CHAPTER -5

CAUSAL RELATION BETWEEN ELECTRICITY CONSUMPTION AND ECONOMIC GROWTH

5.1. Introduction

This chapter deals with the relationship between electricity consumption and economic growth in India. Especially causality between the variables has been examined in this chapter. Here unit root test, co-integration test and Granger causality test are systematically applied for the purpose of causality analysis.

5.2. Unit Root Test

The prime assumption of time series technique is to examine the stationarity of the data for the variables taken in the study. The time series data of the variables taken are electricity consumption (ELECONSPN) and GDP (taken proxy for economic growth). The stationarity 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 stationarity. To avoid the problems of spurious regression, it is necessary to confirm whether a stationarity and co-integration relationship among the variables. In this study has applied ADF test to check the stationarity of the variables. The stationarity test has been carried out at the level as well as at their first and second difference. There are three models of ADF test which are with 'intercept', 'with trend and intercept' and 'without trend and without intercept'. All these models are used for the examination of unit root.

5.2.1. Unit Root at Level

In this section ADF test which has been applied at level in all three models - intercept, trend and intercept and no trend and no intercept. Null hypothesis (H_0) of this test is 'There is unit root' and alternative hypothesis (H_1) is 'There is stationarity in the data'. The acceptance of null hypothesis is based on the criteria of test statistics or probability (p-value) value. If the test statistics is smaller than critical value at 5 percent level of significance, the null hypothesis will be accepted or p-value is greater than 0.05 leads to acceptance of null hypothesis. In the following Table 5.2.1.1 reveals the results of ADF test at level.

Table 5.2.1.1. Unit Root at Level				
Variables	**Model of ADF**	**t-stat.**	**Critical Value (5%)**	**Prob.**
lnELECONSPN	Intercept	0.726	-3.005	0.990
	Trend and Intercept	-3.858	-3.674	0.036
	None	1.797	-1.957	0.979
lnGDP	Intercept	1.463	-2.998	0.999
	Trend and Intercept	-1.686	-3.633	0.723
	None	15.655	-1.956	1.000
Source: Calculated by researcher using E-Views 9.5.				

The results of ADF test has been portrayed in the above Table 5.2.1.1. Electricity consumption (ELECONSPN) is one of the variables taken in this study which unit root has been examined for intercept. It can easily be seen that p-value (0.990) is more than 0.05 that indicates that the null hypothesis would be accepted. It means that the variable electricity consumption has unit root for intercept at level.

'Trend and intercept' is another model of ADF test. For this p-value (0.036) is less than 0.05. This indicates that the null hypothesis for this model cannot be accepted. It means the variable electricity consumption in this model has stationarity characteristics.

The third model of the ADF test for electricity consumption is 'no trend and no intercept'. In this model, the p-value (0.979) is more than 0.05 is. It directs that the null hypothesis would be accepted in this model. It means that the variable electricity consumption has unit root for 'no trend and no intercept' at level.

The second variable is 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 p-value is 0.999 which is more than 0.05. It shows that the null hypothesis is accepted. It means the variable GDP has unit root in this model.

In 'trend and intercept' model, p-value (0.723) is more than 0.05. It displays that the null hypothesis, at this level, is accepted; thus, the variable GDP has unit root in this model.

The third model is 'no trend and no intercept'. For this the p-value (1.000) is greater than 0.05. It means the null hypothesis is accepted. It means the variable has unit root in this model.

In short it can be said that both the variables electricity consumption and GDP have unit root at level.

5.2.2. Unit Root at Level One

The ADF test at level ensured that these two variables, electricity consumption (ELECONSPN) and GDP got unit root. Now it is required to check unit root for these variables at level one. The results of ADF test in three models are depicted in the Table 5.2.2.1. It is clear that for both the variables electricity consumption (ELECONSPN) and GDP, p-values are more than 0.05 for all the models. Therefore, both the variables have unit root at level one.

Table 5.2.2.1. Unit Root at Level 1

Variables	Model of ADF	t-stat.	Critical Value (5%)	Prob.
lnELECONSPN	Intercept	-2.071	-3.005	0.257
	trend and intercept	-2.374	-3.633	0.381
	None	-1.083	-1.957	0.244
lnGDP	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 using E-Views 9.5.

5.2.3. Unit Root at Level Two

Since time series data for the variables are not found stationary at level and level one, it is required to go for the unit root at level two. At this level two, ADF test is again applied 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 5.2.3.1.

Table 5.2.3.1. Unit Root Test at Level 2				
Variables	**Model of ADF**	**t-stat.**	**Critical Value (5%)**	**Prob.**
lnELECONSPN	Intercept	-5.148	-3.012	0.001
	trend and intercept	-5.012	-3.645	0.003
	None	-5.289	-1.958	0.000
lnGDP	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 researcher using E-Views 9.5.				

It is clear that for both the variables electricity consumption (ELECONSPN) and GDP, p-values are less than 0.05 for all the three models - ‘intercept’, ‘trend’ and ‘intercept’ and ‘no trend and no intercept’.

Therefore, at level two of ADF test, the variables electricity consumption and GDP has stationarity criterion for the time series analysis.

5.2.4. Johansen Co-integration Test

It deals with long run relationship between the variables of the study. To examine the long run relationship between electricity consumption (ELECONSPN) and GDP, Johansen co-integration test has been used in this study. This test is based on ‘Trace Statistics’ and ‘Max Statistics’.

Null hypothesis (H_0) of this test is ‘There is no co-integration between the variables’ and alternative hypothesis (H_1) is ‘There is co-integration between the variables’. The acceptance of null hypothesis is based on the criteria of test statistics or probability (p-value) value. If the test statistics is smaller than critical value at 5 percent level of significance, the null hypothesis will be accepted or p-value is greater than 0.05 leads to acceptance of null hypothesis. In the following Table 5.2.1.1 reveals the results of ADF test at level.

Johansen co-integration test results for the variables electricity consumption (ELECONSPN) and GDP are depicted in the Table 5.2.4.1 below.

Table 5.2.4.1. 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
At most one	5.009	3.841	0.025	5.009	3.841	0.252

Source: Calculated by researcher using E-Views 9.5.

The value of trace statistics is 38.464 which is more than 15.495 at 5% critical value. On the other hand the max statistics is 33.455 which is more than 14.265 at 5% critical value. (The p-value for both statistics is 0.000 which is less than 0.05.). This indicates that the null hypothesis (H_0) 'There is no co-integration between the variables' cannot be accepted'. It means that alternative hypothesis (H_1) 'There is co-integration between the variables'. Therefore, it can be concluded that the variables 'Electricity Consumption' (ELECONSM) and 'GDP' have long run relationship.

5.2.5. Granger Causality Test

Granger causality test deals with the causal relationship between the variables of the study. It does not only examine the causality but also it tells the direction of the causality. In this study causality has been examined between electricity consumption and GDP. Granger causality test has been applied here for the purpose of causality analysis; and the results of the test are portrayed in the following Table 5.2.5.1.

Table 5.2.5.1. Granger Causality Test		
Null Hypothesis	**F-stat.**	**Prob.**
lnGDP does not granger cause lnELECONSPN	5.546	0.011
lnELECONSPN does not granger cause lnGDP	2.137	0.144
Source: Calculated by researcher using E-Views 9.5.		

The above table shows that the F- statistics and probability value are 5.546 and 0.011 respectively for the null hypothesis 'lnGDP does not granger cause lnELECONSPN.' Here, the probability value is less than 0.05 which signifies to reject the null hypothesis. It means the GDP causes electricity consumption.

Further, the F- statistics and probability value are 2.137 and 0.144 respectively for the null hypothesis 'lnELECONSPN does not granger cause lnGDP.' Here, the probability value is more than 0.05 which indicates that the null hypothesis would be accepted. It means the electricity consumption does not granger cause GDP.

Therefore, the result of Granger causality test shows that GDP causes electricity consumption but electricity consumption does not cause economic GDP. It means the causality goes from economic growth to electricity consumption. In nut shell, it can be said that there is uni-directional relationship exists between electricity consumption and economic growth in India.

5.3. LM Test for Autocorrelation

Lagrange multiplier test examines the auto correlation between the variables. The term correlation may be defined as correlation between members of series of observations ordered in time or space in time series and cross- sectional data respectively. In the context of regression, the classical linear regression model (CRLM) assumes that such autocorrelation does not exists in the disturbances $u_{i.}$ i.e.

$$E(u_i u_j) = 0 \, , \, i \neq j \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (5.1)$$

In other words, the classical model has the assumption that the error term related to any observation. Auto correlation as lag correlation of a given series with itself, lagged by a number of time units. If there is a series such as u_1, u_2, u_3,…………..,u_{10} and u_2, u_3,…………..,u_{11} in these series former is the latter series lagged by one time period which is auto correlation (Gujrati, 2004). In the assumption of CLRM, efficiency is one of the essential requirement for the best linear unbiased estimator (BLUE). Although the presence of auto correlation, the ordinary least square (OLS) estimators are still linear unbiased, consistent and asymptotically normally distributed, but then, they are no more efficient (i.e., minimum variance). This study has applied the LM test for examination of the presence of auto correlation in the model. The null hypothesis (H_0) of the test is 'There is no auto correlation.' The p-value greater than 0.05 leads to accept the null hypothesis. It means there is no auto correlation. This study has run the LM test; and the results are depicted in the Table 5.3.1.

Table 5.3.1. 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 using E-Views 9.5.

The above table shows that p-value (0.788) is more than 0.05. It leads to acceptance of the null hypothesis. It means there is no presence of auto correlation in the model.

5.4. Jarque-Bera (JB) Test of Normality

The JB test of normality is built on the OLS residuals (u_i). Mainly this test focuses on the normality of residuals (u_i) in the model. The assumptions of CLRM for BLUE properties of OLS needs that residuals terms (u_i) have zero mean value, constant variance and zero auto correlation. Further, it is also needed for hypothesis testing residuals terms (u_i) follows the normal distribution with mean and variance i.e.

$$\ln u_{i} \sim N(0, \sigma^2) \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (5.2)$$

The JB test is the large sample test, based on the OLS residuals. This test computes skewness as well as kurtosis, the measures of the OLS residuals. The null hypothesis (H_0) of the test is 'The residuals are normally distributed.' The p-value greater than 0.05 leads to acceptance the null hypothesis. It means the residuals are normally distributed. This study applies the JB test to check the normality in the model; and results of the test has been portrayed in the Table 5.4.1.

Table 5.4.1. 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 using E-Views 9.5.

In the above table chi-square and p-value have been presented. Here, p-value is more than 0.05 in both of the components as well as in joint components. So, the null hypothesis is accepted. It means the residuals are normally distributed in this model; and thus, satisfy the assumptions of CLRM.

After the detailed analysis, it can be concluded that economic growth causes the electricity consumption while electricity consumption does not cause economic growth in India. Lagrange Multiplier (LM) test and Jarque Bera (JB) test investigated whether there is presence of auto correlation and normality. These two tests scientifically confirmed the absence of auto correlation and presence of normality in data set of the variable under consideration.