1$, Δ $\Pi = 1 - \Pi_1 - ... - \Pi_k$,

Δ denotes the first difference operator, δ is the intercept term and ε_t is white noise.

An examination of the Π matrix enables us to detect existence of cointegrating relations among the Z variables. The most interesting case is 0 less than rank (Π)= r < p. This implies that there are r cointegrating relations among the elements of Z, and there are p.r matrices α and β such that Π = αβ. Here α is a matrix of error correction parameter and β is interpreted as matrix of cointegrating vectors, with the property that $\beta' Z_t$ is stationary, even though Z itself is nonstationary.

Table 2 : Cointegration Results

Variables	Cointegration rank	Without a trend: Test statistics	Without a trend: Critical values	With a trend: Test statistics	With a trend: Critical values
Maximum eigenvalue test					
$GDP - K - L - E$	$r = 0$	66.3587	28.2700	27.5046	31.7900
	$r \leq 1$	17.2256	22.0400	23.1805	25.4200
	$r \leq 2$	12.1831	15.8700	10.9302	19.2200
	$r \leq 3$	1.9330	9.1600	6.2488	12.3900
Trace test					
$GDP - K - L - E$	$r = 0$	97.7005	53.4800	67.8641	63.0000
	$r \leq 1$	31.3418	34.8700	40.3595	42.3400
	$r \leq 2$	14.1162	20.1800	17.1790	25.7700
	$r \leq 3$	1.9330	9.1600	6.2488	12.3900

In Table 2, it can be seen from the maximum eigenvalue test with and without trend that estimated test statistics is greater than the critical value for r = 0. This means that the hypothesis of no cointegration is rejected. To find the number of cointegrating vectors we see that for $r \leq 1$, the estimated test statistics is less than the critical value, which means that there is only one cointegrating vector. Similar results are noticed for the trace test with and without a trend.

Granger Causality Tests

Recent development of the cointegration concept indicates that a VAR model specified in differences is valid only if the variables under study are not cointegrated. If they are cointegrated, a VECM should be estimated rather than a VAR as in a standard Granger causality test (Granger, 1988). Following Granger, we estimate a VECM for the Granger causality test because we found a cointegration relationship between energy and GDP. By the Granger Representation Theorem and by focusing on energy consumption and GDP, equation (2) can be rewritten a

$$\Delta^2 GDP_t = \alpha_1 + \beta_1 ECT_{t-1} + \sum_{i=1}^{n} \gamma_{yi} \Delta^2 E_{t-i} + \sum_{i=1}^{n} \delta_{yi} \Delta^2 GDP_{t-i} + \sum_{i=1}^{n} \lambda_{yi} \Delta^2 K_{t-i} \quad (3)$$

$$+ \sum_{i=1}^{n} \theta_{yi} \Delta^2 L_{t-i} + \varepsilon_{yt}$$

$$\Delta^2 E_t = \alpha_2 + \beta_2 ECT_{t-1} + \sum_{i=1}^{n} \gamma_{ei} \Delta^2 E_{t-i} + \sum_{i=1}^{n} \delta_{ei} \Delta^2 GDP_{t-i} + \sum_{i=1}^{n} \lambda_{ei} \Delta^2 K_{t-i}$$

$$+ \sum_{i=1}^{n} \theta_{ei} \Delta^2 L_{t-i} + \varepsilon_{et} \quad (4)$$

where GDP, *K*, *L,* and *E* are real GDP, capital, labor, and energy consumption, respectively. Both the capital and labor equations are omitted because they are not relevant. It is to be noted here that although the capital and labor equations are not included in our analysis, these two variables have their impact on the GDP and energy equations, which have been augmented and now include capital and labour. As we found the series to be cointegrated, there must be either unidirectional or bidirectional Granger causality. Table 3 shows results of Granger causality tests.

Table 3 : Granger Causality Tests

Dependent variable	ECT	t-statistic	F-statistic
GDP	-90.8040*	-2.3517	5.5306
E	-66.9756	-1.6660	2.7755

Note: * Significant at the 1% level

Using an F-test, we find unidirectional long-run causality between energy consumption and GDP growth because we cannot reject the null hypothesis that the coefficient on the ECT is zero in the GDP equation. The coefficient on the

ECT in the GDP equation is significant at the 1% level. This implies that causality between them runs from energy consumption to GDP growth. But the coefficient on the ECT in the energy equation is not significant, which means that there is no causal relationship running from GDP growth to energy consumption.

4. Conclusions

In this paper we examined the causal relationship between energy and economic growth in Bangladesh for the period 1976–2008 using a multivariate causality analysis that included GDP, energy, capital, and labor. Our results show that there is unidirectional causality running from energy consumption to GDP. This appears to be consistent with the high growth of energy consumption compared to GDP growth in Bangladesh. It should be noted here that although energy consumption grew rapidly, energy demand has outstripped energy supply and Bangladesh is grappling with the issue of meeting this excess demand. Increasing energy supply will assure that energy consumption growth will continue to play its due role, otherwise the tempo generated by it may not be maintained.

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