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Relationship between Electricity Consumption and Economic Growth: A Causality Analysis

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Abstract - The goal of this study is to examine the casual relationship between electricity consumption and economic growth in India during the period of 1991 to 2014. To reach this goal we use Johnson co-integration and granger causality test has applied. The paper is based on Johnson co-integration and granger causality advocate the unidirectional long consumption has a positive impact on the economic growth or electricity consumption cause economic growth.

Keywords: ***Economic growth, electricity consumption, co-integration, Granger causality.***

I. Introduction

Energy is one of the main inputs to the production. Therefore energy is important for both developed countries and emerging and developing countries. The growth of modern economy depends heavily on the performance and growth of electricity sector. Electricity is the prime mover of growth and is vital to the sustenance of developing economy like India. India is the fifth largest producer of electricity in the world. Electricity is considered to be the most convenient and versatile form of energy. It is classified as a secondary source of energy because anyone of the primary sources like coal, gas, petroleum, hydro-power, wind and solar energies may be used to produce electricity. Due to its more adaptable nature, it is a preferred source of energy at the consumer ends. However, energy being a scarce and valuable resource, great emphasis is laid on its optimal uses. Given the characteristics of non-storable nature, requirement of continuous connection between suppliers and consumers and economies of scale, the electricity supply industry was treated as a natural monopoly, all over the world. Electricity is central not only to household activities but to economic development as well. In fact, it is the fuel of economic progress for economic progress in all sectors not only agriculture and industrial but in all allied areas.

Electricity is essentially a prime mover of the economic activities. This paper deals with the relationship between Electricity consumption and economic growth in India. For the purpose of causality analysis time series techniques like unit root test, co-integration test and Granger causality test are utilized.

II. Review of literature

There have been extensive studies on the relationship between energy consumption and economic growth some literature review on the relationship between electricity consumption and economic growth were presented.

Soytas and Sari (2003) examine the casual relationship between GDP and energy consumption from 1950 to 1992 in the top 10 emerging countries. They found bi-directional causality in Argentina, unidirectional causality with energy consumption leading GDP in Turkey, France, West Germany and Japan and the causality with GDP leading energy consumption in Italy and Korea.

Shiu and Lam (2004) study the above relationship for the Chinese economy using data for 1971-2000 periods. By using the Granger causality test, they find a short-run uni-directional casualty running from electricity consumption to real economic growth. This implies that an increase in electricity consumption raises economic growth in China during the review period. According to the authors, around 70-80 per cent of electricity during the 1971-2001 periods was consumed by China’s industrial sector. Moreover, industrial production was one of the significant drivers of China’s economic growth. Therefore, increases in industrial sector demand for electricity consequently increased electrical energy consumption, which in turn raised economic growth. The authors recommend that China needs to enhance its electricity generation capacity and shield the sector from any adverse supply shocks which has the potential to impair China’s economic performance.

Jumbe (2004) also applies the Granger causality test on Malawian time series data over the period 1970- 1999. He finds, based on the Granger causality test, that there exists a bi-directional causality between GDP and electricity consumption. The error correction model, however, portrays a uni-directional relationship running from GDP to electricity consumption.

Yoo (2006) conducts Granger causality test among real GDP and electricity consumption for four ASEAN member countries, namely, Indonesia, Malaysia, Singapore, and Thailand, over 1971-2002. His results reveal a strong bi-directional relationship between electricity consumption and economic growth for Malaysia and Singapore. This suggests that electricity consumption and real GDP are interdependent. Evidence of uni-directional causality running from economic growth to electricity consumption is found for Indonesia and Thailand, implying that energy conservation policies would not dampen economic performance of these two countries. Generally, in all the four countries economic growth is found to stimulate electricity consumption.

Squalli (2006) conducts causality testing for 11 OPEC countries using time series data over the period 1980-2003. Empirical evidence shows that economic growth is largely dependent upon electricity consumption in Indonesia, Iran, Nigeria, Qatar, and Venezuela with evidence of a positive bi-directional relationship running from electricity consumption to economic growth in Iran and Qatar. For Algeria, Iraq and Libya growth is less dependent on electricity consumption. Results suggest a negative causality from GDP to electricity consumption for these 3 countries. For Kuwait, Saudi Arabia and United Arab Emirates there is evidence of negative causality from electricity consumption to growth.

Masih and Mashie (2007) studied the causality between energy consumption and GDP. He found that there is unidirectional relationship between electricity consumption and GDP.

Narayan et al. (2010) examine the long run relationship between energy consumption and GDP and also examine the impact of GDP growth on energy consumption for 93 countries during the time period from 1980 to 2006 .he used unit root tests and co-integration test. Granger test with in an error –correlation framework found that there is bidirectional causality between electricity consumption and GDP.

Oztirk (2010) provide four hypotheses about the direction of causality between energy consumption and GDP. The first is the hypothesis of neutrality which holds that there is no causality between these two variables. The second is energy conservation hypothesis, which holds that there is evidence of unidirectional causality from GDP growth to energy consumption. He also used third hypothesis which is known as growth hypothesis. He found that there is a bidirectional relationship between energy consumption and GDP growth.

Hamden, Sabia, &Jlass (2014) investigated the relationship between per capita electricity consumption and gross domestic product (GDP) per capita for Brazil, India, Indonesia, China and South Africa .This study used panel co-integration analysis and Granger causality test. The study found that electricity consumption and GDP are co – integrated and granger causality test found a long run relationship between electricity consumption and GDP growth for all countries except for South Africa. The study found that there is unidirectional and relationship between these two variables.

Srivastava (2016) investigated the long run relationship between electricity consumption and GDP .The study used cross state panel data from 2000 to 2013 .on this study the granger causality test has been utilized .the result shows the bidirectional relationship between electricity consumption and GDP.

III. Data Description and Sources

This paper has used two variables i.e. electricity consumption and GDP from time period 1990-91 to 2015-16 at constant price at level 05. GDP is taken as the proxy of economic growth. Electricity consumption and GDP data has been collected from planning commission Government of India.

IV. Empirical Methodology and result

4.1. Test of Stationarity

In the time series analysis it is needed that the variables should be stationary. It is so due to the misspecification of the results. The stationary of data has been characterized by a time variant mean and variance. If mean and variance of a data are constant then the data is called stationary. If variables are not stationary at Level then the difference will be required to examine whether they are stationary at Level one. This study has applied Augmented Dickey Fuller (ADF) test suggest that all variables taken in this study are unit root at Level. Before applying the test the natural log (LN) of the variables are taken. Then stationary of variables are examined three different models such as intercept, trend, and no trend and no intercept. There are three models of ADF test which are intercept, trend and intercept and no trend and no intercept. All these models are used for the examination of unit root.

4.2 Unit root at level

In this section Augmented Dickey Fuller (ADF) Test which has been applied at level in all three models such as Intercept, Trend and Intercept and no trend and no intercept. Null hypothesis is there is unit root and alternative hypothesis is there is stationary in the data. The rejection of null hypothesis is based on the criteria of test statistics and probability value. If test statistics is more than critical value at 5 percent level of significant the null hypothesis will be rejected. On the other hand probability value (p-value) plays a crucial role to check significance of the model. The p-value is less than 0.05 leads to rejection of null hypothesis. In the following table 4.2reveals the results of ADF test at level.

Table 4.2:Unit root at level				
variables	model of ADF	t-stat.	5% crit. value	Prob.
lnElec con	Intercept	0.726	-3.005	0.990
	trend and intercept	-3.858	-3.674	0.036
	None	1.797	-1.957	0.979
ln GDP	Intercept	1.463	-2.998	0.999
	trend and intercept	-1.686	-3.633	0.723
	None	15.655	-1.956	1.000

The results of ADF test has been portrayed the above table 4.2. Electricity consumption is one of the variables taken in this study which unit root has been examined for intercept it is found that the absolute value of t-statistics (0.726) is less than absolute critical value (-3.005) at 5%. But the probability value is (0.990) more than 0.05 that indicates that the null hypothesis cannot be rejected. It means that the variable electricity consumption has unit root for intercept at level.

Trend and intercept is another model of ADF test. In this model the absolute value of test statistics for electricity consumption (-3.858) is more than absolute critical value (-3.674) at 5%. Probability value for this model is (0.036) less than 0.05. These values indicate that the null hypothesis for this model can be rejected. It means the variable in this model has stationary characteristics.

The third model of the ADF test for electricity consumption is no trend and no intercept. In this model the absolute value of test statistics (1.797) is less than the absolute critical value at 5% level of significance. The probability value for this model is 0.979 which is more than 0.05. It indicates that the null hypothesis cannot be rejected in this model.

The second variable is Gross Domestic Product (GDP). ADF test has also been adopted for its unit root examination. In this variable three models such as intercept, trend and intercept and no trend and no intercept have been applied. In intercept the absolute value of test statistics is (1.463), less than absolute critical value (-2.998) at 5 % level of significance. The probability value is (0.999), more than 0.05. These results indicate that the null hypothesis cannot be rejected. It means the GDP has unit root in this model.

In trend and intercept model the absolute value of test statistics (-1.686) is less than absolute critical value (-3.633) at 5% level of significance. But the probability is (0.723) is more than 0.05. It shows that the null hypothesis at this level cannot be rejected and GDP got unit root in this model.

The third model is no trend and no intercept in which the absolute value of test statistics (15.655) is more than absolute critical value (-1.956) at 5% level of significance. The probability value (1.000) is greater than 0.05. It means the null hypothesis cannot be rejected and the variable has unit root in this model.

In aggregate it can be said that electricity consumption and GDP has unit root at level.

4.3. Unit root at level one

For the time series analysis it is necessary that the variables should be stationary .we found that the data are unit root or not stationary at level. So it is required to take difference so that the variables might be stationary at level one. The result of ADF test in three models is depicted in the table 4.3. In the model intercept absolute value of t-statistics (-2.071) for electricity consumption is less than absolute critical value (-3.005) at 5% level of significance. The probability value is 0.257, more than 0.05. It indicates that the null hypothesis cannot be rejected. It means that in this model data of electricity consumption has unit root.

Table 4.3: Unit root at level 1

Variables	Model of ADF	t-stat.	5% crit. Value	Prob.
lnElec con	Intercept	-2.071	-3.005	0.257
	trend and intercept	-2.374	-3.633	0.381
	None	-1.083	-1.957	0.244
ln GDP	Intercept	-3.758	-3.005	0.102
	trend and intercept	-3.333	-3.633	0.087
	None	-0.548	-1.957	0.468

Source: Calculated by Researcher by using E-views 9.5.

4.4.Unit root at level two

Since data for the variables are not stationary at level and level one, then it is requires going for the unit root at level two. At this model ADF test have also been utilized to check the stationarity criterion. The models taken in this test are intercept, trend and intercept and no trend and no intercept. The results of the test have been depicted in the table 4.4. In the model of intercept it is found that the absolute value of t-statistics (-5.148) is more than absolute value of critical value at 5% level i.e. (-3.012). The probability value for this model is 0.001, less than 0.05. It indicates that the null hypothesis can be rejected and data of electricity consumption is stationary at level two.

Table 4.4: Unit root test at level 2

Variables	Model of ADF	t-stat.	5% crit. Value	Prob.
lnElec con	Intercept	-5.148	-3.012	0.001
	trend and intercept	-5.012	-3.645	0.003
	None	-5.289	-1.958	0.000
ln GDP	Intercept	-6.440	-3.012	0.000
	trend and intercept	-6.547	-3.645	0.000
	None	-6.620	-1.958	0.000

Source: Calculated by the researcher by using E-Views 9.5.

In the second model of ADF test is trend and intercept. In this model the absolute value of test statistics of electricity consumption is -5.012, more than the absolute critical value (-3.645) at 5% level of significance. The probability value is 0.003, less than 0.05. It means the null hypothesis can be rejected and the data is stationary at this level.
In the model no trend and no intercept the absolute critical value (-5.289) is more than the absolute critical value (-1.958) at 5% level of significance. The probability value 0.000 is less than 0.05. It prompts to reject the null hypothesis. it means that the variables is stationary at this level.

The table 4.4.Shows the results of unit root for GDP. It shows that in the model intercept the absolute value of the test statistics (-6.440) is more than the absolute critical value (-3.012) at 5% level of significance and the probability value (0.000) is less than 0.05. It indicates to reject the null hypothesis. It means the data is stationary at this level in this model.

In trend and intercept the absolute value of test statistics (-6.547) is more than the absolute critical value (-3.645) at 5% level of significance. The probability value is 0.000 which is less than 0.05. It state that the null hypothesis can be rejected and the data is stationary in this model at this level.

In the model when there is no trend no intercept the absolute value of test statistics (-6.620) is more than the absolute critical value (-1.958) at 5% level of significance and the probability value is 0.000, less than 0.05. It shows that the null hypothesis can be rejected and the data of the variable is stationary in this model at this level.

At level two variables, electricity consumption and GDP has stationarity criterion for the time series analysis.

4.5.Johansen co-integration test

After examining the stationarity of variables it is needed to check whether they are co- integrated or not. For this purpose the johansen co- integration test is necessary. After examining the unit root, it is necessary to examine whether they are co-integrated. In test two statistics are utilized one is Trace statistics and other is max statistics. To examine the long run relationship between electricity consumption and GDP Johansen co integration test has been utilized in this study. The results of Johansen test presented in the table 4.5

Table 4.5: Johansen co-integration test

	Trace statistics			Max Statistics		
No. of Co-integration	trace stat.	5% crit. value	Prob.	Max eigen stat.	5% crit. value	Prob.
None	38.464	15.495	0.000	33.455	14.265	0.000
Atmost one	5.009	3.841	0.025	5.009	3.841	0.252

Source: Calculated by researcher by using E-views 9.5.

The above table 4.5 revels that results of co –integration The value of trace statistics and max statistics are more than 5% critical value. These values indicate that the null hypothesis, there is no co integration can be rejected. It means that the variables are co integrated. Further the electricity consumption and GDP have long run relationship.

4.6. Granger Causality Test

To identify the direction of causality it is necessary to estimate the vector auto regression model (VAR) model and then examine the causality. It does not only examine the causality but also it checks the direction of the causality. In this study causality has been examined between Electricity consumption and GDP. Granger causality test has been utilized for the purpose of causality analysis and the results of the test are portrayed in the following table 4.6.

Table 4.6: Granger causality test		
Null Hypothesis	F-stat.	Prob.
Ln GDP does not granger cause LNELEC Con	5.546	0.011
lnElec con does not granger cause Ln GDP	2.137	0.144
Source: Calculated by Researcher by using E-Views 9.5.		

The above table 4.6 shows the results for the direction of causality. The probability value (P-value) which is less than 5% level of significance ensure that causality electricity consumption and to GDP growth. It means economic growth is caused by electricity consumption. Further the F- statistics and probability value are 2.137 and 0.144 respectively for the null hypothesis Ln ELEC Con does not granger cause GDP. Here the probability value is more than 0.05 which indicates that the null hypothesis cannot be rejected. It means the electricity consumption does not granger cause GDP.

a. Lagrange Multiplier (LM)test for auto correlation

Once the causality test is completed it is necessary to examine the robustness of the model taken in this study. For this purpose it is necessary to check the presence of auto correlation and normality test of disturbance terms Lagrange multiplier (LM) test and Jarque – Bera test are applied respectively.

The Lagrange Multiplier test for auto correlation was developed by Brewch (1978) and Godfrey (1978). It investigates the auto –correlation among the variables. It became a slandered tool in applied econometrics. In this test the null hypothesis is there is no auto correlation and it can be rejected if the probability values is less than 5% level of significant. The result of the LM test are presented in table

Table 4.7: Lagrange Multiplier (LM) Test for Auto correlation		
Lags	LM Stat (chi-square)	P-value
1	1.715	0.788
2	7.172	0.127
Source: Calculated by researcher by E-views 9.5		

The above table depicts the statistics for LM test. This study focuses mainly on the p-value. The p-value is more than 0.05, i.e. 0.788. It leads to not to reject the null hypothesis. It means there is no presence of auto correlation in the model.

4.8. Jarque –Bera test for normally distributed disturbances

It was developed to test normality, Heteroscedasticity and serial correlation or auto correlation of regression residuals (Jarque and Bera 1980). The statistics is this test is computed from Skewnessand Kurtosis. It follows the Chi –Squred distribution with two degree of freedom. Here the null hypothesis is residuals are normally distributed which can be rejected if the probability value is less than 5%.

Table 4.8.: Jarque-Bera Test for normal distribution of residuals

Component	Jarque-Bera(chi-square)	df	P-value
1	0.874	2.000	0.646
2	1.777	2.000	0.411
Joint	2.651	4.000	0.617
Source: Calculated by researcher by E-views 9.5			

In the above table 4.8 depicts that the p-value is more than 0.05 level of significant. It means that the null hypothesis cannot be rejected. It means the residuals are normally distributed in this model and thus satisfy the assumptions of CLRM.

V. Conclusion

The prime aim of this paper was to find the causality between electricity consumption and economic growth in India from 1991to 2014.Theresults of this study found that the GDP causes electricity consumption but electricity consumption does not cause GDP. It means the causality goes from economic growth to electricity consumption. It is found in this paper that electricity consumption accelerate the pace of economic growth in India.

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