Causality between Electricity Consumption & Economic growth : Empirical Evidence from India

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Abstract

In this study ,an attempt has been made to investigate causality between electricity consumption and economic growth in India by adopting Granger Engel causality model for 1960-2006 period .Test results shows that electricity consumption has positive effect on economic growth. The paper support for the reforms in power sector and indicates that electricity act as a catalyst in realizing various social and economic goals.

Key Words : Electricity consumption; Economic growth ; Granger Engel causality; India .

1. Introduction

Electricity plays an important role in economic development and it is required for both commercial and non-commercial uses .Commercial usage of power refers to the use of electric power in industry, agriculture and transport. Non-commercial uses include electric power required for domestic lighting ,cooking, use of domestic mechanical gadgets like refrigerators and air-conditioners. Electricity is essentially a prime mover of the economic activities , the use of electricity is associated with improving health and education standards of the poor for example if in a barren land away from development, where there is absolutely no demand for electricity, if we provide basic infrastructure, electricity and other essential facilities. We can see economic activities would be picking up and result in economic growth and development.

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The demand for infrastructure and particularly electricity is growing rapidly in India, as shown in appendix 2. There has been a great use of information and communication technologies (ICTs) which instigates a transition towards a digital economy. In India the service sector helps to boost the economic growth of the country, over the years have been shown in appendix 3. People become reliant on networked ICT such as the Internet and other ICTS such as cell phones, digital video recorders, digital music players, personal computer and etc .

Electricity has become the dominant form of energy as a major source of improvement of the standard of living. Scientific advancement boost the demand for electricity and leads to rapid economic growth in the region. The causal relationship between electricity and economic growth should be investigated in order to make appropriate energy policies . In fact, various advances in science and technology for improving the quality of life leads to shift of resources from manual devices to technological advanced equipments .The technology development has created a large demand for energy and as a result exploring every source of energy is important that are able to meet growing energy requirements to spur economic growth..

In India , present energy scenario indicates that there are serious demand supply mismatch, resulting in hardships on account of shortage of energy availability .India one of the populous country in the world fails to provide access of electricity to every citizen which in turn impede economic growth and quality of life of its citizens . In 2000 ,India had the highest percentage (35%) of the World‘s total population without electricity access.At present 71% of India‘s rural population lives in rural areas of which 95000 villages are still unelectrified .

An examination of global scenario indicates that India's energy intensity is 3.7 times of Japan, 1.55 times of USA, 1.47 times of Asia and 1.5 times of World average .In terms of per capita electricity consumption, India is far behind many countries and behind even the world average. It is just 4% of USA and 20% of the world average in 2004 (Bureau of

Energy Efficiency). The per capita electricity consumption is likely to grow in India , as discussed earlier to improve the standard of living of people and let them enjoy the benefit of economic development . It is therefore, imperative that electricity consumption level is enhanced.

Here, an attempt has been made to study the causality relationship between electricity consumption and economic growth which raises a number of important questions: Is electricity consumption a stimulus to economic growth or economic growth a stimulus for electricity consumption . The answer to these questions have important implications for policy makers (Chontanawat and others,2006).

2. Review of Literature

A number of studies in the last two decades have been conducted to investigate the relationship between electricity consumption and economic growth .Although economic theories do not explicitly state a relationship between these variables ,overall findings are that there exists a relationship between electricity consumption and economic growth as viewed by Altinay and Karagol (2005) in Turkey for the period 1950-2000 in which different methodology employed to test : Granger non-causality, Dolado-Lutkepohl test using the V.A.R. in levels standard Granger causality test using the detrended data .These tests have yielded a strong evidence for unidirectional causality running from the electricity consumption to income implies that an economy is energy dependent and shortage of electricity may negatively affect economic growth or may cause poor economic performance.

In another study, Bohm mentioned the bivariate relationship between energy and GDP for the 15 biggest global consumers between 1978 and 2005. The research paper used panel co-integration analysis and results show a very heterogeneous picture .Energy saving policies could be harmful to countries like Belgium ,Cyprus ,the Czech Republic ,Denmark ,Greece, Luxemburg ,Malta and Slovakia .European Union is very energy dependent as a whole. Unidirectional causality from economic growth to energy use can be established for Canada, Japan, Saudia Arabia and South Africa. The neutrality hypothesis hold for Korea. In Saudia Arabia causality runs from energy consumption to GDP growth.

Morimoto and Hope (2001) revealed that electricity supply have significant impact on a change in real GDP in Sri Lanka.Aqueel and Butt (2001) investigate the relationship in Pakistan and results inferred that electricity consumption leads to economic growth. In a similar study Dhungel (2008) used co-integration and Granger causality test to determine the relationship between energy consumption and economic growth in Nepal during 1980-2004.A unidirectional causality running from per capita electricity consumption is found .This suggests that per capita energy consumption is the stimulating input for enhancing economic growth in Nepal.

In an article ,Stern (2003) presented the relationship between energy and economic growth. In which the principal finding is that energy used per unit of economic output has declined due to shift from direct use of fossil fuels to higher quality fuels especially electricity. The results strengthen Sterns previous conclusions that energy is a limiting factor in economic growth. This article provides picture that there is a strong link between energy Use , economic growth and pollution.

Squalli and Wilson(2006) tests the electricity consumption income hypothesis forG.C.C applied the bounds test procedure. The paper emphasized a long run relationship between electricity consumption and economic growth for all G.C.C. It also opined for the efficacy of energy conservation measures except Qatar. On the basis of his study Ho and Siu (2006) report that a one way causal exists from electricity consumption to real G.D.P in Hong-Kong taken 1966-2002 period .In a recent study Thure Traber(2008) expressed relationship electricity and economic growth using Granger Causality results asserted that electricity demand is likely to increase as long as we experience economic growth.

On the other hand, Ciarreta and Zarrage (2007) computed both linear and non linear causality between electricity consumption and economic growth in Spain. The time period covered from 1971-2005 in which they found unidirectional linear causality running from GDP to electricity consumption. They find no evidence of non linear Granger causality between the series in either direction. The Toda and Yamamoto and Dolado and Lutkepohl and linear Granger causality test in a V.A.R. for the differenced series. In another study, Chebbi and Boujelbene (2008) investigated the co-integration and causality link between energy consumption and agricultural and non- agricultural outputs. In this A.D.F and KPSS(Kwiat Kows Ki et al., 1992), Johansen, V.E.C.M. methods are used for 1971-2003 period in Tunisia. Empirical results suggest that there is only unidirectional causality running from agricultural and non- agricultural sectors to energy consumption. This unidirectional causality signifies a less energy dependent economy.

There are some studies in India which indicated mixed results regarding causal relationship between electricity consumption and economic growth. Ghosh (2002) on the basis of his study found unidirectional relationships in which GDP cause electricity . On the other hand Asafu-Adjaya (2000) viewed that energy caused GDP. The above described studies clearly emphasized that a relationship exists between electricity consumption and economic growth. However, When it comes to whether electricity use is a result of ,or a prerequisite for, economic growth ,there are no clear trends in the literature depending on the methodology used ,country and time period studied so different results are available (Atle,2004).

The above described studies clearly state that a relationship exists between electricity consumption and economic growth. But there are no clear trends in the literature , depending on the methodology used, country and time period studied so different results are available . Therefore in this study attempt has been made to unravel the existing relationship between the above two variables in India.

3. Data and Methodology

Data and Variables

All the data used are annual observations of the variables from 1960 to 2006.The electricity consumption is obtained from the Centre for Monitoring Indian Economy (CMIE) and Economic Survey .The data for real GDP is retrieved from Reserve Bank of India (RBI) website . The units of electricity consumption is measured in kilowatt per hour, it consists of both utility and non-utility i.e. gross electricity consumption are taken into account .The units of real GDP is measured at constant price and denominated in millions.

Econometric methodology

The time series data present a number of methodological problems. It is convenient to estimate relationships through the regression method only if the series are stationary. In the context of a time series, “stationary” refers to a condition wherein the series have constant mean and constant variance. Most of the time series data reflect trend, cycle and/or seasonality. These deterministic patterns must be removed to make the series stationary. Time series that are not stationary and whose properties have not been subjected to an examination could produce invalid inferences.

To examine the Granger causality between electricity consumption and real GDP, the following methodology has been adopted. To check whether or not the variables under consideration are stationary. Tests for stationarity are well known in the literature as Augmented Dicker Fuller (ADF) test and Phillips and Perron are applied to the natural logs of the data series. The specification is

$$\Delta Y_t = \beta_1 + \beta_2 t + \delta Y_{t-1} + \alpha_i \sum_{i=1}^{m} \Delta Y_{t-i} + \varepsilon_t$$

Where ε_t is a pure white noise error term .The error term is assumed to be independent and identically distributed. Dickey and Fuller (1981) proposed the ADF test in order to handle the AR(p) process in the variables .Furthermore, we perform another unit root test proposed by Phillips and Perron (1988) which is based on the same equation as the ADF test but without the lagged differences. While the ADF test corrects for higher order serial correlation by adding lagged difference terms whereas Phillips and Perron test makes a non-parametric correction to account for residual serial correlation without restricting the residuals to be white noise.

Granger causality test

The Granger (1969) approach to the question of whether X causes Y is to determine how much of the current Y can be explained by past values of Y, and then to see whether adding lagged values of X can improve the explanation. Y is said to be Granger-caused by X if X helps in the prediction of Y, or if the coefficients on the lagged Xs are statistically significant. Note that two-way causation is frequently the case: X Granger causes Y and Y Granger causes X.

It is important to note that the statement "X Granger causes Y" does not imply that Y is the effect or the result of X. Granger causality measures precedence and information content but does not of itself indicate causality in the more common use of the term.

It is better to use more rather than fewer lags in the test regressions, since the Granger approach is couched in terms of the relevance of all past information. It is necessary to pick a lag length, l, that corresponds to reasonable beliefs about the longest time over which one variable could help predict the other.

If two series are co-integrated, then a Granger causality test must be applied to determine the direction of causality between the variables under consideration.

The following equations are used to determine the causality:

$$\Delta Y_t = \alpha + \sum_{i=1}^{k} \beta_i \ \Delta Y_{t-i} + \sum_{i=1}^{k} \gamma_i \, \Delta X_{t-i} + \mu$$

$$\Delta X_t = \alpha + \sum_{i=1}^{k} \beta_i \, \Delta X_{t-i} + \sum_{i=1}^{k} \psi_i \ \Delta Y_{t-i} + \mu$$

where Y_t and X_t are defined as Y and X observed over t time periods; Δ is the difference operator; k represents the number of lags; α, β, $\boldsymbol{\psi}$ and γ are parameters to be estimated; and μ represents the serially uncorrelated error terms. The test is based on the following hypotheses:

$$H_0 : \gamma_i = \psi_i = 0 \; for \; all \; i's$$

$$H_1 : \gamma_i \neq 0 \; and \; \psi_i \neq 0 \; for \; at \; least \; some \; i's.$$

At this point, it is necessary to examine the criteria for causality. The hypothesis would be tested by using t-statistics. If the values of the γ_i coefficient are statistically significant but those of the ψ_i are not, then X causes Y (X→Y). On the contrary, if the values of theψ_i coefficients are statistically significant but those of the γ_i coefficients are not, then Y causes X (Y→ X). If both $\psi_i$and γ_i are significant then there exists bidirectional causality between X and Y (X↔Y).

4. Empirical Findings

Unit root test

Owing to the above specified models, the entire empirical analysis has been done through E –Views Package .In the level form the ADF and Phillips –Perron test supports the hypothesis that series under consideration are stationary. The estimated ADF values and Phillips –Perron are greater than the critical values at the 5% level of significance, as shown below are reported in table 1.

Table 1. Empirical results of a unit root tests

Variable	Augmented Dickey Fuller		Phillips-Perron	
	Level	Probability	First difference	Probability
lnELEC*	-4.945880	0.0002	-3.191480	0.0272
lnGDP*	3.372541	1.0000	-6.635030	0.0000

* indicates *significant at 1% level .*
Abbreviations: ln, natural logarithm; Elec , electricity consumption; GDP, gross domestic product (millions of Indian rupees).
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Granger causality test

The results of Granger causality between electricity consumption and real GDP, as well as the computed F values and their respective probabilities for the data of those series during the period 1960-2006 with specific lag period, as calculated through equations (3) and (4), are presented in table 4. To assess whether the null hypothesis is to be accepted or rejected, a significance level of 5 per cent is chosen. The lag lengths were chosen by using Akaike's information criterion and Schwarz Information Criterion (SIC) are given below.

Table 3. Lag order selection criterion

Lag	AIC	SIC
1	-4.561185*	-4.474108*
2	-4.514908	-4.384293
3	-4.463024	-4.288871
4	-4.430835	-4.213144
5	-4.396038	-4.134808
6	-4.347926	-4.043158
7	-4.302011	-3.953705
8	-4.250377	-3.858532
9	-4.199551	-3.764167
10	-4.191005	-3.712083

Note : * *indicates lag order selected by the criterion*
AIC: Akaike information criterion
SIC: Schwarz information criterion

AIC criterion has been used to determine the lag length in an AR(p) model .It is useful both nested and non-nested models .In comparing two or more models ,the model with the lowest value of AIC is preferred .Like AIC,SIC has been used to compare in-sample or out-of-sample forecasting performance of a model.SIC imposes a harsher penalty for adding regressors to the model than AIC.

Table 4. Granger-Engel Test Result

Null hypothesis	F-statistic	p-value	Decision
lnGDP doesn't Granger cause lnELEC (a)	0.79013(1)	0.37901(1)	Do not Reject
lnELEC doesn't Granger cause lnGDP (b)	0.02744(1)	0.86921(1)	Reject*

Note:**indicates the rejection of the null hypothesis at 5% significant level and figures in the parentheses are number of lags.*

$$\Delta Y_t = \alpha + \sum_{i=1}^{k} \beta_i \, \Delta Y_{t-i} + \sum_{i=1}^{k} \gamma_i \, \Delta X_{t-1} + \mu$$

$$\Delta X_t = \alpha + \sum_{i=1}^{k} \beta_i \, \Delta X_{t-i} + \sum_{i=1}^{k} \psi_i \, \Delta Y_{t-i} + \mu$$

Abbreviations: ln, natural logarithm; Elec , electricity consumption; GDP, gross domestic product (millions of Indian rupees).

The Granger causality is found to run from electricity consumption to GDP .The null hypothesis of "electricity consumption does not Granger cause GDP" is rejected at the 1 per cent level of significance in equation (2), where the value of $\gamma_i$is 0.02744 with probability 0.86921 . The null hypothesis "GDP does not Granger cause electricity consumption" is accepted in equation (3), where the value of ψ_i is 0.79013 with probability 0.37901. This indicates that GDP does not Granger cause electricity consumption, as the value of the test statistic is not significant at the 1 per cent level of significance in equation (3). Both results were calculated using one lag period on the basis of AIC and SIC.

Our results indicate that use of electricity is growing fast and it’s faster than the consumption of primary energy .Electricity emerged as a high quality energy carrier and its capability is to serve practically any energy service whether light, appliances, motion, electronics and heat from a single system. Technology innovation in electricity use is a cornerstone of global economic progress. Extremely reliable delivery of high quality “digital-grade” power is needed by a growing number of critical end-uses ,India one of fastest growing economy used approximately 70% of this form of energy to accelerate it` s economic growth.

5. Conclusion

This study has investigated the relationship between economic growth and electricity consumption in India during 1960-2006..To estimate results Granger-Engel method was used in which our findings indicate, that electricity causes higher economic growth. This implies that the increase in electricity consumption can be viewed as a leading indicator of growing economy. This implies that the supply of electricity is vitally important to meet the growing electricity consumption ,hence to sustain economic growth in India and achievement of various other objectives like human welfare goals, millennium development goals ,higher growth, there is an urgent need to remove the power sector inefficiencies. To remove administrative bottlenecks steps should be taken towards unification of various policies at centre and state level and to ensure effective implementation of these policies .At the same time various other alternatives like public private partnership ,clean technologies and diversified energy resources should also be explored in effective manner.

Thus, for developing countries like India high economic growth requires energy infrastructure—particularly electricity. Economic growth rate will in turn increase the consumption of commercial energy. Development of nuclear power projects to generate electricity is one of the best infrastructure option. However, it requires a huge investment and significant amount of time to construct but it would generate long term benefits in the economy .

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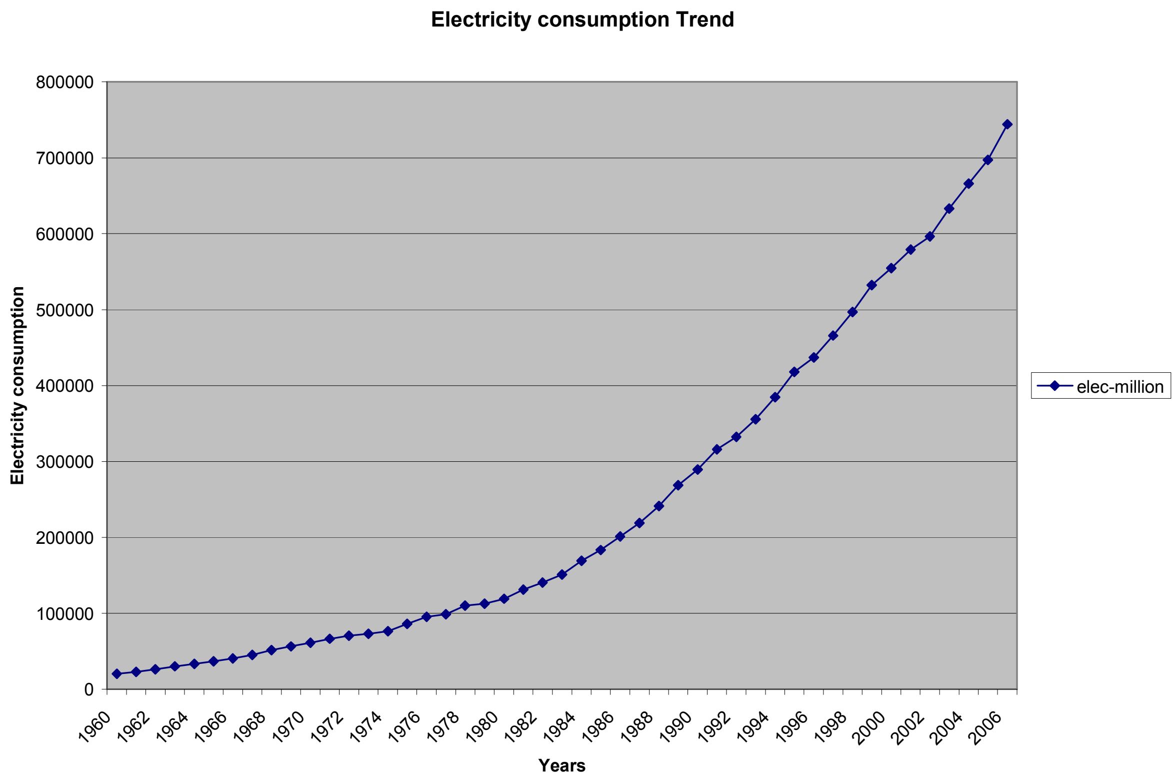
Appendix

Appendix 1. Descriptive Statistics of GDP and Electricity Consumption

Statistics	**lnGDP**	**lnELEC**
Observations	47	47
Mean	15.91895	11.93563
Median	15.83397	11.92437
Maximum	17.17042	13.52020
Minimum	15.00890	9.903488
Standard Deviation	0.631153	1.063016
Skewness	0.336322	-0.187409
Kurtosis	1.915924	1.852724
Jarque-Bera (Probability)	3.187519 (0.203160)	2.852767 (0.240176)

Appendix 2. Electricity Consumption Trend in India (1960-2006)



Appendix 3. Economic Growth in India (1960-2006)