Nexus between Electricity Generation and Economic Growth in Bangladesh

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Abstract

This paper employs Granger-causality test on the nexus between economic growth and electricity generation using Bangladesh data covering the period 1973-2006. The test results indicate that only unidirectional causal relationship exists between electricity generation and economic growth. The short run causal relationship is found from electricity generation to economic growth. Policies and strategies for increasing electricity generation can therefore be implemented for speeding up of economic growth in the country.

Keywords: Economic growth, Electricity generation, Granger causality, Stationarity, Cointegration

1. Introduction

Uninterrupted and sufficient electric power supply is one of the most crucial determinants of stimulating economic growth for any economy. But the electricity sector in Bangladesh has been historically characterized by huge shortage and outages. The total installed capacity stands at only 5,719 megawatts (MW) in 2009 comprising 3,812 MW in public sector and rest 1,907 MW in private sector (GOB, 2009). Of the total power generation, 88.79 percent comes from natural gas, 5.74 per cent from liquid fuel, 3.9 per cent from coal, and 1.57 per cent from hydro power. The aggregate generation of electricity has increased at a rate of around 7 per cent during 1972-73 to 2007-08. However, this growth was unable to meet the growing demand for electricity from industrial, agricultural and other economic activities. From the consumption point of view, only 40 per cent of the population has access to electricity with a per capita availability of 136 kWh per annum which is one of the lowest in the world (GOB, 2009). Bangladesh loses a significant amount of resources due to power outages and unreliable energy supplies; the World Bank estimated the losses to be around US$1 billion per year which resulted in 0.5 per cent reduction in annual GDP growth and USAID estimated the amount to be 11.5 per cent of industrial production and 1.7 per cent of the GDP (Srivastava & Misra, 2007). It is of significant importance to determine the causal relationship between energy generation and economic growth in Bangladesh.

There have been many studies over past three decades to examine the nexus between electricity consumption and economic growth either for a single country or for a group of countries. Although the result on the direction of causality is not conclusive, most studies reveal that there exists a strong relationship between electricity consumption and economic growth (Ferguson, et al. 2000). Some studies found a bi-directional causality (Masih & Masih, 1996; Erol & Yu, 1998; Asafu-Adjaye, 2000; Glasure, 2002; Soytas & Sari, 2003; Jumbe, 2004; Oh & Lee, 2004; Mozumder & Marathe, 2007); some unidirectional causality (Abosedra & Baghestani, 1989; Cheng & Lai, 1997; Cheng, 1999; Yang, 2000; Aqeel & Butt, 2001; Cheng & Wong, 2001; Morimoto & Hope, 2004) and a few studies (Akarca & Long, 1980; Yu & Jin,1992; Cheng, 1995; Glasure & Lee, 1997; Joyeux & Ripple, 2007) showed no causality between electricity consumption and economic growth. However, the causal nexus between electricity generation and economic growth has been hardly investigated in the existing literature. The survey of literature on the relationship between electricity generation and economic growth reveals only one study (Yoo & Kim, 2006) for Indonesia. This study will extend Yoo and Kim study by examining the nexus between electricity generation and economic growth for Bangladesh. Following Yoo and Kim, electricity generation rather than consumption is used in this study because non-technical transmission and distribution losses are around 33 per cent in Bangladesh which is very high compared with 9 per cent in Malaysia and per cent in Japan and Singapore (GOB, 2009; Lean & Smyth, 2010). The reasons behind this huge loss in Bangladesh include theft and pilferage by both metered and unmetered consumers, illegal connection, inappropriate operation of meter, and illegal use and manipulation by utility personnel (Alam et al. 2004). As a result, electricity consumption figures are extremely underestimated in Bangladesh. Nonetheless, total electricity generated other than technical losses contribute to the Gross Domestic Product (GDP). This provides a strong reasoning to use electricity generation as the most suitable proxy for electricity in Bangladesh.

The purpose of this paper is, therefore, to examine the causality between electricity generation and economic growth which is particularly timely because existing literature has not undertaken a study of this type for Bangladesh. Accordingly, we apply time series techniques such as unit roots, cointegration and Granger causality tests to inspect the objective. The organization of this paper is as follows: in section 2 an overview of the methodology is presented, the empirical results are discussed in section 3 and the section 4 concludes the paper.

2. Methodology

2.1 Data and Variables

Following Yoo and Kim (2006) we use two variables, namely, electricity generation and real GDP for Bangladesh. In this study, electricity generation is expressed in terms of million kilowatt hours (MkWh) and economic growth is being operationalized as real GDP. The time series data covering the period from 1972 to 2006 on both the variables are culled from the World Development Indicators (WDI, 2007) and from the Bangladesh Economic Review (GOB, 2007). The variables used are in natural logarithm form and are labeled as LEG for electricity generation and LGDP for real GDP.

2.2 Unit Roots and Stationarity

It is noteworthy that application of the Granger causality test requires the time series of the concerned variables to be stationary which means that the mean and variance of each variable do not vary systematically over time. Because, using non-stationary data directly in the causality tests might yield spurious results. It is, thus, necessary to examine whether the time series of the variables are stationary or not, before performing the causality test. A series is said to be non-stationary (or stationary) if it has non-constant (or constant) mean, variance, and autocovariance (at various lags) over time. If a non-stationary series has to be differenced d times to become stationary, then it is said to be integrated of order d, i.e. I (d).The Augmented Dickey-Fuller (1979) (ADF) and Phillips-Perron (1988) (PP) tests have been applied for examining unit roots and stationarity in this paper.

For each series under the study, the equation for ADF test is as follows:

$$\Delta X_t = \alpha + \delta t + \beta X_{t-1} + \sum_{i=1}^{n} \gamma_i \Delta X_{t-i} + \varepsilon_t \tag{1}$$

where t is the time or trend variable, ε_t is a pure white noise error term and $\Delta X_{t-1} = (X_{t-1} - X_{t-2})$, $\Delta X_{t-2} = (X_{t-2} - X_{t-3})$ and so on. The test for a unit root has the null hypothesis that β=0. If the coefficient is statistically different from 0, the hypothesis that X_t contains a unit root is rejected.

On the other hand, Philips and Perron developed a generalized version of the Dickey and Fuller test as follows:

$$X_t = \beta_0 + \beta_1 X_{t-1} + \beta_2 (t - T/2) + \mu_t \tag{2}$$

where T is the number of observations and the error term μ_t is such that E(μ_t)=0.

2.3 Cointegration

Whether or not two different variables are cointegrated has substantially different implications for how one should carry through the test procedure to test for Granger-causality. In view of this, cointegration test is a prerequisite procedure toward causality testing. There are two main approaches used to test the existence of cointegration relationships: the Engle-Granger and the Johansen procedures. We employ Johansen's procedure to test for cointegration between the two series.

The Johansen (1988) approach relies on the relationship between rank of a matrix and its characteristic roots and estimates long-run relationships between non-stationary variables using a maximum likelihood procedure. The Johansen tests are on the rank of the coefficient matrix Π of the equation Johansen and Juselius (1990) and have the following form:

$$\Delta x_t = \Gamma_1 \Delta x_{t-1} + \ldots\ldots + \Gamma_{k-1} \Delta x_{t-k+1} + \Pi X_{t-k} + \mu + \varepsilon_t$$

The null hypothesis for r cointegrating vector is

$H_0 : \Pi$ has a reduced rank, r $\prec$ k

where X_t is a $k \times 1$ vector of I (1) variables of $\Gamma_1 \ldots\ldots \Gamma_{k-1}$. Π is $k \times k$ matrices of unknown parameters Π , coefficient matrix contains information about long-run relationship. The reduced rank condition implies that the process ΔX_t is stationary and X_t is non-stationary. Three cases are possible for Π . Firstly, if Π is of full rank, all elements of X are stationary, and none of the series has a unit root. Secondly, if a rank of $\Pi = 0$ implies an absence of stationary combinations and no cointegrating vectors. Finally, if the rank of Π is between r and k, the X variables are cointegrated and there exists r cointegrating vectors.

The presence of distinct cointegrating vectors can be obtained by determining the significance of the characteristics roots of Π . We use both the trace test and the maximum eigenvalue test to determine the significance of the number of characteristic roots that are not different from unity. Both tests are expressed as follows:

$$\lambda_{trace} \ (r) = -T \sum \ln(1 - \lambda_1)$$

and

$$\lambda_{\max} \ (r, r+1) = -T \sum \ln(1 - \lambda_{1+1})$$

where λ_i are the estimated values of the characteristic roots obtained from the estimated Π matrix, r is the number of cointegrating vectors, and T is the number of observations. The critical values for these tests are tabulated in Johansen and Juselius (1990).

2.4 Granger-causality test

Based on the results from stationarity and cointegration tests, Granger causality test can be carried out as follows. If the results from stationarity tests show that the two variables are both non-stationary and integrated of order 1 and if they are not cointegrated, then the Granger causality test is performed by estimating the following VAR model with variables in first difference form (Toda & Philips, 1993; Yoo & Kwak, 2004):

$$\Delta Y_t = \beta_{10} + \sum_{i=1}^{L_{11}} \beta_{11i} \Delta Y_{t-i} + \sum_{j=1}^{L_{12}} \beta_{12j} \Delta X_{t-j} + u_{1t} \tag{3}$$

$$\Delta X_t = \beta_{20} + \sum_{i=1}^{L_{21}} \beta_{21i} \Delta Y_{t-i} + \sum_{j=1}^{L_{22}} \beta_{22j} \Delta X_{t-j} + u_{2t} \tag{4}$$

where Y_t and X_t represent natural logarithms of real GDP and electricity generation (EG) respectively; $\beta_{10}, \beta_{11i}, \beta_{12j}, \beta_{20}, \beta_{22j}$ are parameters to be estimated; $L_{11}, L_{12}, L_{21}, L_{22}$ are the numbers of lags which restricted in Johansen's test as $L_{11} = L_{12} = L_{21} = L_{22} = L;$ u_{1t}, u_{2t} are usual error terms and Δ stands for first difference. The interpretation of this VAR model is as follows: changes in X are caused by past changes in both X and Y. The same holds for changes in Y. Given such a specification, X can be said to (Granger) cause Y if one can reject the null hypothesis that the $\beta_{12}s$ are jointly zero. Similarly, one can say that Y does not (Granger) cause X if the $\beta_{21}s$ are jointly insignificant from zero. Again, both cases can be tested by a joint F-test.

As already mentioned above, (3) and (4) can be applied only if X and Y are not cointegrated. If co-integration is found between X and Y, the Granger causality test performed by estimating the VAR model of (3) and (4) will be incorrect and will generate invalid inferences. According to Engle and Granger (1987), a more comprehensive test of causality based on error correction model (ECM), should be adopted. The ECM model for the Granger-causality test is used based on the following two equations:

$$\Delta Y_t = \beta_{10} + \sum_{i=1}^{L_{11}} \beta_{11i}\Delta Y_{t-i} + \sum_{j=1}^{L_{12}} \beta_{12j}\Delta X_{t-j} + \beta_{13}\hat{\varepsilon}_{t-1} + u_{1t} \quad (5)$$

$$\Delta X_t = \beta_{20} + \sum_{i=1}^{L_{21}} \beta_{21i}\Delta Y_{t-i} + \sum_{j=1}^{L_{22}} \beta_{22j}\Delta X_{t-j} + \beta_{23}\hat{\varepsilon}_{t-1} + u_{2t} \quad (6)$$

where all the variables and parameters have the same interpretations as in (3) and (4) except for $\hat{\varepsilon}_{t-1}$, which is the error correction term.

In summary, if both the variables are non-stationary and integrated of order 1, then we further test whether or not they are cointegrated. If there is no cointegration between the variables, equations (3) and (4), i.e. VAR model will be applied; whereas if they are cointegrated, then we should estimate the ECM model of (5) and (6).

3. Empirical Results

3.1 Results from Unit Root Tests

We apply both the Augmented Dickey-Fuller (ADF) and the Philips-Perron (PP) tests to check if the two variables, electricity generation and GDP, suffer from the problem of unit root. Table 1 shows the results of the ADF and PP tests of the integration properties of the series, LGDP and LEG for Bangladesh. Results of the two tests reveal that the two series in their levels are non-stationary but they are stationary in their first differences. This implies that the integration of LGDP and LEG for Bangladesh is of order one, i.e., I (1).

3.2 Results from Cointegration Test

Given that both the variables concerned in the present study are non-stationary and integrated of order 1, cointegration test needs to be conducted as a preceding step toward a causality test to investigate whether the two series are cointegrated. Since the estimated test statistic under both trace test and maximum eigenvalue test in Table 2 is lower than the 5% and 10% critical values, the null hypothesis of r=0 can not be rejected and the null hypothesis of the existence of at most one co-integrating equation ($r \leq 1$) cannot be either rejected at the same level of significance. This indicates that there is no co-integrating equation at the 10% (and also 5%) level of significance. Therefore, there is no long-run relationship between LGDP and LEG for Bangladesh.

3.3 Results from Granger-causality Test

We have just shown in the previous section that LEG and LGDP are not cointegrated, Granger-causality test is, thus, implemented by applying the VAR model of equations (3) and (4) and the estimated results are revealed in Table 3. The results from the table show that for LEG and LGDP, at the 10% significance level, the null hypothesis that LEG does not cause (Granger) LGDP can be rejected while the null hypothesis that LGDP does not cause LEG cannot be rejected. This evidence indicates that there is a unidirectional causal relationship running from LEG to LGDP.

4. Conclusions

The aim of this paper was to examine the causal link between electricity generation and real GDP for Bangladesh. Prior to the testing for causality, the ADF and PP tests are employed to examine for unit roots and

Johansen cointegration test for cointegration. Our estimation results, based on a VAR model, indicate that there is a unidirectional relationship running from electricity generation to real GDP, i.e. an increase in electricity generation would raise real GDP. In other words, the higher electricity generation propels higher economic growth through the use of electricity in different economic activities. This direction of causality shed light on future energy policies relating generation, transmission and distribution of electricity in Bangladesh. In order to avoid any adverse effects of electricity shortage on economic activities, it is urgent for Bangladesh to plan and build new power generating capacity to satisfy the increasing demand for electricity.

Another key finding of this study that economic growth does not result in an increase of electricity generation is of particular interest. This has been reflected in the poor maintenance and operation of the system. This study is significant in the context of the Government's initiative to design a comprehensive Power System Master Plan (PSMP) to raise its electricity generation of 35,000MW by 2030, from the current generation of around 4,000MW. An estimated US$13 billion investment including a $7 billion debt financing would be required to implement the PSMP. Being a developing country and vulnerable to man-made and natural disasters, there are competing uses of scarce resources. This study lends support to the initiative of enhancing power generation capacity to ensure sustainable economic growth. Over half of the country's energy consumption is dependent on noncommercial sources, such as wood, animal and logging wastes and crop residuals, and these sources are shrinking rapidly. Furthermore, this dependence on noncommercial sources generates heavy pressure on country's forest resources.

Realizing the fact that natural gas is of limited supply and nonconventional sources of energy are depleting quickly, Bangladesh needs to diversify its energy sources with a particular focus on renewable energy. Energy conservation strategies, through demand side management and end use energy efficiency measures, can also play a significant role in resolving the shortages.

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Table 1. Results of unit root tests

Variables	ADF test		PP test	
	Levels	First difference	Levels	First difference
LGDP	0.54 (0.87)	6.26 (0.00)	0.43 (0.89)	6.28 (0.00)
LEG	1.85 (0.35)	6.05 (0.00)	2.25 (0.19)	6.04 (0.00)
Critical values (10%)	2.61	2.61	2.61	2.61

P-values are in the parentheses.

Table 2. Results of Johansen Cointegration test

No. of cointegrating equation (r)	Trace test			Maximum eigenvalue test		
	Test Statistic	5% critical value	10% critical value	Test Statistic	5% critical value	10% critical value
None (r=0)	9.55(0.32)	15.49	13.43	7.23(0.46)	14.26	12.30
At most($r \leq 1$)	2.32(0.13)	3.84	2.71	2.32(0.13)	3.84	2.71

Notes: r denotes the number of co-integrating equation,

P-values are in parentheses.

Table 3. F-statistics (based on VAR model in first differences)

Hypotheses	F-statistics	P-values
Ho: LEG does not cause (Granger) LGDP	1.78	0.07
Ho: LGDP does not cause (Granger) LEG	0.68	0.60