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Article

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Energy Consumption and Economic Growth: The Evidence from India

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ABSTRACT

The oil price shock of the 1970s and its disruptive impact on the economic activities all over the world dragged the attention of researchers to study the interaction between energy and real output. However, no conclusive evidence could be submitted about the direction of causality between the two. The present study has been an attempt to understand such relationship in the case of India. The paper has used the data from 1971 to 2014 and has found long run stable relationship between energy use and real output. The study also reveals that in the short run, there is unidirectional relationship between the two and energy Granger causes economic activities in India. In the long run, we find bidirectional relationship between energy and economic prosperity of India.

Keywords: Oil Consumption, Economic Growth, India
JEL Classifications: E20, E22, E31

1. INTRODUCTION

Energy has always been an important determinant of economic growth all over the world and this has also been demonstrated from time to time since 1973 oil shock. This has attracted the attention of number of researchers to investigate the association between energy use and economic growth of a country. These studies, however, have given conflicting results. Few researches like Jumbe (2004), Siddiqui (2004), Chebbi and Boujelbene (2008) have found positive association between energy use and output growth; while findings of Okonkwo and Ghadebo (2009), Noor and Siddiqui (2010) have shown negative relationship between use of energy and progress of an economy. There are studies which have shown absence of any causal link between energy use and economic growth (Sarkar et al., 2010, Yusma and Wahilah., 2010 and some studies have shown bidirectional causality between the two Omotor, 2008, Pradhan, 2010, Loganathan and Subramaniam, 2010). Thus, empirical researches reveal differing and contradictory results about the relationship between energy use and output growth in an economy. The differences in findings might be because of differences in economic conditions of the countries or differences in time horizon (Akarca and Long, 1979; 1980; Masih and Masih, 1996; 1997; 1998; Dogan and Deger, 2016; Glasure and Lee, 1998). Some researchers have argued that the variables included in the models might have also affected the outcomes about the association between energy use and output growth (Yu and Choi, 1985; Ferguson et al., 2000; Payne, 2010; Oztırk and Salah Uddin, 2012; Ozturk, 2015; Alam et al., 2016; Solarin et al., 2017).

The complexity of such relationship and contradictory results tempt us to conduct more enquiry about the short run and long run relationship between energy consumption and real output in the case of developing nations like India. The outcome of such studies is very important from country's perspective if there is causal linkage between energy use and gross domestic output.

From this point of view the present study attempts to explore the bond between energy consumption and level of output in the case of India.

The paper is organised as follows. Next section briefly reviews the researches done on the subject. This is followed by description of methodology. Empirical analysis has been described in subsequent section. At the end we present conclusion and policy implications.

2. LITERATURE REVIEW

The link between energy consumption and economic growth has drawn considerable attention of the policy makers and researchers (Ozturk, 2010). As a consequence, there are plenty of literatures available on the topic. For example, Cheng (1999) has enquired about the nexus between energy consumption and output growth in the case of India using the data from 1952 to 1995 and found no causal link between the two. His main finding was that capital accumulation was main determinant of economic progress in India. Bartleet and Gounder (2010) examined the nexus between energy use and economic growth in the case of New Zealand taking annual data from 1960 to 2004 and found that there is unidirectional relationship between the two from growth to energy consumption direction. Studying the similar relationship in the case of G7 countries applying panel cointegration, FMOLS estimator, dynamic OLS, Narayan and Smyth (2008) found bidirectional causal relationship between the two in selected countries. Wolde-Rufael (2009) studied 17 African countries and did not find similar results for all these countries. They found unidirectional relationship from energy to output direction in the case of 3 countries, from growth to energy direction in the case of 6 countries and bidirdectional relationship in the case of 3 of African countries. In the case of one country no causal link was found in the study. Asafu-Adjaye (2000), while examining the nexus between energy use and growth in the case of India, Indonesia, Philippines and Thailand have found mixed results. For India and Indonesia, they found unidirectional causal relation from energy use to growth, but bidirectional relationship in the case of Philippines and Thailand. Hou (2009) found bidirectional relation in the case of China. Oh and Lee (2004) also found birectional relationship between the two in the long run in the case of Korea. Siddiqui (2004) has found uni-directional relation from energy to output in the case of Pakistan. While studying the link between energy use and income growth of 119 countries belonging to different income groups Yasar (2017) has found different results for different groups. He observed that, for low income countries, no long run relationship existed during the sample period. For upper middle-income group, unidirectional relationship from growth to energy use has been found, thus supporting energy conservation hypothesis for these countries. A feedback hypothesis is supported in the case of higher middle and higher-income group countries as bidirectional relationship has been found between energy use and gross domestic product (GDP).

Stern and Cleveland (2004) have also observed the cointegration relationship between energy and income growth and also found that energy use cause growth when additional factor like energy price or other factors or inputs are added in the model. Whereas, Khobai et al. (2017) have found unidirectional causal relation from output to energy direction in the case of BRICS countries suggesting energy conserving policy may be encouraged without adversely affecting the growth of the countries. Stern et al. (2014) have done a comprehensive on link between energy use and growth. They have two data sets, one comprising of 99 countries for the period 1970 to 2010 and another data set includes data from 1800 for US and some Northern European countries and to later dates in the 19th and early 20th century for other countries. The key findings of the study are that there is stable relationship between GDP per capita and energy use per capita over the last 40 years but the energy intensity in richer countries are lower than that in the poorer countries. Elfaki et al. (2018), however, has found negative impact of energy consumption on growth. Yoo and Kwak (2010), while examining the cause and effect relationship between electricity use and output growth for seven south American countries, have found unidirectional relationship from electricity to growth in the case of 5 countries, bidirectional relationship in the case of one country and no causal relationship in the case of one country. Nadeem and Munir (2016) found causal relation from growth to energy use at aggregate as well as disaggregated energy source in the case of Pakistan. Kasperowicz, R. (2014) has found bidirectional relationship between electricity consumption and economic growth in Poland.

Some researchers have also applied non-linear method to investigate the relationship between energy use and GDP growth. For example, Wei et al. (2008) have enquired about the relationship in the case of US and newly industrialised economies and observed unidirectional relationship in the case of 2 countries, bidirectional relationship in 2 countries and no relationship in the case of 3 countries when linear method was applied. However, when non-linear method was used, bidirectional relationship was found in the case of 5 countries while unidirectional relationship was found in the case of 2 countries. In the case of France, Amiri and Zibaei (2012) have found causal relationship from energy consumption to growth from linear as well as nonlinear method.

From the above studies reviewed, we observe that no conclusive inferences could be drawn about the kind of nexus between energy use and growth of an economy. It varies from country to country, from time to time and also varies with difference in economic status of the country being examined. This has also been the case of India where we find varying result from no causal link to unidirectional relation. Since the result also varies with time, the present study intends to examine similar using the data until the recent one covering from the first oil embargo so that more reliable results may be obtained.

3. PERIOD OF STUDY, VARIABLES DESCRIPTION AND ECONOMETRIC TECHNIQUES

The paper is based on examining the annual data from 1971 to 2014 as the data on energy used was available till 2014 only. The variables used in the study are real GDP, real gross capital formation (GCF) and total energy consumed each year. The data on GDP and GCF were measured in Indian currency at current prices which has been deflated by GDP deflator to change these nominal values into real values. The energy use here refers to use of primary energy before altering to other end-use fuels. This is measured as sum of domestic production, imports and stock changes net of exports and fuels supplied to ships and aircrafts engaged in international transport. The energy used is calculated as kilograms of oil equivalent. The data was available on kilogram of oil equivalent per capita which has been multiplied by population of the country to get total energy use by a country. All these data have been taken from World Development Indicators (2010; 2019).

Energy is an important factor of production which plays important role in determining the growth rate of an economy. But many development theories did not use energy as a separate variable of production. However, the kind of relation varies with time and economic status of the country. Hence, any kind of relationship, positive or negative, may be expected about the energy consumption and economic growth measured in terms of real GDP in the case of India. Another factor included in the model is real GCF which is expected to have positive relation with GDP. Based on this formulation following model has been developed to estimate the relationship between energy consumption and economic growth.

$$lGDP_t = f(lGCF_t, lenergy_t) \quad (1)$$

Where,
l designates log of variables
GDP indicates real gross domestic product
GCF is real gross capital formation
Energy refers to total energy used
t represents time period.

The study will use time series data. It is normally observed that macroeconomic variables reveals a sort trend over a period of time, we will apply Augmented Dicky-Fuller (ADF) test and Philips-Perron (PP) test to ensure stationary nature of the variables. If variables are found stationary, we may estimate long run relation through regression equation. If the data reveals the presence of unit root at level but its absence at first difference, we may apply Johansen cointegration method to understand long run association among the variables. This will be followed by estimation of vector error correction model (VECM) to measure short run and long run dynamics of the relationship.

4. EMPIRICAL RESULTS

The results of unit root tests are given in Tables 1a and b. ADF results are given in Table 1a and PP results are given in Table 1b. It is evident from both the tables that the variables included in the model are non stationary when checked at level but stationary at first difference. Thus we may infer that all the variables are of same order of integration.

Hence, we may apply Johansen's method for estimating cointegration relationship among the variables. Since the result is influenced by lag order, appropriate lag order has been selected using Schwarz information criterion, the result of which is given in Table 2.

The Schwartz information criterion in Table 2 suggests that 1 time period lag would be appropriate for Johansen cointegration test. Hence, Johansen cointegration test has been conducted to predict long run relationship between GDP, gross investment and energy used the result of which is shown in Table 3a and b. The null hypothesis of no cointegration relationship is tested against the alternative hypothesis that the variables are cointegrated using trace value and maximum Eigen value. Table 3a shows that the trace statistics 45.89425 is greater than the critical limit of 35.19275. Thus, the null hypothesis of no cointegration relationship is rejected in favour of alternative hypothesis of at least one cointegration relationship among the variables. Again, since the trace value for at most one cointegration is less than its critical value at 5% significance level, we may accept the null hypothesis and conclude that there is one cointegration relationship among the variables. Maximum Eigen value shown in Table 3b also reveals the same result. The Maximum Eigen statistics of 26.96961 is more than the critical value of 22.29962 when the null hypothesis is no cointegration relationship among the variables. However, at most one cointegration relationship is accepted as maximum Eigen statistics is less than the critical value. Thus, both trace statistics and maximum Eigen statistics confirm that there is long run stable relationship between economic growth, gross investment and energy used in India.

Once finding cointegration relationship among the variables, VECM has been estimated to know long run causal nexus between energy use and economic growth and then Granger causality/block exogeneity Wald test has been estimated to find short run causality between the variables. The results are given in Table 4. The table reveals that lagged error correction term

Table 1a: Stationary test results: (ADF)

Variables	Level		First difference		Inferences
	C	C and T	C	C and T	
$LENERGY_t$	2.161900	−1.157111	−5.714010*	−6.182212*	I (1)
$LGDP_t$	3.342427	−1.920284	−6.601260*	−8.151217*	I (1)
$LGCF_t$	−0.099993	−2.557858	−8.200880*	−8.099122*	I (1)
McKinnon critical values					
1%	−3.592462	−4.186481			
5%	−2.931404	−3.518090			
10%	−2.603944	−3.189732			

*Shows significant at 1%. Schwarz information based lag order. ADF: Augmented Dicky-Fuller

Table 1b: Stationary test results: (PP)

Variables	Level		First difference		Inferences
	C	C and T	C	C and T	
$LENERGY_t$	1.988859	−1.414998	−5.815657*	−6.228557*	I (1)
$LGDP_t$	5.047817	−1.957966	−6.597087*	−9.606079*	I (1)
$LGCF_t$	−0.057879	−2.618754	−8.200880*	−8.099122*	I (1)
McKinnon critical values					
1%	−3.592462	−4.186481			
5%	−2.931404	−3.518090			
10%	−2.603944	−3.189732			

*Shows significant at 1%. Number of truncation lags is based on Newey-West criterion. PP: Philips-Perron

Table 2: Results of various criteria for lag order selection

Lag period	Final prediction error	Akaike information criterion	Schwarz information criterion	Hannan Quin information criterion
0	5.30e-06	−3.634999	−3.509616	−3.589341
1	6.71e-10	−12.61096	−12.10943*	−12.42833*
2	6.62e-10*	−12.63154*	−11.75385	−12.31193
3	7.62e-10	−12.51089	−11.25706	−12.05432

*Indicates selection of lag period

Table 3a: Unrestricted cointegration rank test (trace)

Hypothesized number of CE(s)	Eigen value	Trace value	5% Critical value	Probability**
r=0*	0.473831	45.89428	35.19275	0.0025
r=1	0.252109	18.92467	20.26184	0.0755
r=2	0.147933	6.723766	9.164546	0.1418

*Indicates refusal to accept the hypothesis at 5% significance level. **MacKinnon-Haug-Michelis (1999) probability values

Table 3b: Unrestricted cointegration rank test (maximum eigenvalue)

Hypothesized number of CE(s)	Eigen value	Max-Eigen statistic	0.05 Critical value	Probability**
r=0*	0.473831	26.96961	22.29962	0.0103
r=1	0.252109	12.20091	15.89210	0.1746
r=2	0.147933	6.723766	9.164546	0.1418

Max-Eigen test indicates 1 co-integrating eqn(s) at 5% significance level. *Indicates refusal to accept the hypothesis at 0.05 the level. **MacKinnon-Haug-Michelis (1999) probability values

Table 4: Results of short run and long run causality test

Dependent variable	DLGDP	DLGCF	DENERGYT	ECT (−1)
	Chi-square (P-values)			
DLGDP	____	0.0403	0.0448	−0.071734 (−2.08101)
DENERGYT	0.2119	0.0490	____	−0.093125 (−5.20728)

in both the cases, when GDP is taken as dependent variable and also when energy consumption is taken as dependent variable, is negative and significant implying that there is bidirectional causal relationship between growth and energy consumption in India in the long run.

The result in Table 4 indicates that in the short run, only unidirectional relationship from energy consumption to economic growth exists as the probability value of Wald test is <5% for differenced energy consumption when output is taken as dependent variable. Same is not the case when energy is taken as dependent variable. Here probability of Wald test is more than 10% for differenced GDP variable. Thus, we may conclude that in the short run, there is unidirectional relationship between energy consumption and economic growth from former to later, but there is bidirectional relationship between the two in the long run.

5. CONCLUSION AND POLICY IMPLICATIONS

Realising the crucial role of energy in the process of economic development of any country, the present paper intended at studying link between energy use and real output in the case of India. Covering the period from 1971 to 2014 we find long run cointegration relation between energy consumption, gross investment and economic growth. The evidence from VECM shows that there is bidirectional relationship between energy use and growth of India. The result of block exogeneity Wald test provide the evidence that there is unidirectional relationship between energy consumption and output from energy to real output direction. Since we find bidirectional relationship in the long run, high rate of growth would require more of energy. Hence, an important policy implication of the study is that India has to develop its energy sector in order to mitigate the impact of fluctuation in international price and supply of energy maintain high rate of growth to become one of economic super powers of the world.

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