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ESTIMATING THE LONG RUN RELATIONSHIP BETWEEN ENERGY CONSUMPTION AND NET NATIONAL PRODUCT IN INDIA

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ABSTRACT

Using the yearly time series data of per capita electricity consumption (IEA, 2018) and the per capita net national product (RBI, 2016), this paper seeks to find out the long run relationship between these two variables. The Johansen Co-integration test suggests that they are integrated of order 1. Using least square estimation it is found that over the 43 years (1977-2014) a unit increase in PCNNP has helped to raise the PCKWH by 1 percent per annum in the long run relationship. Also, the Engle-Granger test satisfies the condition of convergency of the two variables in the long run.

Keywords: Co-integration; Consumption; Convergent; Relationship; Variables.

1. INTRODUCTION

Energy consumption, precisely the electrical energy has become a prerequisite for our everyday life activities. It is found that the per capita energy consumption is positively correlated with the GDP of a country, indicating that the per capita electricity consumption is highly associated with the higher GDP of different countries of the world (Ghouri S S, 2006). Researchers are of the opinion that GDP increase causes higher per capita energy availability as well as consumption while they also argue i.e. higher per capita energy consumption increases the GDP of a country. For example, Kraft et.al (1978) found unidirectional causality from GDP to energy consumption in the United States for the 1947-1974. This assertion was proved by Abosedra et.al (1991) by using the standard test of Granger causality. Yang H Y (2000) re-examined the causality between energy consumption and GDP, the causal relationship between GDP and the aggregate as well as several disaggregate categories of energy consumption, including coal, oil, natural gas, and electricity was found to be having bidirectional causality between total energy consumption and GDP. Infact, this suggests that the literature is still contradictory on the direction of causal relationships between the level of energy consumption and the GDP based on the location and sectoral variations of the compositions of GDP of a country or region.

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It is indeed rational to believe that, as the income level of the individual or a household increases their energy consumption level will also increase. This is primarily attributed to the number of electrical equipments used in the households going up as the income level of households' increases. Kamaludin (2013) had found that for developing countries real GDP per capita significantly affects electricity consumption underlying with the interpretation that "…when income increases, people tend to consume more advanced electrical appliance since it reflects their standard of living. When income increases, the consumer's purchasing power also will increase...". A study by Tewathia (2014) had found that the monthly average income of the household, stock of electrical appliances, size of the family and the size of the household had a significant impact on the average monthly household electricity consumption. Studies from a different point of view such as done by Narayan et al. (2010) examined the long-run elasticities of the impacts of energy consumption on GDP in addition to the impacts of GDP growth on energy consumption for 93 countries during the time period from 1980 to 2006. They applied unit root tests and the cointegration test of Pedroni (1999) to calculate long-run elasticities between energy consumption and GDP and GDP and energy consumption.

2. NEXUS BETWEEN PER CAPITA kWh (PCkWh) AND PER CAPITA NET NATIONAL PRODUCT (PCNNP)

The per capita kilowatt hour (PCkWh) is the amount of per head consumption of electricity by the individuals of a country or the total amount of electricity consumed in a country divided by the total population of a country for a year. The net national product (NNP) refers to gross national product (GNP), i.e. the total market value of all final goods and services produced by the factors of production of a country or other polity during a given time period, minus depreciation. While the per capita net national product (PCNNP) is the total market value of all final goods and services produced by the factors of production of a country or other polity during a given time period minus the depreciation divided by the total number of population of a country for a particular year. Intuitively, it is a general belief that as the income level of the individuals increases they look out for better living standards. In quest for their better living standards, people start to consume more of energy in different forms. For example there is the shifting from a fuel-wood for cooking to a LPG gas connection, increase in the size of house dwelling from small to large or more rooms or space. In both the cases it involves the demand for more energy wherein, the later is more attributable to the present study. Primarily, as there is an increase in the size of the house coupled with the higher demand for more electrical equipments for a better standard of living, their demand for electricity becomes more to get the required services out of it. In a whole increase in the demand for electricity rises as the income level of the consumers' increases over the years. As Kamaludin M (2013) had rightly stated that "…when income increases, people tend to consume more advanced electrical appliance since it

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reflects their standard of living. When income increases, the consumer's purchasing power also will increase...". Thus, hypothetically PCkWh is affected by the PCNNP of the individuals of a country.

3. OBJECTIVE, HYPOTHESIS, DATA SOURCE AND METHODOLOGY

3.1 Objective

To measure the impact of PCNNP on PcKWh

3.2 Hypothesis

PCNNP and PcKWh converge in the long run

3.3 Data Source

The study is solely based on secondary sources of data. Data sources have been accessed from International Energy Agency (www.iea.org), Reserve Bank of India (www.rbi.org.in) and other internet sources for article reviews.

3.4 Methodology

The study is designed as follows; firstly the unit root tests are done by using ADF test for both PCkWh and PCNNP of which both of them are found to be non-stationary. Secondly the first differences of both the variables are taken and ADF test is carried out, then both the variables are found to be stationary. Thirdly, the Johansen cointegration test is carried which suggests that the variables are cointegrated of order 1. Fourthly, the OLS estimation is done to find out the rate of dependency between the two variables. Lastly, the error correction model is employed by using Engle-Granger test to ascertain the viability of convergence of the two variables in the long run.

4. TEST FOR STATIONARITY OF THE VARIABLES

Here in the study, the annual data for Per Capita Kilowatt Hour (PCkWh) is obtained from International Energy Agency, Statistics and the Per Capita Net National Product (PCNNP) is obtained from the Reserve Bank of India website for the period 1971-2014 *(Appendix I)*.

Generally the test for stationarity of a data set is carried out for a time series data set before we go ahead for any kind of estimation. Theoretically it is possible to estimate the data sets only if it is stationary or else we have to go for differencing of the data sets to turn them into stationary data sets. Initially, the test results reveal that both the variables are non-stationary or have the unit root which is done by using the ADF test for stationarity *(see table 1a & 1b)*. So therefore

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we cannot go for estimation of the variables'. Indeed if we try to regress one non-stationary series on another non-stationary series this would result into or give us a spurious relationship.

Table 1a: ADF Test Result

Null Hypothesis: PCKWH has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic - based on SIC, maxlag=9)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		2.450944	1.0000
Test critical values:	1% level	-4.186481	
	5% level	-3.518090	
	10% level	-3.189732	

*MacKinnon (1996) one-sided p-values.

Source: Authors calculation, Eviews 9.5 result

Table 1b: ADF Test

Null Hypothesis: PCNNP has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 9 (Automatic - based on SIC, maxlag=9)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		4.556783	1.0000
Test critical values:	1% level	-4.252879	
	5% level	-3.548490	
	10% level	-3.207094	

*MacKinnon (1996) one-sided p-values.

Source: Authors calculation, Eviews 9.5 result.

ADF test results for both the variables are insignificant *(Table 1a & 1b)*. So we can say that the data sets are non-stationary. Now in order to make the data sets stationary we have to go for differencing of the data sets and check its level of stationarity. Hereafter we can go for estimation of the parameters for those variables involved. Here, after taking the first difference and applying the ADF test it is found that both the data sets become stationary *(see Table 2a & 2b)*.

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Table 2a: ADF Test

Null Hypothesis: D(PCKWH) has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic - based on SIC, maxlag=9)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-3.972108	0.0174
Test critical values:	1% level	-4.192337	
	5% level	-3.520787	
	10% level	-3.191277	

*MacKinnon (1996) one-sided p-values.

Source: Authors calculation, Eviews 9.5 result

Table 2b: ADF Test

Null Hypothesis: D(PCNNP) has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 5 (Automatic - based on SIC, maxlag=9)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-4.033552	0.0160
Test critical values:	1% level	-4.226815	
	5% level	-3.536601	
	10% level	-3.200320	

*MacKinnon (1996) one-sided p-values.

Source: Authors calculation, Eviews 9.5 result

Now the ADF test result reveals that both the variables are highly significant at 1 percent level of significance or the data sets have become stationary.

5. COINTEGRATION TEST

To check whether the data sets are cointegrated or not the Johansen test is carried out to find out or ascertain their level of cointegration.

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Table 3: Johansen Cointegration Test

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.317231	18.78485	15.49471	0.0154
At most 1	0.063551	2.757733	3.841466	0.0968

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Source: Authors calculation, Eviews 9.5 result

The Johansen cointegration test reveals that the two variables PCkWh and PCNNP are cointegrated of order 1. This test result is significant at 5 percent level of significance *(see table 3)*.

6. ESTIMATION OF THE PARAMETER USING OLS

Now that we have turned the non-stationary data sets to stationary by taking the first difference of both the data sets and have also found that the two variables are cointegrated of order 1, we can proceed for estimation of the parameters. The model to be estimated is;

$\Delta PCkWh_t = \alpha + \beta \Delta PCNNP_t + U_t$

where

Δ = first difference of the respective variables

PCkWh = Per Capita Kilowatt Hour (electricity consumption)

PCNNP = Per Capita Net National Product

U_t = White Noise Term

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Table 4: Estimation of the Parameter

Dependent Variable: PCKWH
Method: Fully Modified Least Squares (FMOLS)
Date: 09/28/18 Time: 21:09
Sample (adjusted): 1972 2014
Included observations: 43 after adjustments
Cointegrating equation deterministics: C
Long-run covariance estimate (Bartlett kernel, Newey-West fixed bandwidth = 4.0000)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
PCNNP	0.011372	0.000907	12.54242	0.0000
C	171.1553	20.37569	8.399974	0.0000

R-squared	0.916339	Mean dependent var	341.7145
Adjusted R-squared	0.914299	S.D. dependent var	197.9107
S.E. of regression	57.93785	Sum squared resid	137628.6
Long-run variance	9963.178		

Source: Authors calculation, Eviews 9.5 result

The test result reveals that, over the 43 years (1971-2014), a unit increase in the PCNNP has helped to increase the PCkWh by 1 percent per annum in the long run relationship.

7. ERROR CORRECTION OR TEST FOR CONVERGENCE IN THE LONG RUN

Here in the error correction model to test for consistency of the cointegrated relationship between these two variables we find that the adjustment coefficient is negative. Thus we can be sure that the two variables are cointegrated consistently in the long run relationship.

Table 5: Engle-Granger Test

Engle-Granger Test Equation:
Dependent Variable: D(RESID)
Method: Least Squares
Date: 09/28/18 Time: 21:12
Sample (adjusted): 1972 2014
Included observations: 43 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
RESID(-1)	-0.229989	0.094867	-2.424339	0.0197

R-squared	0.116731	Mean dependent var	3.109957
Adjusted R-squared	0.116731	S.D. dependent var	37.95991
S.E. of regression	35.67563	Akaike info criterion	10.00979
Sum squared resid	53455.51	Schwarz criterion	10.05075
Log likelihood	-214.2106	Hannan-Quinn criter.	10.02490
Durbin-Watson stat	2.253629		

Source: Authors calculation, Eviews 9.5 result

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8. OBSERVATIONS AND CONCLUSION

The study has found that there is a long run relationship between the PCkWh and the PCNNP in India. Using the least square estimation it is found that as the PCNNP of India increased, it has also helped or in other terms has raised the electricity consumption level in India by 1 percent. It is also now a established fact that the two variables have a long run relationship based on the results obtained from ECM.

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Appendix I

Year	PCkWH	PCNNP	Year	PCkWH	PCNNP
1971	98.06	763	1993	321.71	7086
1972	100.60	792	1994	342.46	8106
1973	100.92	850	1995	360.05	9292
1974	104.29	1021	1996	361.09	10695
1975	114.89	1169	1997	376.80	12250
1976	124.49	1204	1998	387.20	13352
1977	126.63	1266	1999	393.37	15158
1978	136.33	1421	2000	394.96	16546
1979	136.16	1492	2001	395.10	17381
1980	142.15	1578	2002	411.97	18523
1981	152.36	1852	2003	431.84	19706
1982	158.61	2115	2004	453.01	21763
1983	166.24	2291	2005	469.45	24143
1984	183.92	2634	2006	510.75	27131
1985	194.20	2878	2007	543.36	31206
1986	208.70	3128	2008	562.90	35825
1987	221.00	3408	2009	600.20	40775
1988	240.88	3760	2010	642.11	46249
1989	257.96	4384	2011	698.55	54021
1990	273.05	4934	2012	724.79	61855
1991	291.95	5621	2013	765.56	45461
1992	305.54	6295	2014	805.60	51764

Source: Per capita kilowatt hour (PCkWh) accessed from: https://www.iea.org/statistics/?country=INDIA&year=2016&category=Key%20indicators&indicator=ElecConsPerCapita&mode=chart&categoryBrowse=false&dataTable=INDICATORS&showDataTable=false and Per capita net national product at factor cost (PCNNP) accessed from: https://rbidocs.rbi.org.in/rdocs/Publications/PDFs/TABLE14F93E38DA5134E039BC26AD9E78ECABD.PDF