

ELECTRICITY CONSUMPTION AND ECONOMIC GROWTH: CAUSAL RELATIONSHIP IN INDIA

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ABSTRACT:

Energy is a vital component of human development and is important for developing nations like India. In order to maintain the sustainability of the environment and guarantee the energy supply, global economic growth strategies are being reorganized with energy security and environmental sustainability as key priorities. An analysis of the relationship between India's economic growth and power consumption for the years 1960–2006 has been carried out using the Granger Engel causality model. The test's findings suggest that using electricity encourages economic growth. Over the past 20 years, there have been major institutional changes in the Indian power sector. With the support of ongoing governmental initiatives, the Indian electrical industry is poised for a significant transformation. Consequently, the study makes the case for additional power sector reforms and demonstrates how energy may act as a catalyst to accomplish a variety of social and economic goals.

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

INTRODUCTION

Energy is necessary for both business and non-commercial activities, and it is crucial to economic growth. The use of electricity for transportation, industry, and agriculture is referred to as commercial consumption of power. Electricity needed for home appliances like air conditioners and refrigerators, cooking, and lighting is considered a non-commercial use. In a place where there is no need for electricity, such as a barren land far from development, the use of electricity is linked to raising the health and educational standards of the impoverished. If we provide basic infrastructure, electricity, and other necessities, this can be achieved. It is evident that economic activity is increasing, leading to economic expansion and advancement. Appendix 2 illustrates how quickly infrastructure, and especially power, is needed in India. Information and communication technologies (ICTs) have been widely used, which has sparked the shift to a digital economy. Appendix 3 illustrates how the service sector has contributed to India's economic growth over the years. Individuals grow dependent on networked ICTs like the Internet and other ICTs including personal computers, digital music players, cell phones, and video recorders.

Electricity has emerged as the primary energy source and a key driver of rising living standards. Scientific progress increases the need for electricity and spurs the area's economy to grow quickly. It is important to look into the causal relationship between economic growth and electricity in order to develop proper energy policies. In actuality, resources are shifted from manual to technologically enhanced equipment as a result of numerous scientific and technological advancements aimed at enhancing living quality. Because of the increased need

for energy brought about by technological advancements, it is critical to investigate all available energy sources in order to meet the expanding energy needs and promote economic progress.

The current energy situation in India suggests that there is a significant mismatch between supply and demand, which causes challenges due to a lack of energy availability. One of the most populous nations in the world, India, fails to deliver power to all of its residents, impeding both economic progress and the standard of living for its people. India accounted for the largest share of the global population without access to electricity (35%), in the year 2000.

India's energy intensity is 3.7 times that of Japan, 1.55 times that of the USA, 1.47 times that of Asia, and 1.5 times that of the global average, according to a review of the global picture. India fares significantly worse than many other nations and even the global average in terms of per capita electricity usage. In 2004, it accounted for only 4% of the USA and 20% of the global average (Bureau of Energy Efficiency). As was previously said, India's per capita power consumption is projected to rise in order to raise people's standards of living and enable them to reap the rewards of economic growth. Therefore, increasing the amount of electricity consumed is essential.

A number of significant problems are raised by this endeavour to investigate the causal relationship between power use and economic growth: Does the use of electricity fuel economic expansion or does economic expansion fuel the use of electricity? Policymakers will be greatly impacted by the answers to these issues (Chontanawat and others, 2006).

REVIEW OF LITERATURE

Over the past 20 years, a lot of research have been carried out to look into the connection between economic growth and power usage. Even though economic theories do not specifically state a relationship between these variables, overall findings show that, as viewed by Altinay and Karagol (2005) in Turkey for the period 1950-2000, there is a relationship between electricity consumption and economic growth. Various methodologies were used to test for this relationship, including Granger non-causality, the Dolado-Lutkepohl test using the V.A.R. in levels standard Granger causality test using the detrended data. Strong evidence of unidirectional causality between income and electricity consumption has been produced by these experiments, suggesting that economies are energy-dependent and that a power shortage could have a detrimental impact on economic growth or lead to subpar economic performance. Bohm discussed the bivariate association between GDP and energy for the top 15 worldwide consumers between 1978 and 2005 in another study. Panel cointegration analysis was used in the research report, and the findings paint a widely varied picture. Countries like Belgium, Cyprus, the Czech Republic, Denmark, Greece, Luxembourg, Malta, and Slovakia may suffer from energy-saving policies. The whole European Union depends heavily on energy. It is possible to prove a unidirectional causal relationship between economic growth and energy consumption in Canada, Japan, Saudi Arabia, and South Africa. For Korea, the neutrality hypothesis is valid. In Saudi Arabia, GDP growth is correlated with energy use.

According to Morimoto and Hope (2001), changes in Sri Lanka's real GDP are significantly influenced by the country's energy supply. According to Aqueel and Butt's (2001) investigation, there is a positive correlation between economic growth and power consumption in Pakistan. In a related study, Dhungel (2008) examined the relationship between energy consumption and economic growth in Nepal between 1980 and 2004 using co-integration and the Granger causality test. There is a found unidirectional causal relationship between per capita electricity use. This shows that the driving factor behind Nepal's increased economic growth is the country's per capita energy consumption.

Stern (2003) discussed the connection between energy and economic expansion in an article. Its main conclusion is that less energy is consumed per unit of economic production now than higher-quality fuels, particularly electricity, are being employed in place of fossil fuels. The findings support Stern's earlier findings that energy is a constraint on economic expansion. This article shows how energy use, economic expansion, and pollution are all closely related.

Squalli and Wilson (2006) used the limits test approach to test the income hypothesis for G.C.C.'s electricity usage. The study focused on the long-term correlation between economic growth and power usage across all GCCs. It also expressed support for the effectiveness of energy-saving measures—apart from Qatar. Based on their research, Ho and Siu (2006) conclude that there is a one-way causal relationship between real G.D.P. and energy consumption in Hong Kong for the years 1966–2002. Thure Traber (2008) used Granger Causality in a recent study to show the relationship between electricity and economic growth. The study's findings suggested that as long as the economy is growing, there would probably be a rise in the demand for energy.

Conversely, Ciarreta and Zarrage (2007) calculated the causal relationship between Spain's economic growth and power consumption, both linear and non-linear. They discovered unidirectional linear causality between GDP and power consumption between 1971 and 2005. They discover no proof of non-linear Granger causation in either direction between the series. For the differenced series, the Toda, Yamamoto, Dolado, Lutkepohl, and linear Granger causality test in a V.A.R. Chebbi and Boujelbene (2008) looked into the causal relationship and co-integration between energy use and outputs related to agriculture and non-agricultural activities in another study. For the years 1971–2003, the A.D.F. and KPSS (Kwiatkowski et al., 1992) methodologies are applied in Tunisia by Johansen, V.E.C.M. According to empirical findings, the relationship between energy consumption and the agricultural and non-agricultural sectors is only unidirectional. This economy is less dependent on energy as indicated by this unidirectional causality.

There have been conflicting findings in Indian research regarding the causal relationship between economic growth and energy usage. Based on his research, Ghosh (2002) discovered unidirectional linkages where GDP causes electricity. However, Asafu-Adjaya (2000) believed that GDP was caused by energy. The studies mentioned above made it abundantly evident that there is a connection between economic expansion and electricity usage. However, there are no consistent trends in the research about whether electricity use precedes or follows economic growth; as a result, different answers are available based on the methodology, country, and time period analyzed (Atle, 2004).

The research mentioned above unequivocally show a link between rising economic growth and power usage. However, there are no discernible patterns in the literature, and the available data vary based on the nation, study period, and technique. Thus, an attempt has been made in this study to determine the current link that exists in India between the aforementioned two factors.

DATA AND METHODOLOGY

Data and Variables

From 1960 to 2006, all of the data were annual observations of the variables. The Economic Survey and the Centre for Monitoring Indian Economy (CMIE) provide data on electricity consumption. Real GDP data is taken from the Reserve Bank of India (RBI) website. Kilowatt hours are used to measure electricity use, which includes both utility and non-utility usage, or gross power consumption. Real GDP is expressed in millions and is measured at constant price.

Econometric Methodology

There are some methodological issues with the time series data. Only when the series are stationary can relationships be conveniently estimated using the regression method. When a time series is described as "stationary," it means that its mean and variance are both constant. The majority of time series data exhibit seasonality, cycles, and/or trends. To make the series stationary, these deterministic patterns have to be eliminated. Inaccurate conclusions may be drawn from time series whose attributes have not been examined and which are not stationary. Using the following methods, the Granger causality between real GDP and electricity usage has been investigated, to determine if the variables being examined are stationary. The literature is familiar with tests for stationarity, such as the Augmented Dickey Fuller (ADF) test and Phillips and Perron, which are applied to the data series' natural logs. The specification is

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

Where ϵ_t is a pure white noise error term. It is assumed that the error term has a same distribution and is independent. The ADF test was developed by Dickey and Fuller (1981) to address the AR(p) process in the variables. Additionally, we run another unit root test that was suggested by Phillips and Perron (1988). This test uses the same equation as the ADF test, but it does not account for lag differences. The ADF test incorporates lagged difference terms to adjust for higher order serial correlation, whereas the Phillips and Perron test employs a non-parametric correction to accommodate residual serial correlation without requiring the residuals to be white noise.

Granger Causality Test

When deciding how much of the present Y can be described by previous values of Y, the Granger (1969) method is to first ascertain how much of the explanation can be improved by adding lag values of X. If X aids in the prediction of Y or if the coefficients on the lagged Xs are statistically significant, then Y is considered to be Granger-caused by X. Keep in mind that there is often a two-way causal relationship: X Granger causes Y, and Y Granger causes X.

It's crucial to understand that saying "X Granger causes Y" does not mean that Y follows from or is the outcome of X. Granger causality, as used more commonly, quantifies precedence and information content but does not by itself imply causality.

Using more lags in the test regressions is preferable to using fewer since the Granger technique is based on the idea that all previous data is relevant. The lag length, l, must be chosen to match acceptable assumptions about the longest period of time over which one variable could aid in the prediction of the other.

A Granger causality test must be used to ascertain the direction of causality between the variables under investigation if two series are co-integrated.

The following equations are used to determine the causality:

$$\begin{aligned} \Delta Y_t &= a + \sum_{i=1}^k \beta_i \Delta Y_{t-i} + \sum_{i=1}^k \gamma_i \Delta X_{t-i} + \mu \\ \Delta X_t &= a + \sum_{i=1}^k \beta_i \Delta X_{t-i} + \sum_{i=1}^k \varphi_i \Delta Y_{t-i} + \mu \end{aligned}$$

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; a, β , φ and γ are parameters to be estimated; and μ represents the serially uncorrelated error terms. The test is based on the following hypotheses:

$$H_0 : \gamma_i = \varphi_i = 0 \text{ for all } i's$$

$$H_1 : \gamma_i \neq 0 \text{ and } \varphi_i \neq 0 \text{ for at least some } i's$$

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 φ_i are not, then X causes Y ($X \rightarrow Y$). On the contrary, if the values of the φ_i coefficients are statistically significant but those of the γ_i coefficients are not, then Y causes X ($Y \rightarrow X$). If both φ_i and γ_i are significant then there exists bidirectional causality between X and Y ($X \rightleftarrows Y$).

EMPIRICAL FINDINGS

Unit Root Test

Because of the aforementioned models, the E-Views Package has been used for the full empirical analysis. The premise that the series under examination are stationary is supported in the level form by the ADF and the Phillips-Perron test. Table 1 reports the estimated ADF values and Phillips-Perron, which are greater than the critical values at the 5% level of significance.

Table 1. Empirical results of a unit root tests

Variable	Augmented Dickey Fuller		Phillips-Perron	
	Level	Probability	First Difference	Probability
InELEC*	-4.945880	0.0002	-3.191480	0.0272
InGDP*	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).

Granger Causality Test

Table 4 presents the findings of Granger causality between real GDP and electricity consumption, along with the computed F values and corresponding probabilities for the data of those series over the 1960–2006 time period with a specified lag period, as determined by equations (3) and (4). A significance threshold of five percent is selected in order to determine whether the null hypothesis should be accepted or rejected. The Schwarz Information Criterion (SIC) and Akaike's Information Criterion (AKA) were used to determine the lag durations.

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

The lag duration in an AR(p) model has been ascertained using the AIC criterion. For both nested and non-nested models, it is helpful. The model with the lowest AIC score is the one that is preferred when comparing two or more models. Similar to AIC, SIC has been applied to evaluate a model's in-sample and out-of-sample predicting ability. Compared to AIC, SIC penalizes adding regressors to the model more severely.

Table 4. Granger-Engel Test Result

Null hypothesis	F-statistic	p-value	Decision
InGDP doesn't Granger cause InELEC (a)	0.79013 (1)	0.37901(1)	Do not Reject
InELEC dosen't Granger cause InGDP (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.*

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

$$\Delta X_t = a + \sum_{i=1}^k \beta_i \Delta X_{t-i} + \sum_{i=1}^k \varphi_i \Delta Y_{t-i} + \mu$$

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 γ_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 φ_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.

According to our findings, the use of electricity is increasing more quickly than the consumption of primary energy. As a superior energy carrier, electricity can supply almost any energy need, including heat, motion, appliances, lights, and electronics, all from a single system. The advancement of technology in the usage of electricity is essential to the world's economic prosperity. An increasing number of vital end-uses require extremely dependable delivery of high quality "digital-grade" power; India, one of the fastest-growing economies, used almost 70% of this type of energy to boost its economic growth.

CONCLUSION

The relationship between India's economic growth and electricity usage between 1960 and 2006 has been examined in this study. The Granger-Engel method was employed to estimate the outcomes, and our findings show that faster economic growth is caused by electricity. This suggests that rising power usage may be seen as a precursor to an expanding economy. This suggests that the supply of electricity is essential to meet the rising demand for electricity, and that the power sector's inefficiencies must be eliminated immediately in order to maintain India's economic growth as well as the accomplishment of numerous other goals, including the Millennium Development Goals, Higher Growth, and Human Welfare Goals. In order to

eliminate administrative obstacles, efforts should be made to guarantee that different policies are implemented effectively and to unify them at the federal and state levels. Simultaneously, it is imperative to effectively explore alternative options such as public-private partnerships, sustainable technology, and diverse energy resources.

Therefore, strong economic growth requires energy infrastructure, especially electricity, for developing nations like India. The rate of economic expansion will consequently raise the amount of commercial energy consumed. Building nuclear power facilities is one of the greatest options for infrastructure. Although it will take a long time and a large amount of money to build, the economy would benefit in the long run.

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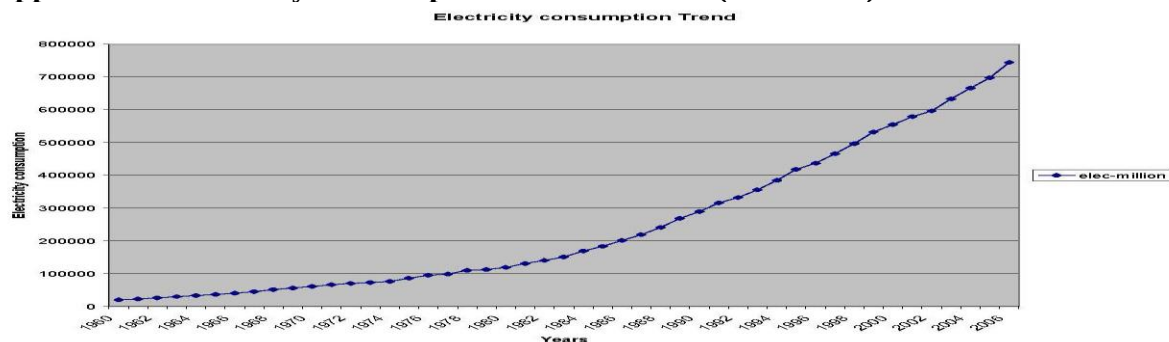
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APPENDIX

Appendix 1. Descriptive Statistics of GDP and Electricity Consumption.

Statistics	InGDP	InELEC
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)

