IF : 3.62 | IC Value 70.36

Volume-5, Issue-10, October - 2016 • ISSN No 2277 - 8160

Original Research Paper

Economics

Energy Consumption and Economic Development: Examining the Causal Relationship

Biswajyoti Sarmah Dibrugarh University

ABSTRACT India's sustainable and sustained economic growth is placing enormous demand on its energy resources. Energy demand in all the three sectors viz. Primary, secondary and tertiary has been increasing tremendously in last six decades. Alongside the economy is also developing at a good pace, at least after the reforms. At this juncture, it is utmost important for the policy makers, especially economists and financial analysts to understand whether economic development causes more energy consumption or it is more energy consumption that brings speedy economic development. This paper is an attempt to study the causal relationship between the two aforesaid key variables using econometric techniques.

KEYWORDS : Energy, Economic development, consumption, Granger causality.

Introduction:

The estimated consumption of crude oil has a steady increase, from 130.11 MMT during 2005-06 to 223.24 MMT during 2014-15 with CAGR of 5.55%. It increased from 222.50 MMT in 2013-14 to 223.24 MMT in 2014-15. The depleting resources and increasing pollution of the environment due to energy use has necessitated optimum use of its resources; which in turn requires proper energy planning to achieve energy security. The relationship between the use of energy and economic growth has been a subject of greater inquiry as energy is considered to be one of the important driving forces of economic growth in all economies. It needs to be noted that India domestically meets up 30 percent of its crude oil requirement and the rest is being imported from the oil producing nations6. In India, the transport sector is the principal consumer of petrol and diesel, followed by big and small industrial units. Similarly, electricity consumption share too is the largest by this sector. The standard economic theory while recognizes labour and capital as two important inputs into the production process, does not treat energy per se as a factor of production. Energy is treated, instead, as an intermediate product of labour and capital. Contrary to the notion of Neo-classical perspective, which demonstrates that energy plays an insignificant role in the development process of an economy, however, the magnitude of energy's influence on the economy has been hotly debated by macroeconomists. Therefore, the study undertakes an empirical analysis, towards verifying this nexus of energy consumption and economic growth and suggesting policies that strikes a balance between consumption and conservation of energy in sustaining and speeding up the growth momentum of the economy.

Objectives of the study:

1. To study the direction of causality among the variables under consideration.
2. The study the dynamic relation between the economic development and energy consumption.

Review of literature:

Hwang and Gum (1991) had evidenced a bi-directional causality for Taiwan, while Masih and Masih (1997) had found the same for both Taiwan and Korea. Subsequently, Yang (2000) had also confirmed a bi-directional causality for Taiwan.

Aqeel and Butt (2001) investigated the causal relationship between energy consumption and economic growth in Pakistan. They found that economic growth leads to growth in petroleum consumption, and electricity consumption leads to economic growth without the presence of their feedback effect.

Examining the causal relationship between GDP, energy consumption, and employment, Soytas and Sari (2003) and San and Soytas (2004) suggested that the causality runs from energy consumption to GDP in Turkey. This indicates that in the long run decreasing energy consumption may retard the economic growth of Turkey.

Wolde-Rufael (2005) investigated the long run relationship between energy use per capita and per capita GDP for 19 African countries using the cointegration technique proposed by Pesaran, et al. (2001) and also the causality test proposed by Toda & Yamamoto (1995). The study found that there is a long run relationship between two series for only eight countries and causality for only 10 countries.

Pokharel (2007) showed how energy is important for Nepal given its economic structure where there exists heavy demand for both the traditional as well as commercial sources of energy in rural and urban areas respectively. Classifying the models into fuel and consumption sector models, Pokharel tried to determine various significant factors influencing energy consumption in different sectors

Research Question:

1. Is there any causal relation between energy consumption and economic development? If yes, in which way it flows?

Data and methodology:

This study is based on the annual data for the period of 1992 to 2014. The data required for the study have been compiled from websites of various government departments, research papers and verified with Indian Petroleum and Natural Gas Statistics, Ministry of Petroleum, Natural Gas Economics and Statistics division, Government of India, and Energy Statistics, Ministry of Statistics and program Implementation, Central Statistical Organization (CSO). The forms of energy are expressed as a ratio to GDP at constant prices (2011-12=100) in order to measure them as per unit of output. The growth rate of GDP is defined as the change in the GDP in two consecutive periods divided by its initial period value. The same formula has also been followed for computing growth rates of the rest of the variables The study employs time series econometric procedures in order to understand the dynamic relationship of growth of various forms of energies consumed with the growth rate of the economy, i.e. whether energy consumption fuels economic growth or it is the growth rate of income measured by GDP at factor cost which drives the demand for more energy consumption in the economy. Before utilizing the time series model for estimating the relationships, the study carries out unit root testing procedures in order to apply suitable time series estimating procedures appropriate to the context as disregarding the unit root tests may result in biased estimates. Since the growth rates are usually expected to be stationary at their levels, therefore, the study proposes to employ Granger causality test and variance decomposition analysis of vector auto-regression (VAR) method for

empirical analysis. One of the important points needs to be borne in mind is that Granger causality test and variance decomposition analysis of VAR are most suitable techniques when all the variables are stationary at their levels. The Granger causality test demonstrates the direction of causality flowing from one to the other variables and vice versa or the information content in one variable in correctly predicting another variable, while variance decomposition analysis explains the variation in one variable due to the shocks in itself and shocks in another in an out of sample forecasts. In other words, variance decomposition can be viewed as an out of sample causality test. In carrying out these econometric tests, one of the important factors is to properly determine the lag length of the variables in the models. The lags of the models have been selected on the basis of Akaike Information Criteria (AIC) and Final Prediction Error (FPE) Criteria. The model can be specified as follows:

$$Y_t = \sum_{j=1}^{m} \alpha j + Y_{t-j} + \sum_{j=1}^{m} \beta_j X_{t-j} + u_t \text{ ----------1}$$

The estimated model in the bi-variate VAR can be specified as:

$$Z_t = \begin{pmatrix} x_t \\ y_t \end{pmatrix} = \beta + \beta_{1t} + \sum_{t=1}^{k+1} A_t \, Z_{t-1} + u_t, \text{ ---2} \qquad A_t = \begin{bmatrix} \alpha_{11} & \alpha_{12} \\ \alpha_{21} & \alpha_{22} \end{bmatrix}$$

X represents the left hand side variables or dependent variables and y represents the right hand variables or independent variables. However, in a VAR system all variables are endogenous.

Results and discussions:

Time series should always be check for the order of integration before regressing on one another. We here apply the two most popular stationarity tests, the ADF and PP tests. The ADF and PP tests results are reported below in the table-1.

Table-1: Unit root tests.

Variables	ADF	PP
Coal	-3.63	-5.45
Petroleum	-3.87	-5.27
Electricity	-3.05	-4.32
Natural gas	-3.71	-4.21
Aggregate energy	-3.71	-4.56
GDP	-3.81	-7.21

Note: The critical values at 1%, 5%, and 10% are - -3.64, -2.95, and -2.61 respectively (without trend but intercept).

Since all of the above variables are found to be of integrated of order zero, therefore, it is an appropriate case for conducting bi-variate Granger causality test by relating growth of different forms of energies with economic growth measured by growth rate of GDP. Table-2 reports the results of the granger causality test.

Table 2: Granger Causality test result.

Growth rates	GDP	Coal	Crude petroleum	Electricity	Natural gas	Aggregate energy
GDP (Grow)	-	0.50(1)	1.76(1)	2.84(2)	4.62(1)	4.30(2)
Coal (coalgr)	7.61(1)	-	-	-	-	-
Crude petroleum (crudepetroleumgr)	0.35(1)	-	-	-	-	-
Electricity (electricitygr)	1.64(2)	-	-	-	-	
Natural gas (naturalgasgr)	0.56(1)	-	-	-	-	-
Aggregate energy	0.23(1)	-	-	-	-	-

Note: The numbers in the above table indicates the F-statistics. The direction of Granger causality flows from the left hand row variables to right hand column variables. The figures in the parenthesis are the lags selected into the model on the basis of AIC criteria for carrying out the Granger causality test.

The Granger causality test results shown in Table 3 indicate that except coal which influences/causes economic growth rate, growth rates of other forms of energy do not cause growth rate of income. Rather, growth rate of income Granger causes growth rate of electricity and natural gas including aggregate energy consumption demand in the country. This provides evidence that except coal energy, other forms of energy considered in the analysis none of them, do play significant role in economic growth rate of the Indian economy. In turn, it is the growth rate of national income that leads to more demand for energy consumption. This implies that when national income rises, it directly leads to more consumption demand for electricity and natural gas energies.

After carrying out the Granger causality test, we have estimated the dynamic causality relationship between growth of energy consumption (coal) and growth rate of GDP through variance decomposition analysis of vector auto-regression (VAR) technique. The variance decomposition is computed for 20 horizons for an out of sample forecast.

The variance decomposition analysis between growth of coal energy and growth rate of GDP reported in Table 3 shows that when one standard deviation shock is given to the growth of GDP, it does not explain the variation in the growth rate of coal energy over the entire horizon. Rather, the variation in growth rate of coal energy is being explained by its own shocks. The bottom part of the table shows the results of variance decomposition of growth rate of GDP. This shows that the growth rate of GDP is being constantly and significantly explained by the shocks in the growth rate of coal energy consumption. It almost explains 18 percent of variation in the growth rate of GDP from 2 horizon to 20th horizon under consideration. This implies that there is a one-way causality from coal energy consumption to growth rate of GDP (income) in the economy. This is also consistent with the previous Granger causality test result.

Table 3. Variance Decomposition of Growth of Coal:

Variance Decomposition of COALGR			
Period	S.E	COALGR	GROW
1	3.82	100.00 (0.00)	0.00 (0.00)
2	3.97	91.91 (-3.72)	0.09(-3.72)
3	3.97	91.91 (-3.72)	0.09(-3.63)
7	3.97	91.91 (-3.72)	0.09(-3.94)
10	3.97	91.91 (-3.72)	0.09(-3.95)
15	3.97	91.91 (-3.72)	0.09(-3.96
20	3.97	91.91 (-3.72)	0.09(-3.96
Variance Decomposition of GROW			
Period	S.E	COALGR	GROW
1	2.81	0.32 (-4.13)	99.68(-4.13)
2	3.10	17.79 (-12.39)	82.21(-12.07)
3	3.11	18.22 (-12.07)	81.67(-12.30)
7	3.11	18.34 (-12.30)	81.66(-12.56)
10	3.11	18.34 (-12.56)	81.66(-12.57)
15	3.11	18.34 (-12.56)	81.66(-12.57)
20	3.11	18.34 (-12.57)	81.66(-12.57)

Note: The values in parentheses shows corresponding standard errors of respective coefficients of error variances. Grow indicates GDP growth.

Conclusion:

The paper examined the linkage between various forms of energy

consumption growth and economic growth in India. . The relationship has been examined using Granger causality test as well as variance decomposition analysis. e. Granger causality method is applied to examine whether the information content in a variable (independent) is correctly able to predict the other variable (dependent) and vice versa, whereas variance decomposition of VAR analysis, as an out of sample causality test, explains the variation in one variable how much can be attributed to its own shock as against the shock to the other variables in a system. The result from the application of Granger causality test suggests that it is the growth rate of GDP which leads to more demand for the natural gas and electricity and the overall energy consumption, and it is only the coal energy consumption which has an influence on GDP growth. The study provides mixed and contradictory evidence on the relationship between energy consumption and GDP growth rate as compared to the previous studies carried out in the Indian context.

References:

1. Abosedra, S., Baghestani, H., "New Evidence on the Causal Relationship between U.S. Energy Consumption and Gross National Product", Journal of Energy and Development, 1989, Vol. 4, pp. 285-92.
2. Akarca, A. T., Long, T. V., "On the Relationship between Energy and GNP: A Reexamination", Journal of Energy and Development, 1980. Vol. 5, pp. 326- 331.
3. Aqeel, A. & Mohammad Subihuddin Butt., "The Relationship Between Energy Consumption and Economic Growth in Pakistan", Asia-Pacific Development Journal, 2001, Vol. 8, pp.101-10.
4. Berndt, E. R. and D. O. Wood, "Engineering and Econometric Interpretations of Energy Capital Complementarity.", American Economic Review, 1979, Vol.69, pp.342- 54.
5. Cleveland, C. J., "Biophysical Constraints to Economic Growth, In D. Al Gobaisi" Editor-in-Chief. Encyclopedia of Life Support Systems, 2003, (EOLSS Publishers Co.,Oxford, UK).
6. Dickey, D., Fuller, W., "Distribution of the Estimators for Autoregressive Time Series with a Unit Root", Journal of the American Statistical Association, 1979, Vol. 74, pp. 427-31.
7. Ebohon, O. J., "Energy, Economic Growth and Causality in Developing Countries: A Case Study of Tanzania and Nigeria", Energy Policy, 1996, Vol.24, No.5, pp.447-53.
8. Ediger, V. S., "Energy Productivity and Development in Turkey", Energy and Cogeneration World, 2004, Vol. 25, pp.74-78.
9. Ediger, V. S. Huvaz, O., "Examining the Sectoral Energy Use in Turkish Economy (1980-2000) with the Help of Decomposition Analysis", Energy Conversion and Management.
10. Hwang, D., Gum, B., "The Causal Relationship between Energy and GNP: the Case of Taiwan", Journal of Energy and Development, 1991, Vol.16, pp.2 19-26.
11. Masih, A. M. M, Masih, R., "Energy Consumption, Real Income and Temporal Causality: Results from a Multi-country Study based on Cointegration and Error-correction Modeling Techniques", Energy Economics, 1996, Vol. 18, pp.165-83.
12. Masih, A. M. M., Masih, R., "On the Temporal Causal Relationship between Energy Consumption, Real Income, and Prices: Some New Evidence from Asian- energy Dependent NICs Based on a Multivariate Cointegration/Vector Error- correction Approach", Journal of Policy Modeling, 1997, Vol. 19, pp.417-40.
13. Pesaran, M. H., Pesaran, B., "Working with Microfit 4.0", Cambridge, 1997, England.
14. Pokharel, S. H., "An Econometrics Analysis of Energy Consumption in Nepal", Energy Policy, 2006, pp. 1-12.