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Revisiting Nexus Between Economic Growth and Electricity in India

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ABSTRACT

Energy is the backbone of economy, wherein electricity gains momentum as it turns a basic amenity. There are few studies in India that discuss the nexus between economic growth and electricity consumption. However, the earlier studies failed to consider the generation of electricity. Thus, this study attempts to unveil the relationship among GDP, electricity generation and electricity consumption in India. This study employs the annual time series data collected from the World Development Indicators database of the World Bank for the period of 1971 to 2011. The result of this study is inconsistent with the earlier literature expressing no long run nexus among GDP, electricity generation and electricity consumption as it is insignificant to explain one another. However, there exists short run relationship running from GDP to electricity generation and electricity consumption. Consequently, the government can initiate electricity conservation policies to scale up the economic growth.

Keywords: Nexus; Electricity; GDP; Economic development.

INTRODUCTION:

Electricity is an important source of energy which ensures sustainable growth of the country. It is a decisive input for production, education, healthcare, discovery and all other functions of populace. It has become one among the basic amenities for the survival of human being. India is the fifth largest power generating country in the world; however, it has a low per capita consumption of 684 kWh; less than half of China. Iceland has the highest per capita electricity consumption of 52,621 kWh whereas; Afghanistan has the least electricity consumption of only 8 kWh (Central Intelligence Agency, 2012).

In view of macroeconomic growth theories, labour and capital are the two major concerns, whereas that has no attention on the role of energy, which is imperative for the progress of the economy (Stern & Cleveland, 2004). Electricity is a great contribution of science to mankind to illuminate all their activities. The growth and opulence of the country is determined by the availability of affordable and sustainable electricity. At present, power infrastructure has gained momentum in India. In absolute terms, the deployed power capacity has augmented from 1,362 MW in 1947 to 2,23,344 MW as on March 31, 2013 (Central Electricity Authority, 2013). Electricity consumption per capita rose merely from 15.6 kWh in 1950 to 684 kWh in 2011 (The Energy and Resources Institute, 2011). However, it is a distressing issue that the per capita consumption of electricity is low. Moreover, substandard power supply and recurrent power cut threaten the fast growing trade and industries in India.

Energy plays an imperative role in ensuring food security to the deprived through better usage of energy technologies in irrigation and water pumping. Better access to affordable energy would guarantee gender parity and school enrolment of girls, especially in rural areas (International Institute for Applied Systems Analysis, n.d.). The Energy Development Index (EDI) published by World Energy Outlook considered four indicators to measure the role of energy in human development such as commercial energy utilisation per capita, electricity utilisation per capita in the residential sector, share of modern fuels in total residential sector energy consumption and the number of people with access to electricity. The overall performance indicator is expressed in a value between 0 and 1 which exhibits the best to worst performance of the countries. India obtained a value of 0.294, and it bagged 34th rank of 66 countries which took part in the assessment. Therefore, India has to go long to reach better EDI which depicts the role of energy in human progress (International Energy Agency, 2011).

The growth of the nation is persuaded by energy consumption. Assessing the nexus between energy consumption and economic growth is a key to formulate energy and environmental policies (Lau, Chye, & Choong, 2011). In case of energy driven economy, causality runs from energy consumption to economic growth. Thus, the dearth of energy supply becomes a barricade for economic growth, retarding the economic progress and enhancing redundancy (Jumbe, 2004). In contrast, if causality runs from economic growth to energy consumption, it implies that the energy is not an impetus to economic growth. Consequently, energy conservation strategies may be executed without harming economic development and employment. If there is no causality in either way, then economic growth and energy consumption are independent and hence the country can implement energy conservation plans without affecting economic progress of the country.

Gross Domestic Product (GDP) has been considered as a proxy to measure the economic progress of the nation (Ghosh, 2002); (Ray, 2014). The historical trends of GDP, electricity generation and consumption in India depicts that GDP was escalated to Rs. 90,097.22 billion in 2011 from Rs. 509.99 billion in 1971. Electricity generation and consumption had also been increased to 1,052.33 billion kWh and 835.4 billion kWh in 2011 from 66.384 billion kWh and 55.52 billion kWh in 1971 respectively. It is evident from the figure that all three variables are having relationship but the nature of relationship is still concealed (Fig. 1). Consequently, this study intends to explore the relationship between GDP and electricity to facilitate policy implication.

EMPIRICAL EVIDENCES:

The outcome of causality between energy and economic growth is varying according to the place where employed and time frame. Numerous studies have been done to assess the link between energy and economic growth in different angle. In India, only few studies were carried out to assess the relationship, which discloses unidirectional causality running from economic growth to electricity consumption (Ghosh, 2002). The energy consumption fuels the economic growth (Fatai, Oxley, & Scrimgeour, 2004); (Li & Li, 2011); (Mohanty & Chaturvedi, 2015). However, bi-directional causality exists between energy consumption and economic growth (Paul & Bhattacharya, 2004); (Ray, 2014). Moreover, there exists mixed and inconsistent relationship between energy consumption and economic growth (Behera, 2015). No causality exists in either direction between economic growth and different energy consumption in India (Asghar, 2008).

The studies which were carried outside India also explore diverse linkages between energy and economic growth. Economic growth causes energy consumption (Onuonga, 2012); (Kalyoncu, Gürsoy, & Göcen, 2013). However, unidirectional causal relationship running from electricity consumption to economic growth (Javid, Javid, & Awan, 2012); (Hu & Lin, 2013). Causality runs from gas consumption to economic growth and also economic growth to electricity consumption. Oil and coal consumption do not granger cause economic growth and vice versa (Shaari, Hussain, & Ismail, 2013). Causality effect runs from electricity consumption to the output of agricultural, industrial, and transportation sectors. However, only the service sector output granger causes electricity consumption (Nathan & Liew, 2013).

The earlier studies which scrutinised the relationship between economic growth and electricity focused the energy consumption data only and none of the study was carried out in India with the energy generation data. Thus, this study has taken into account both electricity generation and consumption data till 2011 as the data availability is up to that year. Some of the relevant studies are cited in table 1.

METHODOLOGY:

This study employs the annual time series data of GDP and electricity generation and electricity consumption for the period of 1971 to 2011. Data has been collected from the World Development Indicators (WDI) database of the World Bank. In this study, electricity generation and consumption are articulated in terms of kWh and GDP is considered in current local currency. Both the variables were transformed into logarithm form to trim down the setback of heteroskedasticity (Gujarati, 2012). The various econometric tools used to explore the relationship between the variables are unit root test, cointegration and granger causality test.

Unit Root Test:

Generally, the econometric models can be developed when the data is stationary, but in most of the cases, time series data would be non-stationary at level. Unit root is the test that helps to overcome this problem by taking differences to make the series stationary. In order to verify whether the data are stationary or not, the econometrics furnishes various tests. It is apparent that each test has its own pros and cons. In this study, Augmented Dickey-Fuller (ADF) and Phillips Peron (PP) test were employed to shun the criticisms of each individual test. The ADF test is based on the following model:

$$\Delta y_t = \alpha_0 + \alpha_1 y_{t-1} + \sum_{i=1}^{n} \alpha_1 \Delta y_i + e_t \quad \text{..... (i)}$$

Where $\Delta =$ first difference operator, n = optimal number lags, e_t= disturbance term considered as a white noise and y = time series data of GDP, electricity generation and consumption.

The PP test is based on the following model:

$$\Delta y_t = \alpha + bY_{t-1} + \varepsilon_t \quad \text{..... (ii)}$$

Where Δ = first difference operator, α = constant, ε_t= error term and y = time series data of GDP, electricity generation and consumption.

Johansen Cointegration Test:

For cointegration test it is necessitated that the selected time series variables should be integrated at the first order i.e. *I*(1), when this condition is fulfilled then probing the existence of long run relationship of the selected time series is possible. This test helps to ensure long run relationship between the selected variables. Johansen method indicates the maximum likelihood procedure to identify the existence of cointegrating vectors for chosen non-stationary time series data. It determines the number of cointegrating vector. There are two different likelihood ratio tests proposed by the Johansen namely, trace test and maximum eigen value test. Trace test examines the null hypothesis of cointegrating vector against the alternative hypothesis of n cointegrating vectors.

$$\lambda_{trace} = -T \sum_{j=r+1}^{k} \ln(1 - \hat{\lambda}_j)$$

Maximum Eigen Value test analyses the null of r cointegrating vectors against the alternative hypothesis of r+1 cointegrating vectors.

$$\lambda_{max} = -T \ln (1 - \hat{\lambda}_{r+1})$$

Where T= Sample size and $\hat{\lambda}_j$ =Estimated values of characteristic roots ranked from largest to smallest.

Granger Causality Test:

The Granger causality test is a convenient and very general approach for sensing the existence of a causal relationship between two variables (Yoo, 2005). It is obvious that using non-stationary data in causality test can yield spurious causality results (Stock & Watson, 1989). According to Granger causality, if X_t granger causes Y_t, then the past values of X_t should contain the information that helps to predict Y_t and beyond the information contained in the past values of Y_t alone. Its mathematical formulation is based on linear regression modeling of stochastic processes (Granger, 1969).

The outcome of granger causality may be bi-directional, unidirectional or directionless. If there exists bi-directional causality between the two variables then both the variables cause one another. If there exists unidirectional causality then the causality runs from one variable to another and not vice-versa. There is no causality run in either direction in case of no causality.

RESULTS & DISCUSSION:

Energy and economic development go hand in hand as the energy fuels the economy to attain self-sufficiency. The broad spectrum of energy consists of oil, coal, gas, electricity and renewable resources. However, this paper is confined to the most significant energy of electricity. Thus, it has unearthed the relationship between economic progress and electricity generation and consumption. In this study, the variables are normally distributed as the Jarque-Bera probability value is greater than 0.05 and the null hypothesis is accepted such as the data follows normal distribution (Table 2). The unit root test result reveals the time series variables are integrating at $I(1)$ after transforming into logarithm form. Both ADF and PP test confer the same results (Table 3). The cointegration result indicates that there is no cointegration among GDP, electricity generation and electricity consumption. Since the p value is greater than 0.05, the null hypothesis of no cointegration among GDP, electricity generation and consumption is being accepted. Both trace statistic and max-eigen statistic has suggested that there is no long run relationship among GDP, electricity generation and electricity consumption (Table 4).

As there is no long run relationship in the study, it further examined the existence of short run relationship among GDP, electricity generation and electricity consumption. Granger causality test has been performed to assess the short run relationship. The optimal lag is being decided by lag selection criterion and all the criterion apart from Schwarz information criterion suggested that the lag one is the optimal lag to do further analysis (Table 5). Granger causality test discloses that there exists unidirectional causality from GDP to electricity generation and electricity consumption meaning that economic growth causes electricity generation and electricity consumption. However, there is no causality runs from either electricity generation or electricity consumption to GDP. Moreover, bi-directional causality runs from electricity generation to electricity consumption meaning that electricity generation granger causes electricity consumption and vice versa (Table 6). Thus, the government can execute energy conservation policies which would not distress the growth of the nation.

CONCLUSIONS AND POLICY IMPLICATIONS:

The earlier studies which were undertaken in India show that there exists long run relationship between GDP and electricity consumption (Paul & Bhattacharya, 2004); (Ray, 2014); Mohanty & Chaturvedi, 2015). This study is paradoxical with some earlier studies divulging that there is no long run relationship between the two as it is insignificant to explain one another (Ghosh, 2002); (Fatai, Oxley, & Scrimgeour, 2004); (Asghar, 2008); (Li & Li, 2011). However, there exists short run relationship running from GDP to electricity generation and electricity consumption. It is evident from this study that there is no causality running from electricity generation and electricity consumption to GDP. Therefore, the government can initiate electricity conservation policies to scale up the economic growth. In this context, efficient use of electricity and its conservation has paramount value. Electricity conservation is cheaper than its generation and avoids the environmental costs combined with the additional power generation (Ghosh, 2002). Therefore, the government can execute electricity conservation policies so as to uplift the economic condition of the nation. In future, the relationship among economic growth, various energy generation and consumption can be probed to make a clear picture in the arena.

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Figure: 1 Nexus Between Economic Growth and Electricity

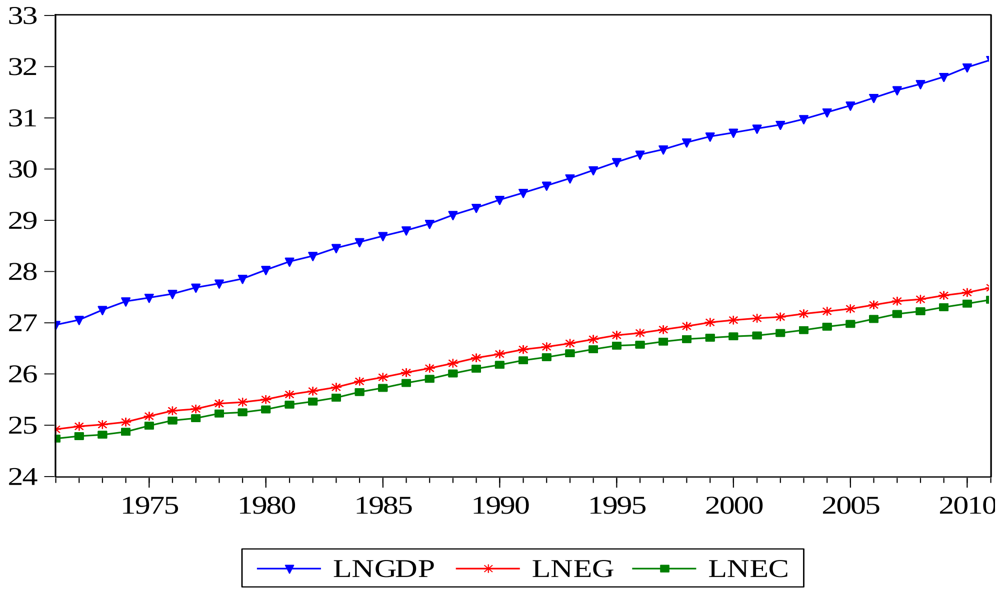

Table 1: Evidence from Select Earlier Studies

Authors	Variables	Methodology	Country & Period	Results
Sajal Ghosh (2002)	GDP per capita, electricity consumption per capita	Johansen Cointegration, Granger Causality	India 1950-1997	There exists unidirectional causality running from economic growth to electricity consumption.
Fatai K, Les Oxley and Scrimgeour F.G (2004)	GDP and coal, oil, gas, electricity and total energy consumption	Johansen Cointegration, Granger Causality, ARDL	New Zealand, Australia, India, Indonesia, the Philippines and Thailand 1960-1999	Energy conservation policies may not have significant impact on GDP growth in industrialised nations such as New Zealand and Australia compared to some Asian economies.
Shyamal Paul, Rabindra N, and Bhattacharya (2004)	Energy consumption and economic growth	Engle-Granger Cointegration, Granger Causality, VECM	India 1950-1996	Bi-directional causal relation between energy consumption and economic growth.
Asghar, Zahid (2008)	GDP, Petrol, electricity, gas, coal and total energy consumption	Engle-Granger Cointegration, Granger Causality, ECM	Pakistan, India, Sri Lanka, Bangladesh and Nepal 1971-2003 SL1980-2003	For India no causality in either direction between GDP and different energy consumption.
Jinke Li, Zhongxue Li (2011)	GDP and coal consumption	Engle-Granger Cointegration, Granger Causality, VECM	China and India 1965-2006	Unidirectional causality runs from GDP to coal consumption in China. Whereas, unidirectional causality runs from coal consumption to GDP in India.
Sarbapriya Ray (2014)	Electricity consumption and economic growth	Regression, Johansen Cointegration, Granger Causality	India 1970- 2011	Bi-directional causality between economic growth and total electricity energy consumption is found if all the sectors are considered together
Jeganath Behera (2015)	GDP and lignite, petroleum, natural gas and electricity consumption	Granger Causality test, VAR	India 1970-2011	Mixed and inconsistent results are found
Asit Mohanty & Devtosh Chaturvedi (2015)	GDP, Electricity consumption	Regression Engle-Granger Cointegration, Granger Causality,	India 1970-2011	Electricity consumption fuels economic growth both in short run and long run.
Susan M. Onuonga (2012)	GDP per capita, energy consumption per capita	Engle-Granger Cointegration, Granger Causality, ECM	Kenya 1970-2005	Economic growth causes total energy consumption.
Attiya Yasmin Javid, Muhammad Javid and Zahid Ashraf Awan (2012)	GDP per capita, electricity consumption	Engle-Granger Cointegration, Granger Causality, SVAR	Pakistan 1971-2008	Unidirectional causal relationship from electricity consumption to economic growth.
Xiaohua Hu, Xiao Lin (2013)	GDP, Electricity consumption in Primary, Secondary and tertiary industry	Johansen Cointegration, Granger Causality, ECM	Hainan Island, China 1988-2009	Electric power consumption of the primary industry and the tertiary industry granger cause the economic growth.

Authors	Variables	Methodology	Country & Period	Results
Hüseyin Kalyoncu, Faruk Gürsoy and Hasan Göcen (2013)	GDP per capita, energy consumption per capita	Engle-Granger Cointegration and Granger Causality test	Georgia, Azerbaijan and Armenia 1995-2009	Unidirectional causality from GDP per capita to energy consumption per capita for Armenia. However, there is no relationship between the two in Georgia and Azerbaijan.
Mohd Shahidan Shaari, Nor Ermawati Hussain and Mohammad Shariff Ismail (2013)	GDP, Consumption of oil, coal, electricity and gas	Johansen Cointegration, Granger Causality test	Malaysia 1980- 2010	Causality runs from gas consumption to GDP and also GDP to electricity consumption. Oil and coal consumption do not granger cause GDP and vice versa.
Thurai Murugan Nathan, Venus Khim-Sen Liew (2013)	Electricity consumption, sectoral outputs including agricultural, industrial, services, and transportation	ARDL bound testing approach, Granger causality test, Wald test	Cambodia 1986-2010	Causality effect runs from electricity consumption to the output of agricultural, industrial, and transportation sectors. However, service sector output granger causes electricity consumption.

Table 2: Descriptive Statistics

Descriptive Statistics	D(LnGDP)	D(LnEG)	D(LnEC)
Mean	0.129356	0.069083	0.067778
Median	0.134492	0.071024	0.069895
Standard Deviation	0.032347	0.024796	0.026764
Skewness	-0.199979	0.037175	-0.139120
Kurtosis	2.357934	2.144736	2.290000
Jarque-Bera	0.953692	1.228340	0.969198
Probability	0.620738	0.541090	0.615944

Table 3: Unit Root Estimation

Variables	ADF	PP
$\ln GDP_t$	0.077	0.376
$\Delta \ln GDP_t$	-4.351***	-4.445***
$\ln EG_t$	-1.326	-1.227
$\Delta \ln EG_t$	-5.364***	-5.431***
$\ln EC_t$	-0.839	-0.648
$\Delta \ln EC_t$	-4.374***	-4.485***

Note: *** denotes significant at 1per cent level. The optimal lag order for ADF test is determined by SIC, while the bandwidths for PP test is decided by using the Newey-West Bartlett kernel.

Table 4: Johansen Cointegration Test

Variables	Null hypothesis	Trace Statistic	0.05 Critical Value	Max-Eigen Statistic	0.05 Critical Value
GDP	r = 0	19.16	29.80	14.49	21.13
EG	r ≤ 1	4.67	15.49	4.19	14.26
EC	r ≤ 2	0.48	3.84	0.48	3.84

Table 5: Optimal Lag Selection

Lag	LogL	LR	FPE	AIC	SC	HQ
0	268.8004	NA	1.16e-10	-14.36759	-14.23697*	-14.32154
1	283.5142	26.24627*	8.51e-11*	-14.67644*	-14.15398	-14.49225*
2	290.4065	11.17678	9.64e-11	-14.56252	-13.64821	-14.24018
3	295.1891	6.979889	1.24e-10	-14.33454	-13.02839	-13.87406

* indicates lag order selected by the criterion

Table 6: Granger Causality Test

Null Hypothesis	F-Statistic	Prob.	Decision
ΔLNEG does not Granger Cause ΔLNEC	8.369	0.006	Reject
ΔLNEC does not Granger Cause ΔLNEG	4.784	0.035	Reject
ΔLNGDP does not Granger Cause ΔLNEC	5.406	0.026	Reject
ΔLNEC does not Granger Cause ΔLNGDP	0.191	0.664	Accept
ΔDLNGDP does not Granger Cause ΔLNEG	7.577	0.009	Reject
ΔLNEG does not Granger Cause ΔLNGDP	0.022	0.884	Accept
