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Is energy consumption really matter for economic growth in Bangladesh? An ARDL approach

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Abstract

Despite the great interest in the energy-growth nexus over the world, the energy-growth nexus is always overlooked by the prior researchers of Bangladesh. Using the data set of the period 1979-2014, the study injects new insights into the scant knowledge about the nexus between the two aggregated variables in the country. To do so, the study investigates both long-run and short-run causal relationship applying a developed method of bound testing (ARDL) and dynamic VEC model, respectively. The estimation results find strong long-run relationship between the energy consumption and economic growth and in the short-run energy consumption has significant impact on economic growth in Bangladesh. But the VECM Granger causality test finds no causality running in either direction. Therefore, the study suggests that energy conservation policy should be revised as growth is inevitable without energy in Bangladesh.

Keywords: Energy, Growth, Bound Test, Causal Relationship, Bangladesh.

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1. INTRODUCTION

Energy gears up an economy (Voser, 2012) as its urban factories, transportation and even agricultural farms are highly dependent on energy (Nathan et al., 2016). Thus, it is observed that greater energy consumption can transform the economic structure of a developing country (Solow, 1978; Cheng, 1998). As developing countries of Asia are progressing with transforming their economies to faster growth, greater energy is demanded by them rather than OECD countries (Dudley, 2017). Among the Asian countries, China and India are greater consumers of energy in recent years (BP, 2017). However, Bangladesh is another vital country of Asia who keeps pace with the growing demand of growth. It is recently observed that the country has grown at the rate of 7.28 percent (BBS, 2017). In order to continue this rising growth of the country, energy is very crucial object to gear up the country's production.

Although it is certainly true that economic development of a country is forced by energy consumption (Chontanawat, et al. 2008), the level of energy consumption can also be raised by faster growth through spending more on energy services (Woody, 2013). This indicates a clear casual relationship between energy consumption and economic growth. Researchers over the world have already studied multidimensional nexus between energy/electricity consumption and economic growth. They applied conventional methodologies in repetitive manner using different data sets but failed to draw conclusive conclusion (Ozturk, 2010). Payne (2010a) and Payne (2010b) provide a comprehensive survey on the literatures of causal relationship between energy/electricity consumption and economic growth. Mozumder and Marathe (2007) also list a detail review of literatures on the energy consumption and economic growth nexus. After an extensive literature survey study of Ozturk (2010), researchers have still continued their efforts to make new consensus about the energy-growth nexus with the reference of different countries.

Ozturk and Acaravci (2010); Ozturk et al. (2010); Apergis and Payne (2010); Shahbaz et al. (2011); Shahbaz et al. (2012); Fatai, (2014) and Rezitis and Ahammad (2015) are some examples of latest rigorous studies on the nexus between energy consumption and economic growth. In establishing the relationship, they applied developed methods and observed null or unidirectional or bidirectional causality between energy consumption and economic growth depending on specific context. The specific

Table 1: Descriptive Statistics of the Sample Variables

Attributes	GDP per capita (constant 2005 US $)	Energy Use (kg of oil equivalent per capita)
Mean	5.41E+10	142.3828
Median	4.58E+10	134.4242
Maximum	1.19E+11	222.221
Minimum	2.30E+10	99.39656
Std. Dev.	2.77E+10	36.56086
Observations	36 (1979-2014)	36 (1979-2014)

Source: Calculated from the data of different years, World Bank

context was tagged by country or multi-country specific studies, different methodologies and data sets. But the idea was deviated from the nexus between energy and growth to the electricity consumption-growth nexus by the studies like, Jumbe (2004); Shiu and Lam (2004); Yoo (2005); Squalli (2007); Chen et al. (2007); Apergis and Payne (2009) etc. They established multidirectional causality and explained the role of electricity as a major ingredient of economic growth. Although the studies on energy-growth nexus in Bangladesh are rare, Mozumder and Marathe (2007); Ahamad and Islam (2011); Masuduzzaman (2012) and Khan et al. (2016) have tried to investigate the nexus between electricity consumption and economic growth for Bangladesh. Again, Sarker and Alam (2010) explained the role of electricity generation to cause economic growth in Bangladesh. Chowdhury et al. (2017) lately investigated the long-run relationship between growth and energy consumption but overlooked the causality between the aggregated energy consumption and growth.

Thus, the study looks forward to investigating the nexus between aggregated energy-growth in Bangladesh using Engle and Granger model. This model constitutes two step procedures such as, it applies a developed method of bound testing (autoregressive distributed lag, ARDL model) for investigating long-run relationship and dynamic vector error correction, VEC model for short-run causality as well. In adopting this methodology, the study actually follows the methodology of the study of Ozturk and Acaravci (2010). The ARDL model for cointegration test is applied here in this study was developed by Pesaran et al. (2001).

The rest of the paper is organized by different sections and sub-sections. Section two outlines the methodology of the present including data sources, functional form, ARDL and VEC models. Section three presents and discusses the results obtained from the estimated models. Finally, section four draws a conclusive conclusion with some recommendations.

2. METHODOLOGY

2.1. Data and Description

The study uses secondary data (time series) to fix the short and long-run relationship between energy consumption and economic growth. The time series data over the periods of 1979 to 2014 are collected from the World Bank data catalog, World Development Indicators (WDI). Based on the availability and probity of data, the sample includes annual data of Bangladesh on real GDP at constant 2005 price (US dollars) and energy use measured by kg of oil equivalent per capita. The following statistical characteristics have been observed from the collected data.

Table 1 shows the simple descriptive statistics of the sample variables attributed by mean, median, maximum, minimum and standard deviation. These statistics indicates that Bangladesh have substantial GDP with an average 5410 million US dollar whereas energy use pattern cannot be able to keep pace with the growing GDP per capita. The following figure 1 and 2

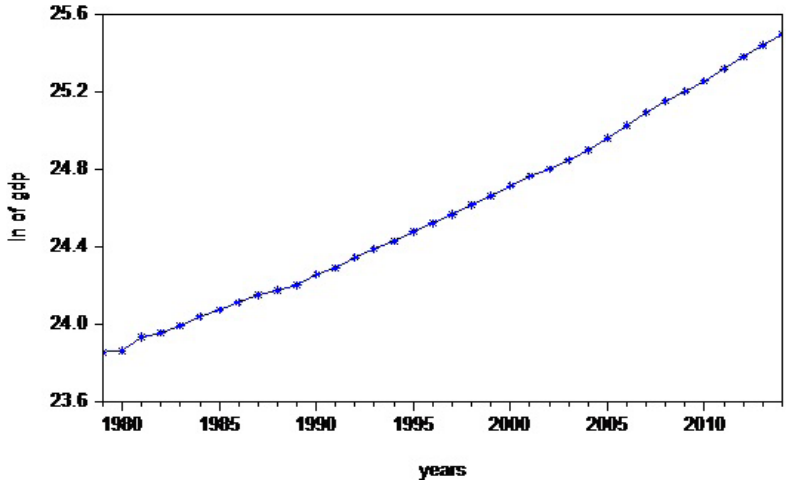

Figure 1. Ln of GDP in Banglasdesh (constant 2005 price, US)

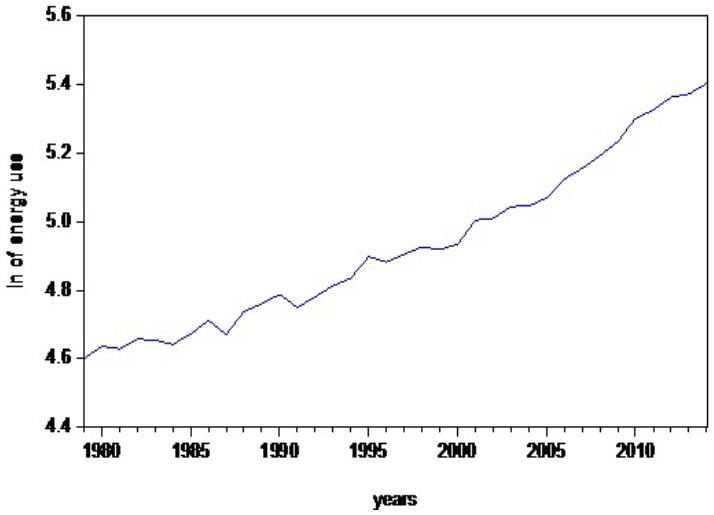

Figure 2. Ln of Energy Use (Kg of oil equivalent per capital)

shows the trend of GDP and energy use per capita over the periods of 1979 to 2014.

Figure 1 illustrates the trend of accumulated per capita GDP in Bangladesh over the periods between 1979 and 2014. This indicates a gradual rising trend of GDP per capita in Bangladesh throughout the observed sample periods. On the other hand, figure 2 illustrates a fluctuating pattern of energy use per capita in Bangladesh during earlier periods, such as 1979-2005 whereas in recent periods it is observed a rising trend in per capita using pattern of energy in the country.

2.2. Functional Model

The theoretical literature supports the nexus between GDP and energy consumption to be transformed into a mathematical expression like:

$$GDP_t = F(ECt) \quad \text{..... (1)}$$

Where GDP_t is the GDP per capita (constant 2010 US$) and EC_t is the energy use (kg of oil equivalent per capita). The function (1) can be transformed into a standard log-linear model for determining the long-run relationship between energy use and GDP per capita in Bangladesh as:

$$\ln GDP_t = a + b \ln EC_t + e_t \quad \text{..... (2)}$$

The log-linear model (2) shows all the variables are transformed into logarithms for similarity standard of growth rate and reducing heteroscedasticity. Whereas e_t is the error term.

2.3. Empirical Model

The Autoregressive Distributive Lag (ARDL) bounds testing approach is a developed method of cointegration test. The approach was developed by Pesaran (1997); Pesaran and Shin (1999) and Pesaran et al. (2001). The other cointegration methods such as Engle and Granger (1987), Johansen (1988), and Johansen and Juselius (1990) procedures, despites their great promise appeared somewhat restricted. The method ARDL has broadened the outlooks of cointegration test as it can be applied for small samples without considering the order of integration and can be adopted with different optimal lags. Moreover, in this procedure, a single reduced form equation without unit root pre-testing can be estimated to obtain the long-run relationship. Thus, the method ARDL bound testing procedure is greatly advanced.

In estimating long run relationship between GDP and energy consumption, the following reduced form equation (3) are applied in this study.

$$\Delta \ln GDP_t = \alpha + \sum_{i=1}^{n} a_i \Delta \ln GDP_{t-i} + \sum_{j=0}^{m} b_j \Delta \ln EC_{t-j} + \gamma_1 \ln GDP_{t-1} + \gamma_2 \ln EC_{t-1} + v_t \quad \text{..... (3)}$$

Where α is a constant term; a_i and b_i are the coefficients of first differenced variables; γ_1 and γ_2 are the coefficients of lagged variables; v_t is the first difference operator and is the white noise error term. In order to estimate this equation (3), the study uses appropriate lag selected by Akakie Information Criterion (AIC). This bound testing approach of cointegration uses both F-statistic and Wald statistic for thesting the null of no cointegration, $H_0 : \gamma_1 = \gamma_2 = 0$. As the estimation of equation (3) confirms cointegration between the two variables, the following equation (4) and (5) represents the long-run and short-run dynamics.

$$\ln GDP_t = \alpha + \sum_{i=1}^{l} a_i \ln GDP_{t-i} + \sum_{j=0}^{k} b_j \ln EC_{t-j} + \mu_t \quad \ldots\ldots(4)$$

$$\Delta \ln GDP_t = \alpha + \sum_{i=1}^{n} a_i \Delta \ln GDP_{t-i} + \sum_{j=0}^{m} b_j \Delta \ln EC_{t-j} + \phi ECT_{t-1} + \lambda_t \quad \ldots\ldots(5)$$

Where ϕ is the coefficient of Error Correction Term (ECT); μ_t and λ_t are white noise error term. Error Correction Term (ECT) has a negatively signed statistically significant coefficient shows the speed at which the variables converges to the equilibrium.

After verifying the existence or absence of long-run relationship between the variables, a vector error correction model (VECM) should be estimated for indicating the direction of causality. Thus, in order to investigate the Granger causality between energy consumption per capita and the GDP per capita, the following VEC models are constructed.

$$\Delta \ln GDP_t = \alpha_1 + \sum_{i=1}^{n} a_i \Delta \ln GDP_{t-i} + \sum_{j=0}^{m} b_j \Delta \ln EC_{t-j} + \phi_1 ECT_{t-1} + \lambda_{1t} \quad \ldots\ldots(6)$$

$$\Delta \ln EC_t = \alpha_2 + \sum_{i=1}^{n} \varphi_i \Delta \ln GDP_{t-i} + \sum_{j=0}^{m} \theta_j \Delta \ln EC_{t-j} + \phi_2 ECT_{t-1} + \lambda_{2t} \quad \ldots\ldots(7)$$

Where λ_{1t} and λ_{2t} are residual terms which are independently and normally distributed.

3. RESULTS AND DISCUSSION

The nexus between energy consumption and economic growth in Bangladesh is checked by a two step procedure. Firstly, the study applies ARDL model of bound testing approach for investigating long-run relationship between the two variables. In order to fit ARDL model, the variables of interest need to be stationary at order either 0 or 1. It will restrict the use of ARDL model, if any of the variables is integrated of order 2. Therefore, to identify the order of integration of the interested variables in the study, the study applies both Augmented Dickey-Fuller (ADF) and Phillips Pearson (PP) tests of unit root and the results are presented in the following table. The variables of interest in the model are transformed into logarithmic form.

Table 1 shows that the variables of interest are not stationary at level in both ADF and PP tests. But all the variables are stationary at first difference with 1 percent significance level in both the tests. Thus, this validates to conduct ARDL bound tests as none of the variables are integrated of order 2.

In the next step, it is required to select an optimum lag for the adopted ARDL model. The study uses both AIC and SBC criterion of lag selection for reducing confusion and selects the smallest possible lag (6) fitted model to minimize the loss of a degree of freedom. A bound testing approach is applied to investigate the long-run relationship between energy consumption and economic growth. The bound testing results are presented in table 2. The test results reports the bound F-statistics which should be compared with the critical values of pesaran et al. (2001). The calculated value of F-statistics is well above the upper critical bound at 1%, 5% and 10% significance levels. This suggests rejecting the null hypothesis of Wald test which confirms long-run relationship between the interested variables.

Therefore, the results of the estimated ARDL model are presented in table 3. The model is stable and no evidence of serial correlation and heteroscedasticity (Table 3 and Figure 3). The Jarque-Bera test and Ramsey RESET test confirm normality of error term and the correct specification of model, respectively.

Table 3 presents both short-run and long-run results of the estimated models. Long-run results indicate that energy consumption has significant long-run impact on GDP of Bangladesh. The short-run results are presented with the error correction term. The error correction term (ECT (-1)) is conventionally negative (-0.1572) and significant at 1% significance level which indicates the speed of adjustment toward long-run equilibrium. That is, the last year's disequilibrium will be disappeared at the speed of 15.72% and get back to long-run equilibrium. The short-run coefficients are reported in table 3 which are almost consistent with the long-run coefficients. The joint causality test results are reported in table 4. It is found from the table 4 that there exits short-run causality running from energy consumption to economic growth of Bangladesh.

After investigating short-run and long-run impact of energy consumption on economic growth, the study examines the Granger causality between the two variables. Table 5 presents the results of the VECM

Table 1: Unit Root Tests including Trend and Intercept

Variables	Augmented Dickey-Fuller tests statistics		Phillips Pearson tests statistics		Order of Integration
	Level	First Difference	Level	First Difference	
Ln of GDP	4.755246	-5.568721*	6.374668	-5.666316*	I(1)
Ln of EC	1.307842	-7.386143*	3.955055	-7.366223*	I(1)

Note: *, ** and *** shows the level of significance at 1%, 5% and 10% respectively.

Table 2: Bound Test Results

Test Statistic	Value	df	Probability
F-statistic	7.628475	(2, 14)	0.0057
Chi-square	15.25695	2	0.0005
Null Hypothesis: C(gdp(-1))=C(ec(-1))=0			
Null Hypothesis Summary:			
Normalized Restriction (= 0)	Value	Std. Err.	
C(gdp(-1))	0.153654	0.041465	
C(ec(-1))	-0.300274	0.093125	
Pesaran et al. (2001)			
Level of Significance	Lower Bound Value	Upper Bound Value	
1%	3.41	4.68	
5%	2.62	3.79	
10%	2.26	3.35	

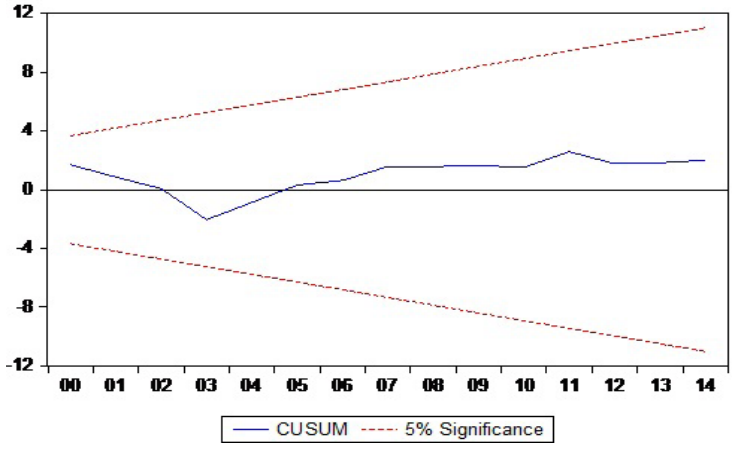

Figure 3. Stability Test (CUSUM Test)

Table 3: Long-run and short run results of the ARDL Model

Variables	Co-efficient	Std. Error	t-statistics [prob.]
Long-run Results			
C	14.64130	0.212910	68.76767* (0.0000)
EC	2.019077	0.043147	46.79547* (0.0000)
Short run results			
C	0.030030	0.009866	3.043942* (0.0082)
D(GDP(-1))	0.128711	0.182592	0.704912 (0.4917)
D(GDP(-2))	-0.329281	0.181498	-1.814239 (0.0897)
D(GDP(-3))	0.231943	0.162624	1.426250 (0.1743)
D(GDP(-4))	-0.766751	0.171811	-4.462760* (0.0005)
D(GDP(-5))	0.141799	0.132262	1.072101 (0.3006)
D(GDP(-6))	0.123183	0.124760	0.987360 (0.3391)
D(EC(-1))	0.310292	0.097794	3.172904* (0.0063)
D(EC(-2))	0.419548	0.099186	4.229925* (0.0007)
D(EC(-3))	0.206612	0.086106	2.399493** (0.0299)

D(EC(-4))	0.340452	0.076323	4.460667* (0.0005)
D(EC(-5))	0.202594	0.066016	3.068850* (0.0078)
D(EC(-6))	0.177339	0.055589	3.190213* (0.0061)
ECT(-1)	0.157160	0.039258	4.003297* (0.0012)
Diagnostic test	**Null hypothesis**	**Statistics**	**Decision**
Jarque-Bera test	H0: Normality of error term	Jarque-Bera: 0.940648 (0.624800)	Accept H_0
Breusch-Godfrey serial correlation LM test	H0: No autocorrelation	F: 0.435836 (0.529088)	Accept H_0
ARCH test	H0: Homoskedasticity	F: 1.219341 (0.3469)	Accept H_0
Ramsey RESET test	H0: The model is correctly specified	F: 1.234730 (0.3723)	Accept H_0

Note: *, ** and *** shows the level of significance at 1%, 5% and 10% respectively.

Granger causality analysis that have investigated the causal relationship between real GDP and energy consumption per capita in Bangladesh. The results indicate that there is no Granger causality running from either real GDP to energy consumption or energy consumption to real GDP in Bangladesh.

4. CONCLUSIONS

It is widely accepted that energy consumption and economic grwth go hand in hand. Thus, the researchers over the world continuously show their interest in empirical investigation of the nexus between the two variables considering different data sets in different contexts. The study lately investigates the nexus in the context of Bangladesh using data set of the period 1979 to 2014. This study follows two step procedures, such as: ARDL model of bound testing approach for investigating long-run and short-run relationships and VECM Granger causality test for the direction of relationship. The ARDL results indicate that energy consumption has both short-run and long-run significant impact on the economic growth of Bangladesh. But VECM Granger causality test finds no causation in either direction. Therefore, the study draws an implication that government should revise energy generation and conservation policies and target high economic growth due to energy consumption in Bangladesh.

Competing interests

There is no competing interest in relation to this work.

Ethics approval and consent to participate

Not applicable.

Table 4: Short-run Causality: Joint causality test

Test Statistic	Value	df	Probability
F-statistic	5.315444*	(6, 15)	0.0040
Chi-square	31.89266*	6	0.0000
Null Hypothesis: C(ec(-1))=C(ec(-2))=C(ec(-3))=C(ec(-4))=C(ec(-5))=C(ec(-6))=0			
Normalized Restriction (= 0)		Value	Std. Err.
c(ec(-1))		0.310292	0.097794
c(ec(-2))		0.419548	0.099186
c(ec(-3))		0.206612	0.086106
c(ec(-4))		0.340452	0.076323
c(ec(-5))		0.202594	0.066016
c(ec(-6))		0.177339	0.055589

Note: *, ** and *** shows the level of significance at 1%, 5% and 10% respectively.

Table 5: VEC Granger Causality/Block Exogeneity Wald Tests

Dependent variable: D(GDP)			
Excluded	**Chi-sq**	**df**	**Prob.**
D(EC)	6.125616	5	0.2942
All	6.125616	5	0.2942
Dependent variable: D(EC)			
Excluded	Chi-sq	df	Prob.
D(GDP)	9.017399	5	0.1084
All	9.017399	5	0.1084

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