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AN EMPIRICAL STUDY OF THE RELATIONSHIP BETWEEN ENERGY CONSUMPTION AND ECONOMIC GROWTH IN INDIA

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ABSTRACT

Energy is central to achieve the interrelated economic, social, and environmental aims of sustainable development. The relationship between use of energy and economic growth has been a subject of greater inquiry as energy is one of the important driving forces of economic growth. This paper examines the relationship between energy consumption and Gross Domestic Product (GDP) per capita of India. It used the annual data from 1970-71 to 2015-16, obtained from Central Electricity Authority and Energy Statistics, 2016-17. Augmented Dickey Fuller test has been used to check the stationary of the variables and Granger Causality test was used to verify the casual relationship between both the variables. It has been found that Indian economy is energy dependant. This relationship suggests the policy implication that, to keep the pace of fast economic growth, efforts should be made for efficient energy use, availability of clean energy and domestic energy production.

Keywords: Clean Energy, Economic Growth, Energy Consumption, GDP.

I. INTRODUCTION

Energy plays crucial role in the development of a country. It has always been critical for the development and growth of the country. Adequate energy supply is necessary to meet the needs of the country. Energy is also necessary for poverty reduction. If there is more energy it means there is an adequate access of water and electricity that is necessary for growth. There are four groups of economists who talk about the relation between energy consumption and economic growth.

The relationship between use of energy and economic growth has been a subject of greater inquiry as energy is one of the important driving forces of economic growth in all economies (Pokharel, 2006). India, home to 18 per cent of the world's population, uses only 6 per cent of the world's primary energy. Energy has been universally recognized as one of the most important catalysts for economic growth and human development. According to Energy

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Information Administration (EIA, 2010) "There is a strong two-way relationship between economic development and energy consumption. On one hand, growth of an economy, with its global competitiveness, hinges on the availability of cost-effective and environmentally benevolent energy sources, and on the other hand, the level of economic development has been observed to be depended on the energy demand.' Energy is needed for economic growth, for improving the quality of life and for increasing opportunities for development. About 600 million Indians do not have access to electricity and 700 million Indians use biomass as their primary energy resource for cooking. Ensuring life line supply of clean energy to all is essential for nurturing inclusive growth, meeting the millennium development goals and raising India's human development index that compares poorly with several countries that are currently below India's level of development. The broad vision behind India's integrated energy policy is to reliably meet the demand for energy services of all sectors including the lifeline energy needs of vulnerable households in all parts of the country with safe, clean and convenient energy at the least-cost.

Since 2013, total primary energy consumption in India has been the third highest in the world after China and the United States. India is the second top coal consumer in the year 2015-16 after China. India ranks third in oil consumption with 195.5 million tons in 2015-16 after the United States and China. It must, meet its development needs by using all available domestic resources of coal, uranium, oil, hydro and other renewable resources, and supplementing domestic production by imports. This paper attempts to explore the possible impact of various forms of energy consumption sources and consumption pattern. The prime motivation of the study relates to addressing the increasing levels of energy consumption in India and its relationship with economic growth in India. Energy is needed for economic growth, for improving the quality of life and for increasing opportunities for development.

II. REVIEW OF LITERATURE

Masih (1996) illustrated how the finding of co-integration i.e. long-term equilibrium relationship) between these variables, may be used in testing Granger causality. Based on the most recent Johansen's multivariate co-integration tests preceded by various unit root or non-stationarity tests, we test for co-integration between total energy consumption and real income of six Asian economies: India, Pakistan, Malaysia, Singapore, Indonesia and the Philippines. Non-rejection of co-integration between variables rules out Granger non-causality and impels at least one way of Granger-causality, either unidirectional or bi-directional. Secondly, by using a dynamic vector error-correction model, we then analyse the direction of Granger-causation and hence the within-sample Granger-erogeneity or endogeneity of each of the variables. Thirdly, the relative strength of the causality is gauged (through the dynamic variance decomposition

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technique) by decomposing the total impact of an unanticipated shock to each of the variables beyond the sample period, into proportions attributable to shocks in the other variables including its own, in the bivariate system. Results based on these tools of methodology indicate that while all pair-wise relationships shared common univariate integrational properties, only relationships for three countries (India, Pakistan and Indonesia) were co-integrated. For these countries, temporal causality results were mixed with unidirectional causality from energy to income for India, exactly the reverse for Indonesia, and mutual causality for Pakistan. The VDCs were not inconsistent with these results and provided us with an additional insight as to the relatively more dominant direction of causation in Pakistan. Simple bivariate vector-autoregressive models for the three non-co integrated systems did not indicate any direction of causality, significantly in either direction.

Kamal Raj (2008) finds the relationship between energy consumption and economic growth in Nepal. He finds uni-directional causality running from GDP to electric consumption. He says energy consumption stimulates economic growth. He says increase in income will raise energy consumption as people spend more proportion of their income on goods and services that consumes energy like cars, tractors, water pumps at farms etc. Higher growth needs energy infrastructure and this growth will increase energy consumption at commercial level. The writer suggests small and micro projects as an alternative source like biogas at rural areas.

Majid (2011) investigates the causal relation between renewable energy consumption and economic growth for 7 Asian developing countries. He uses time series data for the period of 1985 to 2007. His findings show uni-directional causality running from economic growth to renewable energy consumption in these four countries (India, Iran, Pakistan, Syrian Arab Republic).

Shaari, Hussain and Ismail (2012) while studying for the case of Malaysia, used annual data from 1980 to 2010, to find relationship between energy and GDP growth. They started by doing a stationary test using the Augmented Dickey Fuller test which show that the variable is stationary allowing Johansen cointegration, which was used to analyze the data in order to determine the long run relationship between all variables. The findings were that energy consumptions are related to economic growth without catching the direction of the relationship. In order to catch the direction, Granger causality model was used to examine the direction of causality relationships by measuring the causal effect of Gross Domestic Product. Their finding showed that there is no causality effect between both oil and coal consumption and economic growth. However, there is causality from GDP growth to the electricity consumption, in addition and more surprising is the unidirectional relationship existing between gas and economic growth, this relationship seems to have a negative impact to the economy. Additionally, Shaari et al

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(2012) concluded by saying that it would be absurd to decrease the gas consumption as it would have mostly a negative impact.

Stern and Enflo (2013) in this study, there is an analysis of the relation between energy and economic growth, for a long period of 150 years. Starting from 1850 in order to catch the transition period from one of the poorer countries in Europe at the mid of the 19th century to one of the richest today. As it was an industrialization period, they checked if the switch in energies quality and the increases of energy consumption affected the economic growth. The Unit Root Test was used in this literature as well, which is a fundamental to proceed to the co-integration and Granger cause test, for that PP test was used. The period of 150 years is split into three-time series. As model, they used multivariate models. All their finding point to that energy consumption fuels the economy and accelerates the growth rate. However, the range of the sample periods and the as we know that thing change other time specially other 150 years, Stern et all noticed that the relation between energy consumption and economic growth could have changed, in addition they stressed Energy prices have big role in this process in our days.

Csereklyei, Rubio Varas, and Stern (2014) is an investigation of historical pattern and stylized facts, which where enlisted and in addition it is a study giving more evidences about fact from the relationship between energy intensity, energy per capita, energy per capital with the GDP per capita. To do that they used a large sample of 99 countries covering time period from 1971 to 2010 and for some countries as United States or England they started the analysis from the 19th century. This study does not just analyse the cross sectional relationship it also seek after the convergence of these ratios to a kind of a steady state. The main finding of this paper is that for the data from 1971 to 2010 there is a stable cross sectional relation between the energy per capita and the GDP per capita. Moreover, for the long-run historical data, the authors stated, there is a convergence in energy intensity towards the current distribution, per capita energy use has tended to raise, energy quality to increases.

III. ECONOMIC GROWTH AND ENERGY CONSUMPTION IN INDIA

The trend of energy consumption and economic growth in India has been poor. Mostly India faces energy shortage and it imports large share of energy from other countries. Recent condition is worse. In 1970, GDP was 517148 (Rs. Crore) and energy consumption was 663.99 (billion KWH). While there has been a drastic change in 2016. When GDP of India was 10427191(Rs. Crore) and energy usage was 7849.44 (billion KWH). This trend of energy usage and economic growth in India can been seen graphically.

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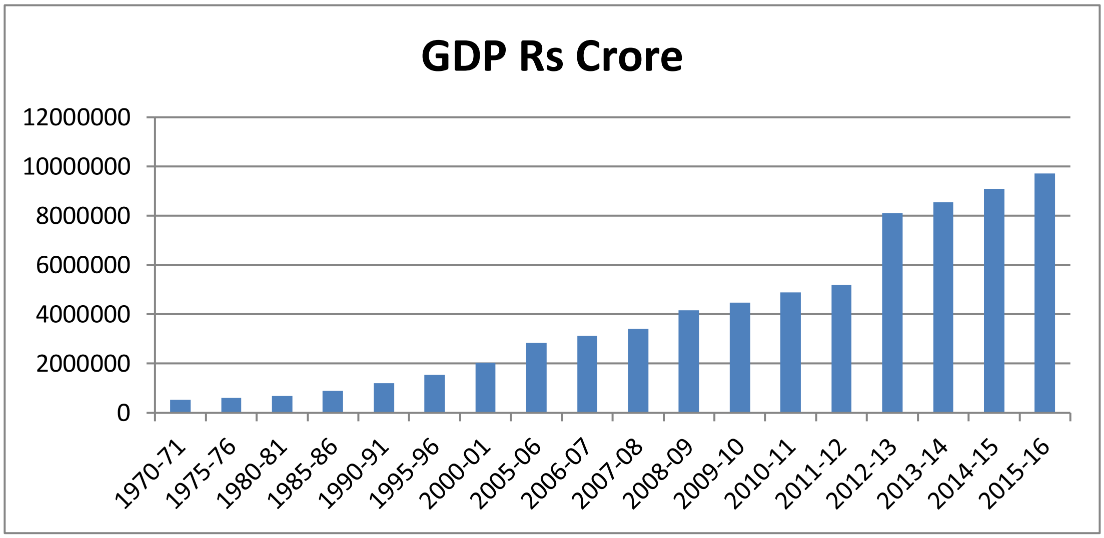
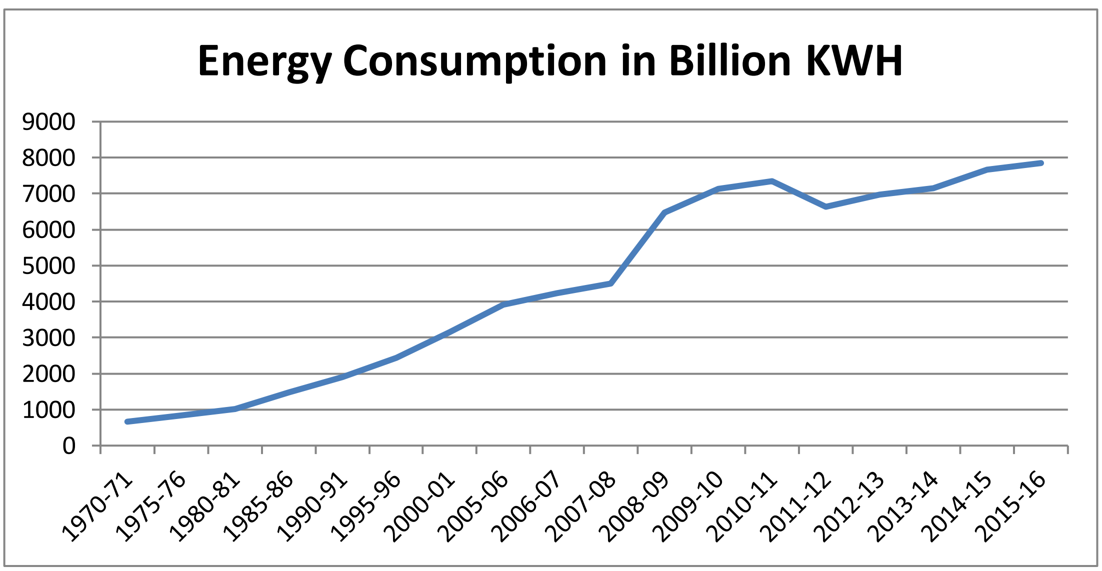
Figure 1: Yearly Increase in GDP



Source: Various Issues of Energy Statistics

Figure 2: Yearly Increase in Energy Consumption



Source: Various Issues of Energy Statistics

IV. STUDY OBJECTIVES

The basic objective of this paper is to find the relationship between energy consumption and economic growth of India.

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V. HYPOTHESIS

H_0: There exists no relation between energy consumption and economic growth of India.

H_1: There exists positive relation between energy consumption and economic growth of India.

VI. DATA COLLECTION AND METHODOLOGY

In order to study the impact of energy usage on Gross Domestic Product of India, a time series data has been used for the period of 1970-71 to 2015-16. Data source is World Development Indicator (WDI) and International Financial Statistic.

The Cobb-Douglas Production Function with constant returns to scale can be as:

$$GDP=\alpha EC\beta 1\mu \quad \text{--} \quad (1)$$

Here *GDP* is the Gross Domestic Product of India (Rs. Crore), α is the total factor productivity, *EC* is the energy usage (billion KWH), $\beta 1$is the coefficient of energy consumption and μ is the white noise error term. The multiplicative form of equation can be written in a linear form by taking log from both sides of the equation.

$$LOGGDP=LOG\alpha+\beta 1LOGEC+LOG\mu \text{---}(2)$$

LOGGDP is the log of Gross Domestic Product, $LOG\alpha$ is the intercept that is equal to $\beta 0$, $\beta 1$ is the coefficient of *LOGEC* while *LOGEC* is the log of energy consumption and

$LOG\mu$ is the log of white noise error term.

Expectation: $B0>0$, $B1>0$.

The Granger causality test can be specified as:

$$LOGGDP=\Sigma\phi iLOGECt-1+\Sigma\Theta jLOGGDPt-1+\mu t1 \text{------------------------------------}(3)$$

$$LOGEC=\Sigma\alpha iLOGECt-1+\Sigma djLOGGDPt-1+\mu t2 \text{---------------------------------------}(4)$$

VII. EMPERICAL FINDINGS

Initially, Augmented Dickey-Fuller test has been used to check the unit root of the variables so that it can be seen what technique is appropriate for the model. Usually, time series data show trend with the time. This trend can be removed by differencing. The results of ADF test are in table 1:

Variables	ADF (t critical) value at 1per cent significance level	ADF (t critical) value at 1per cent significance level	T-Value	Probability
D(LOGGDP)	-3.920300	-3.065585	-3.989847	0.0088
D (LOGEC)	-3.920350	-3.065585	-3.277880	0.0339

Source: Author's Calculation

Table 1 shows the result of the analysis for the unit root test LOGGDP and LOGEC. For the abstraction of a unit root the differentiation of LOGGDP is conducted. Considering that LOGGDP had a unit root the variable has been differentiated and the unit root test has been done, and the results are displayed. The analysis has shown that the p-value is less the 5 per cent, which excludes the assumption that the series has a unit root. For the abstraction of a unit root the differentiation of LOGEC is conducted. Differentiated series has no unit root, P-value is 0.0339, which is less than 5 per cent, which leads to rejections of null hypothesis about the existence of a unit root.

Table 2: Results of Granger Causality Test

Lags 2 Sample 1970-71 to 2015-16				
Null Hypothesis	Obs	F-Statistic	Prob.	Decision
LOGEC does not Granger Cause LOGGDP	16	5.61425	0.0340	Reject Null hypothesis
LOG GDP does not Granger Cause LOGEC	16	0.34071	0.5694	Accept null hypothesis

Source: Author's Calculation

The results show that Energy Consumption does Granger Cause GDP of India as the p-value is 0.0340 which is less than 5 per cent level of significance. This signifies that energy consumption has the ability to effect or predict GDP of India. Here F-Statistic is 5.61425. However, the results also show that GDP does not Granger Cause Energy Consumption as the p-value is 0.5694 which is greater than 5 per cent level of significance and thus in this case null hypothesis is accepted. Here, The F-Statistic is 0.34071. Hence, there exists uni-directional causality running from economic growth to energy consumption in India.

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Table 3: Results of VAR model

Vector Autoregression Estimates
Date: 03/08/18 Time: 23:43
Sample (adjusted): 3/21/1980 1/16/2015
Included observations: 16 after adjustments
Standard errors in ( ) & t-statistics in [ ]

	Y	X1
Y(-1)	1.091780	-557.6328
	(0.29644)	(280.951)
	[3.68292]	[-1.98480]
Y(-2)	-0.199162	774.0895
	(0.30580)	(289.819)
	[-0.65128]	[2.67094]
X1(-1)	-4.44E-05	0.859714
	(0.00025)	(0.23668)
	[-0.17798]	[3.63244]
X1(-2)	0.000107	0.013962
	(0.00028)	(0.26210)
	[0.38846]	[0.05327]
C	658.1670	411068.1
	(336.605)	(319013.)
	[1.95531]	[1.28856]
R-squared	0.957808	0.975584
Adj. R-squared	0.942465	0.966706
Sum sq. resids	3734326.	3.35E+12
S.E. equation	582.6528	552202.0
F-statistic	62.42826	109.8830
Log likelihood	-121.5869	-231.2522
Akaike AIC	15.82337	29.53152
Schwarz SC	16.06480	29.77296
Mean dependent	4990.212	4367211.
S.D. dependent	2429.101	3026323.
Determinant resid covariance (dof adj.)		8.46E+16
Determinant resid covariance		4.00E+16
Log likelihood		-351.2217
Akaike information criterion		45.15271
Schwarz criterion		45.63558

Source: Authors Calculation

Models showing coefficients:

Y = C (1) *Y (-1) + C (2) *Y (-2) + C (3) *X1(-1) + C (4) *X1(-2) + C (5)

X1 = C (6) *Y (-1) + C (7) *Y (-2) + C (8) *X1(-1) + C (9) *X1(-2) + C (10)

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Table 3.1 P-values of various coefficients using OLS

System: UNTITLED
Estimation Method: Least Squares
Date: 03/08/18 Time: 23:54
Sample: 3/21/1980 1/16/2015
Included observations: 16
Total system (balanced) observations 32

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	1.091780	0.296444	3.682919	0.0013
C(2)	-0.199162	0.305801	-0.651280	0.5216
C(3)	-4.44E-05	0.000250	-0.177979	0.8604
C(4)	0.000107	0.000277	0.388459	0.7014
C(5)	658.1670	336.6046	1.955312	0.0634
C(6)	-557.6328	280.9514	-1.984802	0.0598
C(7)	774.0895	289.8193	2.670939	0.0140
C(8)	0.859714	0.236677	3.632439	0.0015
C(9)	0.013962	0.262098	0.053270	0.9580
C(10)	411068.1	319012.8	1.288563	0.2109
Determinant residual covariance		4.00E+16		

Equation: Y = C(1)*Y(-1) + C(2)*Y(-2) + C(3)*X1(-1) + C(4)*X1(-2) + C(5)
Observations: 16

R-squared	0.957808	Mean dependent var	4990.212
Adjusted R-squared	0.942465	S.D. dependent var	2429.101
S.E. of regression	582.6528	Sum squared resid	3734327.
Durbin-Watson stat	1.989721		

Equation: X1 = C(6)*Y(-1) + C(7)*Y(-2) + C(8)*X1(-1) + C(9)*X1(-2) + C(10)
Observations: 16

R-squared	0.975584	Mean dependent var	4367211.
Adjusted R-squared	0.966706	S.D. dependent var	3026323.
S.E. of regression	552202.0	Sum squared resid	3.35E+12
Durbin-Watson stat	2.513495		

Source: Authors Calculation

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Table 3 shows the results of VAR model evaluation with two lags. Based on the results of above evaluated equation of the influence of GDP change on total primary energy consumption change, the result shows that there exists relationship between energy consumption and GDP.

In order to have better and clear understanding of the linkages between energy consumption and GDP dairy through vector auto regression model, we have also estimated the probability values (p-values) of various coefficients as indicated in table 3.1. Ten coefficients such as C(1), C(2), C(3),C(4), C(5), C(6),C(7),C(8),C(9) and C(10) and ten p-values have been estimated at a time by framing the system equations. In first model, energy consumption (Y) is taken as a dependent variable and three coefficients C(1), C(2), C (3) have been considered. From the above table 3.1, it can be interpreted that C (1) is significant as its p-value is 0.0013 which is less than 5 per cent. The coefficients C (2), C (3) and C (4) are not significant as their p-values are 0.5216 ,0.8604 and 0.7014 respectively which are more than 5 per cent and thus it signifies that C (2), C (3) and C(4) are not effecting the Y variable i.e. energy consumption. Similarly, the C (5) coefficient is not significantly affecting the dependent variable Y as its p-value is 0.0634 which is more than 5 per cent. In the second model, GDP (X1) is taken as a dependent variable. The table 3.1 clearly demonstrates that coefficients C (6), C (7) and C(8) are significant as their p-values are less than 5 per cent, whereas, coefficient C(9) is not significant in explaining the relation between GDP and energy consumption as its p-value is 0.9580 which is more than 5 per cent. The last coefficient C (10) is insignificant in explaining the dependent variable GDP(X1) as its p-value is 0.2109 which is greater than 5 per cent.

That leads to conclusion that variable Y i.e. lggdp(t-1) is significant in the model. Results show that change of GDP of 1 per cent in period t-1 would affect the annual total primary energy consumption for 0.000127 per cent in period t. The significance of gained results can be seen in the fact that both GDP and energy consumption have relation with each other and does affect each other.

VIII. CONCLUSION

The objective of this paper was to find the relationship between energy consumption and economic growth of India using time series data for the period of 1970-71 to 2015-16. India is facing the problem of energy shortage. Gap between energy usage and production is increasing constantly over the time. It is expected from this gap to retard economic growth. The results of Granger Causality test showed uni-directional causality running from GDP to energy consumption. On the other hand, the VAR model evaluation has been done. Based on the results it leads to conclusion that variable Y i.e. lggdp (t-1) is significant in the model. Results show that change of GDP of 1 per cent in period t-1 would affect the annual total primary energy consumption for 0.000127 per cent in period t. The significance of gained results can be seen in

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the fact that both GDP and energy consumption have relation with each other and does affect each other. This relationship suggests the policy implication that, to keep the pace of fast economic growth, efforts should be made for efficient energy use, availability of clean energy and domestic energy production.

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