

ELECTRICITY CONSUMPTION & ECONOMIC GROWTH IN BANGLADESH: EVIDENCE FROM TIME-SERIES CAUSALITY APPROACH

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Abstract

This paper attempts to identify the relationship between electricity consumption and economic growth in Bangladesh through co-integration and vector error correction model (VECM) over the period 1982 to 2012. The Johansen co-integration test indicates that there exists a long run association between the variables. The VECM long run causality model indicates that there is a long run causality running from electricity consumption to economic growth in Bangladesh. Similarly in the short run a causal relationship has also been found between the variables as well. Further variance decomposition results say that electricity consumption can explain the major variations in economic growth in Bangladesh. The implication of our findings is that in Bangladesh the increase of electricity consumption is likely to increase our economic growth in the long run. Policymakers in Bangladesh need to pay special attention to utilize our electricity consumption as well as identifying the alternative sources of electricity generation in order to boost our economic growth.

Keywords: Electricity consumption, growth, Bangladesh, cointegration, economy, causality.

JEL Classification: C22, Q43, E10.

1. Introduction:

Electricity is one of the critical factors of today's modern life and it also plays a critical role in economic development. In all economies the demand for electricity has been an upward trend. This demand is motivated by several important factors such as industrialization, extensive urbanization, population growth as well as rising standard of living. In Bangladesh industrial sector as well as agricultural sector plays a critical role in economic growth. This two contributes nearly 67% of the total aggregated output in Bangladesh. According to the Bangladesh power development board nearly 60% of total electricity is consumed by industrial and agricultural sector. Though Bangladesh installed electric generation capacity (10289 MW) in 2014 but only 62% of the population has access to electricity with a per capita availability of 321 kWh per annum. According to the

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Bangladesh Power Development Board (BPDB) assessment, peak demand of the electricity will be an upward trend. The peak demand would be about 17,304 MW in FY2020 and 25,199 MW in 2025. In Bangladesh most of the power plants were gas based. But very recently government has adopted to develop coal based power generation strategy to keep pace with the fast growing demand. However we are still running short of fulfilling the demand. At the same time the demand for electricity power had increased in the rural areas in Bangladesh because of significant business activities noticeable there. A large number of small business units had been set up in rural areas in last couple of years with the help of financing by our banking sector as well. Electricity plays a critical role for the growth of those small businesses. Therefore electricity is critical for the economic development in Bangladesh. Several studies has identified the role of electricity consumption towards economic growth. Karg (2014) mentioned that industrial demand for energy is directly proportional to economic growth whereas consumer demand for electricity is directly proportional to economic development. Ferguson et al. (2000) found strong positive correlation between electricity use and wealth creation in 100 developing countries. Moreover they also stressed the need to analyze the causality test to get an idea over whether knowledge of past electricity consumption movements improves forecasts of movements in economic growth or not. The view of Leug and Meisen (2005) was that an increase in electricity consumption by per capita is an indication of social development and economic growth. Further Fu et al. (2014) in their study on energy consumption and economic growth in Brazil and found that energy consumption appears to be real GDP elastic. They also suggested that Brazil should adopt a dual strategy of increasing investment in energy infrastructure in order to avoid having a negative effect on economic growth by reducing energy consumption. Present government has also initiated a long term development strategy “Vision 2041” where the country would like to enter into the era of first world. To accomplish this dream into reality Bangladesh needs to increase its economic growth and develop appropriate policies to sustain that growth. As it is evident that our industrial sector is contributing mostly in our growth which also consumes major portion of electricity production, therefore a causal relationship between electricity consumption and economic growth can extract important policy implication. Therefore the study has attempted to identify the relationship between electricity consumption and economic growth in Bangladesh from a time series modeling.

2. Literature Review:

The study of electricity consumption and economic growth has been an area of interest for a long time. Among the researchers the pioneer in this area was Kraft and Kraft (1987). Jamil and Ahmad (2010) in their study on GDP, electricity price & electricity consumption using cointegration and granger causality test found that growth of GDP is likely to causes energy consumption in Pakistan. At the same time growth in output in commercial, manufacturing and agriculture sectors tends to increase electricity consumption in Pakistan. Aqeel and Butt (2001) worked over per capita GDP & per capita energy consumption using cointegration and error correction model. They found that GDP growth causes energy consumption as well as petroleum consumption in the long run. However Ghosh (2002) found no cointegration between electricity consumption and GDP growth in India. Morimoto and Hope (2004) in their study over Sri Lanka pointed out that current and past

changes in electricity supply have a significant impact on a change in real GDP in Sri Lanka. Saeki and Hossain (2011) in their cross country analysis in south Asia found that there is a unidirectional causality running from economic growth to electricity consumption in India, Nepal and Pakistan, and from electricity consumption to economic growth in Bangladesh. Other than south Asia Asafu-Adjaye (2000) investigated the existence of causal relationship between energy consumption and output in four Asian countries using the co-integration and error-correction. He found a bi-directional causality in case of Thailand and the Philippines. Further, Yuan et al. (2007) explored that electricity consumption and real GDP for China were co-integrated and there was unidirectional Granger causality from electricity consumption to real GDP. Other than Asian countries, Chontanawat et al. (2008) worked on existence of causal relationship between energy economic growth nexus in 30 OECD developed economies and 78 non OECD developing economies. They found that causality running from energy consumption to GDP was more prevalent in the developed OECD economies compare to the developing non OECD economies. Other than cointegration and causality approach Chandran et al. (2010) used autoregressive distributed lag (ARDL) approach to identify the relationship between electricity consumption and real GDP growth in Malaysia. Their conclusion was Malaysia is an energy-dependent country where they found a uni-directional causal flow from electricity consumption to real GDP. In the African perspective Akomolafe and Danladi (2014) in their study on Nigeria to examine the relationship between electric power consumption and economic growth found that Nigeria's growth is highly dependent on electricity consumption. They found a unidirectional causality from electricity consumption to real gross domestic product. Finally from a European perspective we also found a similar result as well. Kargi (2014) in their study over Turkey on electricity consumption and economic growth found a bi directional causality between electricity consumption and economic growth. He also found a long run as well as short run causal relationship between those variables. Lee and Chein (2010) in their study on Canada, Italy and England found that energy saving may hinder growth in those economies. From the above literatures it has been found that there is a strong evidence that a country's economic growth can be accelerated by electricity consumption. In this study we add value to the existing literature by adding results from a developing country's perspective.

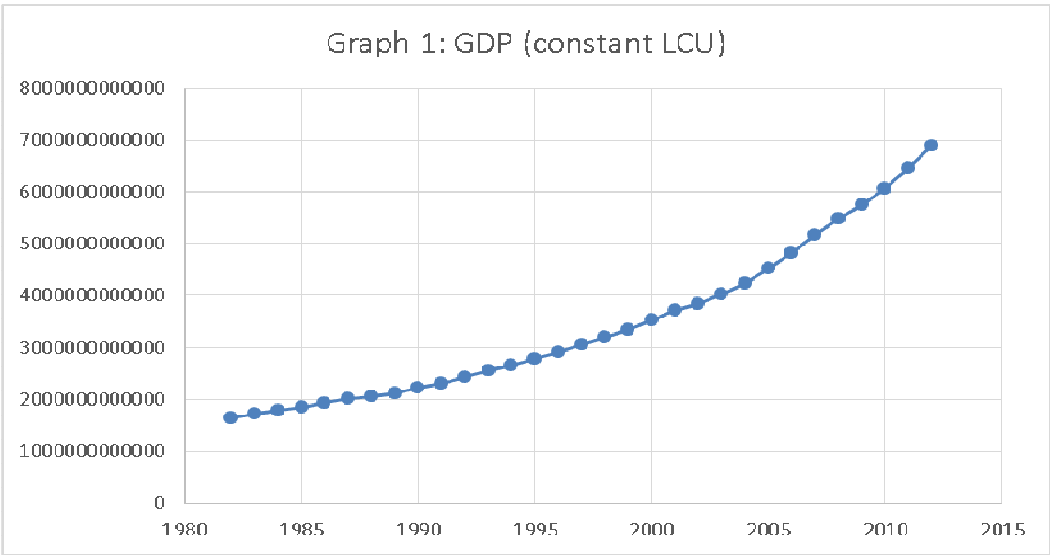
3. Data, Modeling & Methodology:

3.1 Data:

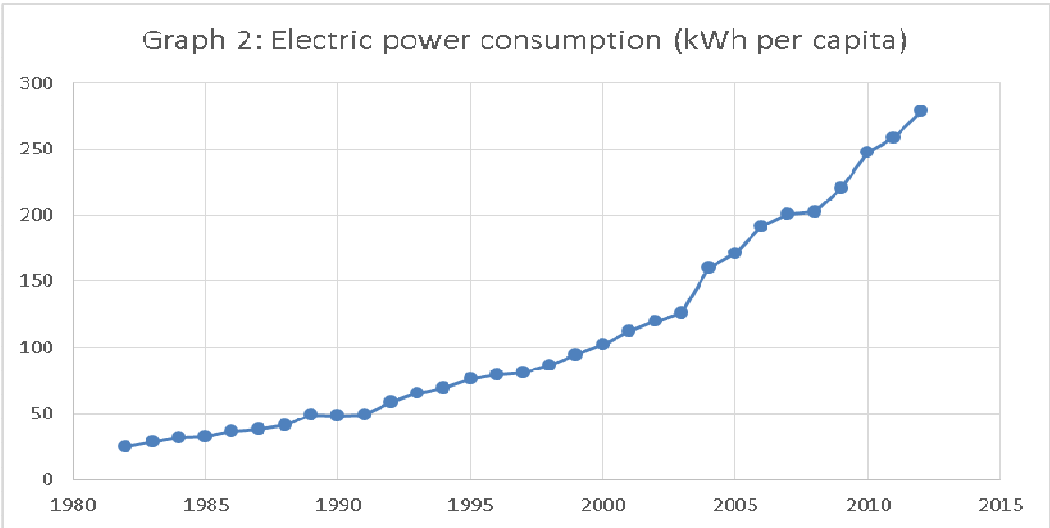
Table 1 presents descriptive statistics for the variables employed in the study. Graph 1 and 2 presents the time series of each of the variables in graphical form. In this study our dependent variable is gross domestic product and independent variable is electricity consumption. Most of the previous studies used GDP as an indicator of economic growth. Here GDP is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products (WDI, 2014). Here our GDP value is in constant local currency. On the other hand electric power consumption is measured by the production of power plants and combined heat and power plants less transmission, distribution, and transformation losses and own use by heat and power plants. Data has been collected from world development indicators of World Bank data sheet from 1990 to 2014.

Table 1: Descriptive Statistics

Variables	Mean	Median	Skewness	Kurtosis
Electric power consumption (kwh per capita)	109	81	0.858431	-0.485806076
GDP (Constant LCU)	3456233180129	3044566000000	0.772504	-0.478204291



Source: World Development Indicator 2014



Source: World Development Indicator 2014

3.2 Econometric Modeling Strategy:

The econometric modeling strategy proceeds in several steps, consistent with previous studies. The unit root test is carried out to check the stationarity of the variables for their non-stationarity. The Augmented Dickey Fuller (ADF) test is then carried out to detect the existence of unit root and as a result of which, some of the variables are found to be non-stationary and thus could not be regressed unless made stationary. The null hypothesis for the ADF unit root test is that the variable has a unit root against the alternative of stationarity. We performed the ADF tests based on the following model:

$$\Delta y_t = \alpha + \beta t + \gamma y_{t-1} + \delta_1 \Delta y_{t-1} + \dots + \delta_{p-1} \Delta y_{t-p+1} + \epsilon_t, \quad (1)$$

The cointegration test is run to find out possible linear combinations of the variables which could be considered stationary. To test for cointegration we use the maximum likelihood test developed by Johansen and Juselius (1990). We use the AIC to determine lag length. Johansen and Juselius multivariate cointegration equation is given below:

$$\Delta \mathbf{X}_t = \sum_{i=1}^p \pi_i \Delta \mathbf{X}_{t-i} + \Pi \mathbf{X}_{t-1} + \square_t \quad (2)$$

Once the variables are found to be cointegrated, then Vector Error Correction model (VECM) can be employed to identify the long run and short run causality running from our variables. The long-run multivariate model is as follows:

$$\mathbf{Y}_t = \alpha + \beta_1 \mathbf{EC}_t + \mathbf{u}_t \quad (3)$$

Where $\mathbf{Y}_t$ = GDP (Constant LCU), $\mathbf{EC}_t$ = Electricity Consumption, $\mathbf{u}_t$ = error terms

If there is a long run relationship between the series, shocks will result in disequilibrium in the short-run before the series return to their long-run equilibrium. The short run model corresponding is as follows:

$$\Delta \mathbf{GDP}_t = \sum \beta_i \Delta \mathbf{GDP}_{t-i} + \sum \alpha_i \Delta \mathbf{EC}_{t-i} + \square_t \quad (4)$$

Where, GDP = Gross Domestic Product (Constant LCU), EC = Electricity Consumption (kWh per capita).

4. Results:

Initially, we opted for ADF test to check the datasets and we observed that the datasets were non-stationary at level. In the level and first difference, we found both the series become non-stationary (Table 2). However in the second difference we found both the series become stationary (Table 2). So it became possible for us to investigate the existence of a long-run relationship within a Johansen cointegration testing framework.

Table 2: Augmented Dickey–Fuller Unit Root Test

Variables	Level	First Difference	Second Difference
	t-statistic	t-statistic	t-statistic
GDP (Constant LCU)	4.132799	-1.814127	-4.739755
Electric Power Consumption (kWh per capita)	0.181022	-5.018289	-5.967596

In Johansen's method, both the Eigen value statistics and Trace statistics can be used to determine whether variables are cointegrated or not. To trace out the presence of cointegration, we could rely on both Trace statistics and Eigen value. From the Trace statistics (table 3); it was found that all variables have been cointegrated at 5% level where the null hypothesis is rejected indicating long-term association between the variables. Further Maximum Eigenvalue statistics indicates that there is at least two cointegrating equation. It indicates that all the variables move together in the long run. We used Akaike information criterion (AIC) to select the number of lag. The rule is lower the AIC better the model. Therefore we have selected lag 2. As all variables are cointegrated, we can run vector error correction model.

Table 3: Johansen Cointegration Test Result

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)		Trace Statistic	0.05 Critical Value	Prob.**
None *	0.730227	49.15883	15.49471	0.0000
At most 1 *	0.399819	13.78414	3.841466	0.0002

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.730227	35.37468	14.26460	0.0000
At most 1 *	0.399819	13.78414	3.841466	0.0002

The Granger causality test is done with 2 lag intervals and the result shows that there are unidirectional causal relationships running from electric power consumption to GDP.

Table 4: Result of Granger Causality

Null Hypothesis:	Obs	F-Statistic	Prob.
DDGDP does not Granger Cause DDEC	26	1.97390	0.1521
DDEC does not Granger Cause DDGDP		4.65483	0.0133

Table 5 shows the Vector Error Correction Model long run causality result. Here C (1) represents the speed of the adjustments towards long run equilibrium. We see that our C (1) is negative and is also significant which indicates that there is long run causality running from electricity consumption to gross domestic product. Further we can say that electric power consumption has influence on our dependent variable GDP in the long run.

Table 5: VECM Long Run Causality result

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-0.192779	0.050388	-3.825876	0.0011
C(2)	-0.827130	0.161782	-5.112626	0.0001
C(3)	-0.620747	0.167361	-3.709025	0.0014
C(4)	-5.95E+09	1.91E+09	-3.119544	0.0054
C(5)	-2.51E+09	9.51E+08	-2.643711	0.0156
C(6)	1.79E+09	5.98E+09	0.298793	0.7682
R-squared	0.693277	Mean dependent var		4.46E+08
Adjusted R-squared	0.616597	S.D. dependent var		4.88E+10
S.E. of regression	3.02E+10	Akaike info criterion		51.30185
Sum squared resid	1.83E+22	Schwarz criterion		51.59218
Log likelihood	-660.9240	Hannan-Quinn criter.		51.38545
F-statistic	9.041102	Durbin-Watson stat		1.934149
Prob(F-statistic)	0.000128			

Now we want to estimate whether there is any short run causality between our variables. To do this we depend on wald statistics test result. Table 6 shows short run causality result between electricity consumption and gross domestic product in Bangladesh. Result suggests that there is short run causality between electric power consumption and GDP in Bangladesh since chi-square value is less than 5%.

Table 6: Short Run Causality between Electricity consumption and Economic Growth

Test Statistic	Value	df	Probability
F-statistic	4.930185	(2, 20)	0.0182
Chi-square	9.860369	2	0.0072

Now we want to examine whether our model where GDP (constant LCU) is the dependent variable has any statistical error or not. Here our value of R^2 is 70% which is good. Our F statistics is also significant which a good sign of our model. Breusch-

Godfrey's LM Test (table 7) indicates that there is no serial-correlation in our model. Further Breusch-Pagan-Godfrey's Heteroskedasticity Test (table 8) indicates that this model does not have Heteroskedasticity problem.

Table 7: Serial Correlation LM Test

Breusch-Godfrey Serial Correlation LM Test:

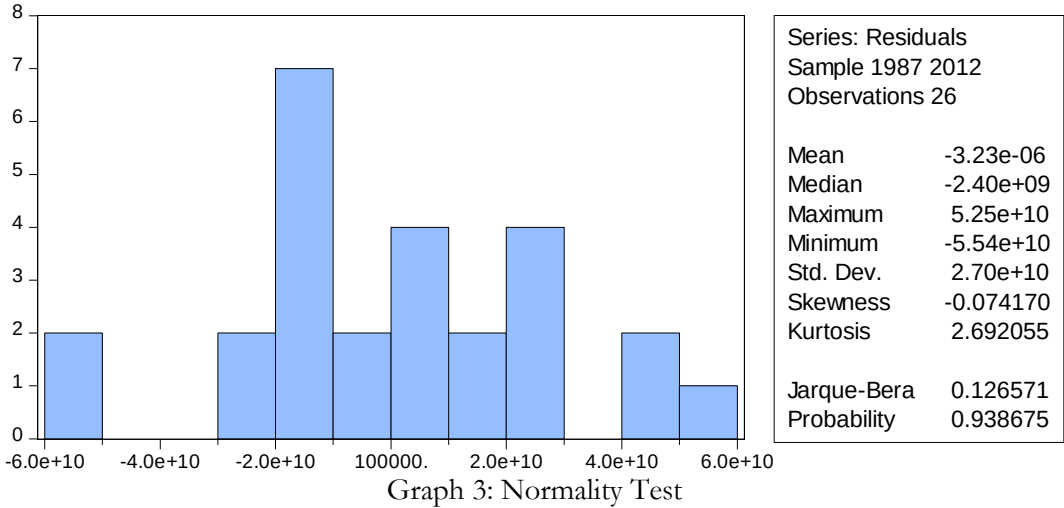
F-statistic	0.250654	Prob. F(2,18)	0.7810
Obs*R-squared	0.704492	Prob. Chi-Square(2)	0.7031

Table 8: Heteroskedasticity Test

Heteroskedasticity Test: Breusch-Pagan-Godfrey

F-statistic	0.289822	Prob. F(6,19)	0.9345
Obs*R-squared	2.180066	Prob. Chi-Square(6)	0.9024
Scaled explained SS	1.091358	Prob. Chi-Square(6)	0.9819

Moreover residuals our model is found to be normally distributed (Graph 3). Therefore we can conclude that the model we used in this study is fit.



4.1. Result of Variance Decomposition:

As impulse response function does not show the extent of the relationships between variables. Therefore, in order to judge the relative strength of different influences on a given variable, we conducted variance decomposition analysis. Table 9 shows Variance Decomposition of Gross Domestic Product. Here in the short run (year 3) impulses or innovation or shock to GDP accounts for 52.98% variation of the

fluctuation of GDP (own shock). At the same time shock to electricity consumption can cause 47.01% variation to the fluctuation of GDP. On the other hand in the long run (year 10) shock to GDP accounts for 54.48% variation of the fluctuation of GDP (own shock). At the same time shock to electricity consumption can cause 45.51% variation to the fluctuation of GDP. Therefore we can conclude that electric power consumption might explain the major variations along with GDP itself in our proposed model.

Table 9: Result of variance decomposition

Period	Standard Error	GDP	Electricity Consumption
1	3.02E+10	100.0000	0.000000
2	4.34E+10	52.31107	47.68893
3	4.52E+10	52.98793	47.01207
4	5.00E+10	56.53303	43.46697
5	5.27E+10	55.40161	44.59839
6	5.61E+10	54.01167	45.98833
7	5.94E+10	55.10766	44.89234
8	6.18E+10	54.40393	45.59607
9	6.46E+10	54.33268	45.66732
10	6.74E+10	54.48519	45.51481

5. Concluding Remarks:

The study has found long run as well as short run causal relationship between electricity consumption and economic growth in Bangladesh. It is evident that increase in electricity consumption likely to increase our economic growth in Bangladesh. There is no alternative for economic growth than to go for generation of more power for Bangladesh, which is needed especially for transforming into a developed country by 2041. Bangladesh is considered one of the most moving energy growth nations in the world. But more than a third of Bangladesh's 166 million people still have no access to electricity, while the country often is able to produce only some of its 11500 MW electricity generation capacity. Recent survey indicates that extensive load shedding results in severe disruption in the industrial production and other economic activities in Bangladesh. Further power outages result in a loss of industrial output worth \$1 billion a year which reduces the GDP growth by about half a percentage point in Bangladesh. To meet up the huge demand of electricity government of Bangladesh plans to set up the 2000 MW Nuclear Power Plant at Rooppur, Pabna district 200 km (120 miles) northwest of the capital Dhaka, by 2018. At the same time renewable energy technology has a huge potential to solve electricity problem in Bangladesh. The energy provided by the sun (solar energy) is many times greater than the current electricity demand. Therefore it is important for the policymakers to set appropriate policies in order to boost our economic growth by using electricity consumption.

References:

- Akomolafe, J. K. A. & Danladi, J. (2014) Electricity Consumption and Economic Growth in Nigeria: A Multivariate Investigation. *International Journal of Economics, Finance and Management*, 3 (4), 177-182.
- Aqeel, A. & Butt, M. S. (2001) The relationship between energy consumption and economic growth, *Asia Pacific Development Journal*, 8 (2), 101-110.
- Asafu-Adjaye, J. (2000) The Relationship between Energy Consumption, Energy Prices and Economic Growth: Time Series Evidence from Asian Developing Countries. *Energy Economics*, 22 (2), 615-625.
- BPDB (2015), Bangladesh Power development Board, Available at: <http://www.bpdb.gov.bd/bpdb/> Accessed on November, 2015.
- Chandran, V. G. R., Madhavan, K. & Sharma, S. (2010) Electricity Consumption-growth Nexus: The case of Malaysia, *Energy Policy*, 38 (1), 606-612.
- Chontanawat, J., Hunt, L.C. & Pierse, R. (2008) Does energy consumption cause economic growth? Evidence from a systematic study of over 100 countries. *Journal of Policy Modeling*, 30 (2), 209-220.
- Ferguson, R., Wilkinson, W., & Hill, R. (2000) Electricity use and economic development. *Energy Policy*, 28 (13), 923-934.
- Ghosh, S. (2002) Electricity consumption and economic growth in India, *Energy Policy*, 30 (2), 125-129.
- Jamil, F. & Ahmad, E. (2010). The relationship between electricity consumption, electricity prices and GDP in Pakistan, *Energy Policy*, 38 (10), 6016-6025.
- Johansen, S., & Juselius, K. (1990) Maximum likelihood estimation and inference on cointegration, with applications to the demand for money. *Oxford Bulletin of Economics and Statistics*, 52 (2), 169-210.
- Karg, B. (2014) Electricity Consumption and Economic Growth: A Long-Term Co-integrated Analysis for Turkey. *International Journal of Economics and Finance*, 6 (4), 285-293.
- Kargi, B. (2014) Electricity Consumption and Economic Growth: A Long-Term Co-integrated Analysis for Turkey. *International Journal of Economics and Finance*, 6 (4), 285-293.
- Kraft, J., & Kraft, A., (1978) On the relationship between energy and GNP. *Journal of Energy Development*, 3 (2), 401-403.
- Lee, C. C., & Chein, M. S. (2010) Dynamic modelling of energy consumption, capital stock, and real income in G-7 countries. *Energy Economics*, 32 (3), 564-581.
- Leung, C. S., & Meisen, P. (2005) How electricity consumption affects social and economic development by comparing low, medium and high human development countries. GENI.
- Morimoto, R., & Hope, C. (2004) The impact of electricity supply on economic growth in Sri Lanka. *Energy Economics*, 26 (1), 77-85.
- Saeki, C. & Hossain, M. S. (2011) Does Electricity Consumption Panel Granger Cause Economic Growth in South Asia? Evidence from Bangladesh, India, Iran, Nepal, Pakistan and Sri-Lanka. *European Journal of Social Sciences*, 25 (3), 316-328.
- The World Bank, World Development Indicators (2014). Country: Bangladesh [bgd_Country_en_excel_v2]. Retrieved from: <http://data.worldbank.org/country/bangladesh>
- Yuan, J., Zhao, C., Yu, S., & Hu, Z. (2007) Electricity Consumption and Economic Growth in China: Co-integration and Co-feature Analysis. *Energy Economics*, 29 (2), 1179-1191.