Journal of Energy Technologies and Policy
ISSN 2224-3232 (Paper) ISSN 2225-0573 (Online)
Vol.5, No.6, 2015

Energy Consumption and Economic Growth in India: A reconciliation of Disaggregate Analysis

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Abstract
The present study examines whether energy consumption fuels economic growth or vice versa. The relationship is examined by using the annual data covering the period from 1970 to 2011. By employing the Granger causality test, the study empirically found that it is economic growth that fuels more demand for lignite and electricity consumption and there is growth of any energy variables that causes economic growth. In contrast, the out of sample forecasts in variance decomposition of VAR suggests that there is a bidirectional influence between electricity consumption and economic growth and lignite consumption and economic growth. Whereas a unidirectional influence from GDP growth in a natural gas consumption is found from this result. Therefore, the current study found, mixed and inconsistent results as compared to the previous studies in the Indian context. Moreover, on the basis of two econometric tools, the study with little more belief could suggest for reducing natural gas and oil consumption for boosting higher rates of economic growth in the country.
Key Words: Energy, Consumption, Causality, VAR, Variance Decomposition, Economic growth and India.

I. Introduction

Energy consumption and economic growth has long been establish to be highly correlated. Extensive research have been conducted to establish the dynamic relationship between energy consumption and economic growth. Nevertheless, no schematic facts have been established. Most of the earlier studies have focused on developing countries and newly industrial countries. There is less or sporadic studies have been conducted in the context of developing countries. Given the magnitude of India's energy consumption and economic growth, it attracts high attention in this line of research and there have been very few studies conducted in the recent years and most of the studies are based on the aggregate analysis of energy consumption. However, this paper aims to establish a dynamic relationship between energy consumption and economic growth on the disaggregate energy consumption. Therefore, this study fills the gap to shed the new light on the area of study in the context of India. The argument over the link between energy consumption and output has been wide spread. Mainly since the global oil shocks of the early 1970s. The directional of causality between these variables has been an emerging issue in recent decades. The findings in the existing literature not necessarily conform to this stereotyped causality. Therefore, it is an important task to examine the relationship between these variables on the basis stages and structure of the economy.

Taking into account certain factors like Environmental quality reduction, rapid growth of population, High energy requirement for the soaring production to meet the growing demand in the economy, increasing worldwide energy price and reduce dependency from foreign energy resources, the importance of the subject to design efficient and practical policies is beyond question. The relationship between energy consumption and economic growth is a controversial issue which is evident from the number of empirical studies.

From the very commencement, Kraft and Kraft (1978) investigated the causal relationship between energy consumption and economic growth covering the sample period from 1947-1974. The study found that unidirectional causality running from energy consumption to GNP growth in the United States. Akarca and Long (1980) found that a causal relationship does not exist between energy consumption and economic growth when, the study period is concise merely by 2 years. Ozturk (2010) examined the relationship taking into consideration about 100 studies with a roughly uniform distribution and concluded that four obtainable outcomes, namely unidirectional causality from energy consumption to growth, unidirectional causality from growth in energy consumption, bidirectional causality and neutrality.

Over the years, much research has been done to determine the key factors impacting on economic growth, an energy being a new factor for growth but, no single study have not included in the traditional growth models. (Stern, 2011; Pir lo Geo and Eicea, 2012). We have seen most of the studies have explained growth and economic activity on the way of the production function. If we look at the neo classical models we could observe that capital, labour and land treated as the primary factors of production, while energy is used as an intermediate input finally produced by the primary factors of production. In addition to, neo classical economist like (Solow, 1974) assumes that capital and energy are perfectly substitutable. A reduction is energy consumption does not, under state of affairs of economic efficiency, which results in a reduction in economic growth. These analyses have lead to an importance in the conventional growth theory on the primary inputs, and in Fastidious, labour and capital, other given that land is treated as a subcategory of capital. Whereas, energy has played a minor role

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in economic production in the conventional theory of growth.

Ecological economist is strongly criticised to the new classical growth theory, which is beached in the biophysical theory of the role of the energy. According to the law of thermodynamics a certain quantity of energy is required to carry out the transformation of matter. Though we know all production process deals with the transformation or movement of matter, therefore, energy is necessary for economic production and as a result economic growth. Moreover, some econometric studies, like (e.g Barndt and Wood, 1997; Apost a Lakis, 1990; Stern, 1995; Fronded and Schmidt, 2002) have used different functional forms to estimate elasticities of substitution between capital and energy. The above studies indicated that energy and capital are, at best weak, complements and substitutes.

From the above analysis, we observed that energy is a vital input in the production process, seeing as it is used in other economic activities. In the Morden times climate change and energy security become a key issue in recent decades. Given changes in energy policies to investigate the caused relationship between energy consumption and economic growth has become a compelling area.

From an economic point of view, the energy consumption and economic growth have two important aspects. (i) High dependency of economic growth on energy. (ii) Economic growth promotes advance energy technology, utilisation of energy and large scale development. Various studies, like (e.g Masih and Masih, 1996, 1997; 1998, Akarca and Long, 1979; 1980; Glasure and Lee, 1998) have shown (I) the relationship between energy consumption and economic growth varies depending on the categorisation of (Developed, developing and underdeveloped) countries. (ii) The relationship varies at different times in the same country. This divergence results from a number of factors like (i) structure and stages of economic development. (ii) The use of different econometric methods (iii) Variation of the analysis time horizon. (iv)The type and number of variable inclusion in the process. (Yu and Chai, 1985; Ferguson et al, 2000; Toman and Jemelkova, 2003; Karanfil, 2009; Payne, 2010).

In this present study, we attempt to include these issues by investigating the relationship between energy consumption and economic growth in the case of India. The study fills the research gap in the form of disaggregate analysis of energy consumption. Where, relatively less researched using a multivariate approach in this area has been conducted.

This paper is organised as follows, review of literature is in the section II, variable description and period of study is considered in section III. Methodology has been dealt with section IV. The empirical results are discussed in section V and concluding remarks are conferred in section VI.

II. Review of Literature

There has been ample of literature on the causal relationship between energy consumption and economic growth. The issue become very crucial after the oil crisis in the 1990s to the more recent concern on energy prices, energy security and reduction of greenhouse gases and impact of environmental policy. The present study motivated on international studies first before moving to Indian studies. In the late 1970s the pioneer work done on the causal relationship between energy consumption and economic growth by Kraft and Kraft (1978). By using the U.S data for the period 1947 to 1974 the study found that increased in GNP leads to increase energy consumption on U.S. Akarca and Long (1979) studied the linkage between energy consumption and economic growth for U.S using employment to substitute to growth. The empirical findings suggest that increased energy consumption leads to higher level of employment. Akarca and Long (1979), Erol and Yu (1987a), Murrya and Nan (1992) using the annual time series data from the period 1970 to 1984 in the context of U.S. They found that no causal relationship between energy consumption and employment. Erol and Yu (1984b) examined the causal relationship between energy consumption and real GNP for Canada, France, Germany, U.K, Italy and Japan. By employing Granger and Sims causality methods they found that there is a bidirectional causality between the two variables for Japan and no causal relationship between the two for the U.K and France. Whereas, increased in GNP leads to increased energy consumption in the case of Germany and Italy and vice-versa for Canada. Murray and Nan (1992) studied the relationship energy consumption and employment by employing Granger causality method for the U.S data from 1974 to 1988. The study found that increased employment results in increased energy consumption. Yu and Hwang (1984) by employing the employment when investigating the relationship between energy consumption and GNP, they found that increased employment leads to increased energy consumption for the U.S. Stem (1993) investigated the relationship between energy consumption and GNP by adding employment and capital in the analysis and found that no causal relationship between energy consumption and GNP. Glasure and Lee (1998) investigated the relationship between energy consumption and real GDP by applying Engle-Granger cointegration and Error Correction Model in the context of South Korea and Singapore. The study found that there is a bidirectional causality between energy consumption and real GDP growth. Francis et al. (2007) examined the relation between the energy consumption and real GDP growth for Jamaica, Haiti, Tobago and Trinidad. The empirical result suggests that there is a bidirectional causality between two. Yet Cheng and Lie (1997) found unidirectional causality relationship between real GDP to energy consumption and energy consumption to employment in the context of Taiwan. Studies like, Yu and Jin (1992), Cheng (1996), Paul and Bhattacharya (2004) and Pirlogea and Cicea (2012) all these studies added measures of labour and capital in the context of a production framework model. Glasure and Lee (1995) included energy prices and wages and, Later, energy price and wages, real government spending and real money supply (1996) into their analysis to find out the relationship energy consumption and economic growth. Glasure and Lee (1995, 1996) and Paul and Bhattacharya (2004) examined the bidirectional relationship between two. Yu and Jin (1992) and Cheng (1996) investigated no long run and causal relationship between energy consumption and economic growth. Most of the studies deal with the causal relationship between energy consumption and economic growth employing aggregate energy consumption data. Which, could cover the differential impact links with different types of energy consumption. Yang (2000a, 2000b) Yoo and Kim (2006), Jinke et al. (2008) and Pirlogea and Cicea (2012) investigated the impact of different disaggregated of energy consumption like electricity, Natural gas, Coal by different sectors. Again, they found that there is no agreement on the causal relationship between energy consumption and economic growth within and across countries. Some studies have employed disaggregated measures of energy consumption by sector and by source among the majority of the studies are bivariate model, Masih and Masih (1996), Soytas and Sari (2003), Yoo (2005, 2006a, 2006b, 2006c), Yoo and Jung (2005), Chen et al. (2007) and Zachariadis (2007) included energy, employment and output. Other studies added measure of labour and capital, such as Stern (2000), Ghaliand El-Sakka (2004), Oh and Lee (2004a, 2004b), Paul and Bhattacharya (2004), Soytas and Sar (2006a, 2007), Yuan et al. (2008). Masih and Masih (1997, 1998) and Asafu- Adjaye (2000) included consumer prices. Glasure (2002) incorporated real money supply, dummy variable oil price shock and real government expenditure. There are certain studies found contradictory and inconsistent results Masih and Masih (1996, 1997, 1998) investigated no causal relationship between energy consumption and economic growth in the context of Malaysia, Philippines and Singapore while, bidirectional causality takes place between the two in South Korea, Pakistan and Taiwan. Furthermore, they examined that increased energy consumption cause's growth In India, Sri Lanka and Thailand, when economic growth leads to increased energy consumption in Indonesia. Stern (2000) examined greater energy consumption leads to growth in the United States, While Soytas and Sari (2003) found no causal relationship in the United States, Canada, Poland, and Indonesia, the United Kingdom and Bidirectional causality in Turkey and Argentina. Unidirectional causality with high energy consumption leads to increased GDP Japan, France and West Germany and causality with increased GDP, leading to increased energy consumption in South Korea and Italy. In contrast to the studies like Soytas and Saris (2003), Ghali and El-Sakka (2004) examined the bidirectional relationship between energy consumption and growth in Canada. Oh and Lee (2004a, 2004b) concluded that inconsistent result in the case of Korea when using different models and data set. The Engle-Granger/Johansen-Juselius cointegration methods and consistent error-correction model have been highly used to study a causal relationship between energy consumption and economic growth, these approaches have been criticised due low power and small sample size deals with unit root tests (Harrris and Sollis, 2003). A recent study has used the Autoregressive Distributed Lag Model (ARDL) and Bound testing approach, with the Toda-Yamamoto (1995) and Dolado-Lutkepohl (1996) long run causality test, which can be done regardless whether the variables possess a unit root and whether cointegration occurs among the variables. Alitnay and Karagol (2005) examined the relationship between electricity consumption and economic growth by employing Dolado-Lutkepihl test in the case of Turkey. The study found that there is a unidirectional causality runs from electricity consumption to Higher GDP growth. Lee (2006) By employing Toda-Yamamoto methodology, he found that no causal relationship between energy consumption and real GDP per capita in the case of Sweden, Germany and the United States; and bidirectional causality between the energy consumption and real per cpaital GDP in the United States; high energy consumption leads to real GDP per capita in Canada, Switzerland and Belgium; and increases in real GDP per capita boost to greater energy consumption in Italy, France and Japan. Soytas and Sari (2006b) by using Toda-Yamamoto causality test for their study, adding real GDP, energy consumption, labour force and real gross fixed capital formation variables to examine the causal relationship between energy consumption and economic growth in China. The result of the study suggests that an absence of a causal relationship between the two. Zachariadis (2007) Examined the relationship between energy consumption and economic growth by applying ARDL bound test and Toda-Yamamoto test in the context of France, Canada, Itlay, Germany, United Kingdom, Japan and the united states. The result found an inconsistent and conflicting result due to the adoption of different methodology. Bowden and Payne (2010) examined the causal relationship between the disaggregated processes by sector and real GDP in United States by employing Toda and Yamamoto causality test. The study includes employment variables and real gross fixed capital formation in their model and concluded that no causal relationship between real GDP and commercial energy consumption; and unidirectional causality, with industrial non-renewable energy consumption leads to an increase in real GDP. Sari et al. (2008) studied the causal relationship between disaggregated measures energy consumption and industrial production by employing ARDL bound test. The result found that unidirectional causality runs from industrial production to energy consumption, apart from coal consumption, which found to lead growth.

Moreover, a different approach that concern with the low power and size properties of small samples related to a conventional cointegration and unit root test in the panel cointegration tests. The panel study provides additional power by combining the time series and cross section data permitting for the heterogeneity across countries Lee (2005), Chen et al. (2007), Narayan and Smyth (2007), Lee and Chang (2008), Lee et al. (2008) and Payne, (2010) employed this approach. At the same time, Huang et al. (2010) used dynamic panel estimation to study the relationship between energy consumption and economic growth. Lee (2005) using real gross capital formation in the analysis and suggest that unidirectional causality, the highest increase in energy consumption leads to real GDP growth for the developing countries panel. Yet Chen et al. (2007) examined the relationship between electricity consumption and real GDP for countries like Hong Kong, Indonesia, Korea, India, Malaysia, Singapore, Thailand, China, The Philippines and Taiwan. The study suggests that there is a bidirectional causality runs between electricity consumption and real GDP for all countries. Mehrara (2007) studied real GDP per capital growth leads to commercial energy consumption for the oil exporting countries through a panel study. Narayan and Smyth (2007) examined the relationship between energy consumption and per capital GDP growth for the G7 countries. The study concludes that energy consumption per capital cases real GDP growth per capita. Lee et al. (2008) examined by directional causality between the two variables. Lee and Chang (2008) investigated by incorporating real gross fixed capital formation and labour force and concluded unidirectional causality runs from energy consumption to real GDP growth for Asian countries, APEC countries. Huang et al. (2008) examined mixed results on the impact of electrify and non-electricity on economic growth in a global panel (East/the pacific region/South Asian, Central Asian region and Europe, the Caribbean region and Latin America, and Sub-Saharan, Middle Eastern region and North America). Sharma (2010) examined the relationship, includes inflation, trade, energy, capital stock and labour force for the same country.

Paul and Bhattacharya (2004) examined a recent study by applying alternative econometric time series models such as; Engle-Granger, Granger causality test and Johnsen's multivariate cointegration technique in the context of India covering the sample period from 1950 to 1996. The study found that in the long run economic growth leads to economic growth, but the standard Granger causality test shows that energy consumption leads to economic growth. Cheng (1999) investigated a unidirectional relationship from economic growth in energy consumption but Adjaya (2000) examined the reverse direction. Ghosh (2005) examined the total petroleum products consumption and economic growth in India for the period 1970 to 2002. The study found that there is a long run relationship between the two variables. Moreover, here it is found that the above studies try to relate the aggregate energy consumption and economic growth in India, but there may be practical difficulties in aggregating the different forms of real energy consumption as their units of measurement is different. The conversion of measurement is depends on the productivity and quality of energy. Thus, the present study is different from the earlier studies in relation with various forms of energy consumption and economic growth. As a consequence of this study, which will help to formulate different policy strategies forms of energy demands. Earlier studies have taken aggregate energy consumption or if there is a disaggregation, they are considered some forms of energy consumption and leaving the most vital component of energy like electricity. Thus, the current study used the different forms of growth of real energy consumption and then try to include with a real growth rate of the economy.

III. Variables Description and Period of Study

The present study used the annual time series data covering the period from 1970-71 to 2011-12. The data source is cumulated form the www.Indiastat.com and RBI (Reserve Bank of India) Handbook of statistics, 2014. The study considers the growth of various forms of energy consumption, such as Lignite, Petroleum, Natural Gas and Electricity. The growth of all variables in the empirical analysis has been related to a simple growth rate of GDP. The growth rate of GDP is defined as the changes in GDP in the two consecutive periods divided by initial period value. The study applied the same method of computing growth rates to the rest of the variables.

IV. Methodology

The study employed time series econometric methods in order to make a deep understanding the dynamic relationship of growth of different forms of energy consumption and the growth rate of the economy. Basically, the study trying to find out that whether energy consumption fuels economic growth or the economic growth stems the demand for more energy consumption in the economy. Before performing the time series methods for estimating the variables, the study conduct unit root test to examine the stationary properties of the time series variables and to avoid bias and spurious results. Since the growth rates of all these variables are stationary at level, hence, the study employed Granger causality test and variance decomposition analysis of vector auto regression (VAR) method for empirical analysis. As we know that when all the variables are stationary at their levels Granger causality test and variance decomposition analysis of VAR are most appropriate for analysis of the data.

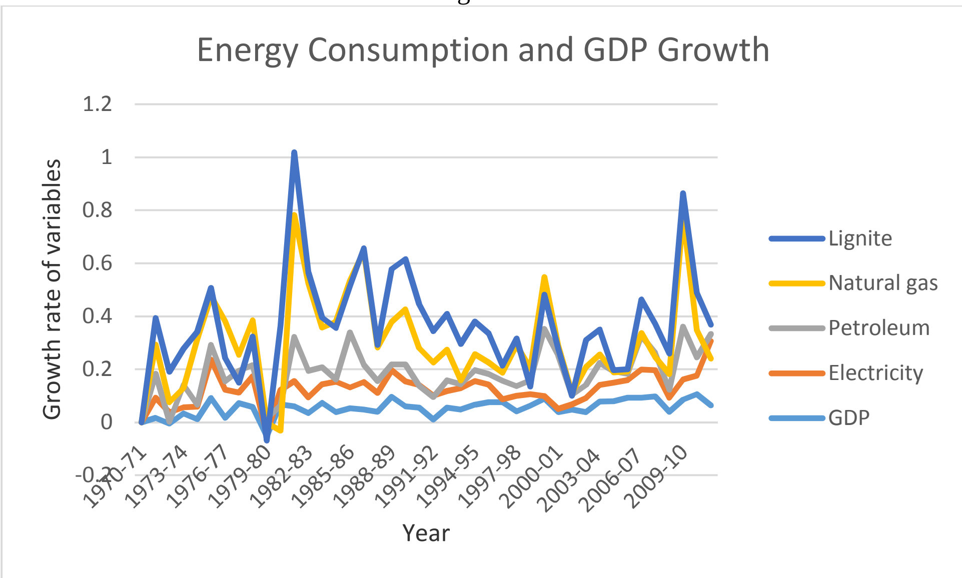
The Granger causality test defines that the direction of causality running from one to other variables and vice versa, or the information gratified in one variable in correctly predicting another variables, while variance decomposition analysis examined the variance in the one variable due to the shock in the itself and shock in another in an out of sample forecasts. In other words, we can say variance decomposition can be regarded as an out of the sample causality test. Before carrying out all these econometric tests, one of the crucial factors to specify the proper lag length of the variables in the models. The lags of the model have been selected on the basis of Akaike Information Criteria (AIC). If not, it is understood that the integration of insignificant variables may over parameterise in the model estimation, generates biased estimates and henceforth arriving of wrong inferences.

Here we are not endeavouring to elucidate all these time series techniques because these are many illustrious methods and are available in any standard textbooks of time series econometrics.

V. Empirical Findings

Before undertaking any time series econometric analysis of the data, it would be useful to see the broad trends and behaviour of the variables, which may help in interpreting the model results latter. For this purpose time series plots are drawn for all the variables.

Figure: 1



Source: www.Indiastat.Com & RBI (Reserve Bank of India)

Descriptive Statistics

The importance of descriptive statistics rests in their as tools for interpreting and analyzing data. Descriptive statistics is the discipline of quantitatively describing the main features of a collection of data or the quantitative description itself. The objective of the descriptive statistics of summarizes sample, rather than use the data to learn about the population that the sample of the data is thought to represent. The use of descriptive and summary statistics has an extensive history and indeed, the sample tabulation of population and of economic data was the first way the topic of statistics appeared more recently, a collection and summarization techniques has been formulated under the heading of exploratory data analysis. In this study the sample consisting more than one variable which is used to describe the relationship between pairs of variables.

Table: 1 Descriptive Statistics

	Electricity	GDP	Lignite	Natural Gas	Petroleum
Mean	0.07	0.05	0.06	0.11	0.06
Median	0.06	0.05	0.05	0.08	0.04
Maximum	0.24	0.10	0.39	0.45	0.25
Minimum	0.00	-0.05	-0.13	-0.09	-0.05
Std. Dev.	0.04	0.03	0.10	0.12	0.06
Skewness	1.35	-0.87	0.59	0.95	1.17
Kurtosis	7.52	4.15	4.22	3.70	4.45
Jarque-Bera	48.69	7.68	5.05	7.31	13.44
Probability	0.00	0.02	0.07	0.02	0.00
Sum	2.98	2.24	2.71	4.79	2.59

The Table: 1 presents the summary statistics of the variables in which in which kurtosis of the coefficients, a measure of the thickness of the tail of the distribution, is quite high in the case of all variables. A Gaussian (normally) distribution has the kurtosis equivalent to three, and thus, this denotes that the assumption of

Gaussianity cannot be made for distribution of the concerned variables. This finding further strengthen and by Jarque-Bera test for normality which in our case yields very high values and, thus, the result reject the null hypothesis of normality at any significant levels. The result also indicates the skewness is negative for GDP and positive for all other variables.

Correlation Statistics

In order to find out the pair wise degree of association among the variables, the study used the correlation matrix.

Table: 2 Correlation Matrix

	ELECTRICITY	GDP	LIGNITE	NAGS	PETROLEUM
ELECTRICITY	1				
GDP	0.29	1			
LIGNITE	0.21	0.23	1		
NAGS	0.15	0.00	-0.10	1	
PETROLEUM	-0.15	0.26	-0.24	0.38	1

The Table: 2 indicates the result of correlation among the variables as expected. From this table it is observed that there is positive relationship between GDP and electricity, Lignite and electricity, Lignite and GDP, Natural Gas and GDP, Petroleum and GDP, petroleum and Natural Gas. Whereas, there is no correlation exist between Natural Gas and GDP. However, the table also reveals that there is a negative relationship between Natural Gas and Lignite, Petroleum and Electricity, petroleum and Lignite.

Unit Root Test

When we are pursuing any time series model, the unit root test is conducted on the level of the variables. This is because when the data have unit root characteristics, the analysis may lead to spurious results and misleading conclusions. Prior to applying causality test, the study investigates the order of integration of the variables used in the analysis.

Table: 3 Unit Root Test

Variables	ADF Test	PP Test
Electricity	-3.88 (0.00)	-3.91 (0.00)
GDP	-5.67 (0.00)	-5.69 (0.00)
Lignite	-3.73 (0.00)	-3.82 (0.00)
Natural Gas	-4.98 (0.00)	-5.00 (0.00)
Petroleum	-6.26 (0.00)	-6.26 (0.00)

Note: The Mackinnon (1996) critical values at 1%, 5% and 10% are -3.60, -2.93 and -2.60 respectively. The parenthesis ( ) indicates probability values.

The above Table: 3 presents the result of Augmented Dickey Fuller (ADF) test and Phillips Peron (PP) test. The result shows that the null hypothesis of unit root is rejected for all the variables of their levels. It can be concluded that all variables are stationary and integrated of order zero. i.e. I (0).

Granger Causality Test

Granger (1969) causality test regresses a variable y on a lagged value of itself and other variable x. lf x is considered to be significant, then explains some of the variance of y which is not described by lagged values of y. This shows that x is causally previous to y and said to dynamically cause y. The study used the following specification model of Granger causality.

$$Y_t = \sum_{i=1}^{n} \delta_i \, y_{t-i} + \sum_{i=1}^{n} \gamma_i \, x_{t-i} + u_t$$

From the above stationary test we have seen all of the variables found to be integrated of order zero, therefore, it is a suitable case for conducting a bivariate causality test by relating the growth of different forms of energy consumption with economic growth measures by growth rate of GDP.

Table: 4 Pair Wise Granger Causality

Null Hypothesis	Obs.	F-stat.	Prob.
GDP −ELECTRICI	40	1.94	0.15
ELECTRICITY −GDP		1.81	0.17
LIGNITE−ELECTRICITY	40	1.27	0.29
ELECTRICITY →LIGNITE		7.71	0.00
NAGS →ELECTRICITY	40	3.08	0.05
ELECTRICITY−NAGS		0.02	0.97
PETROLEUM −ELECTRICITY	40	0.68	0.51
ELECTRICITY −PETROLEUM		0.20	0.81
LIGNITE −GDP	40	0.08	0.91
GDP →LIGNITE		7.34	0.00
NAGS −GDP	40	0.20	0.81
GDP →NAGS		3.44	0.04
PETROLEUM −GDP	40	0.15	0.85
GDP− PETROLEUM		0.78	0.46
NAGS −LIGNITE	40	0.88	0.42
LIGNITE −NAGS		1.82	0.17
PETROLEUM −LIGNITE	40	0.21	0.80
LIGNITE −PETROLEUM		0.26	0.76
PETROLEUM −NAGS	40	1.60	0.21
NAGS− PETROLEUM		1.38	0.26
PETROLEUM −NAGS			
40		1.60	0.21
NAGS −PETROLEUM		1.38	0.26

Note: −shows that no causality and → indicates unidirectional causality

The Table: 4 presents the pair wise Granger causality results among the variables. From this table we find that the null hypothesis is rejected in case of electricity causes lignite, natural gas causes electricity, GDP causes lignite and GDP causes natural gas. The result suggests that growth rate of all forms of energy do not cause the growth rate of GDP rather, GDP growth rate causes the growth rate of lignite and natural gas consumption demand in the country. This provides evidence that the country needs more amount of energy consumption of lignite and natural gas to meet the growing demand of energy consumption and economic growth. In other words, it is growth rate of GDP that leads to more demand for energy consumption. This implies that when GDP growth rate of the country rises, it directly leads to more consumption demand for lignite and natural gas.

Lag Length Criterion

To determine the suitable optimum lag length for the variables in the VAR, we have used different lag augmentation criterion such as Sequential Modified Likelihood Ration Test Statistics, Final Prediction Error, and Akaike Information Criterion, Schwarz Information Criterion and Hannan Quinn Information Criterion. The result of this optimum lag based on the above based mentioned criterion is reported in the Table: 5.

Table: 5 Lag Length Criterion for Variance Decomposition Test

Lag	LogL	LR	FPE	AIC	SC	HQ
0	271.4152	NA	8.02e-13*	-13.66232*	-13.44904*	-13.58580*
1	295.5029	40.76370*	8.51e-13	-13.61553	-12.33587	-13.15640
2	318.3698	32.83464	1.01e-12	-13.50615	-11.16010	-12.66440
3	341.1578	26.87815	1.36e-12	-13.39271	-9.980275	-12.16836

*Indicates lag of order selected by the criterion

LR: Sequential Modified LR test statistics (each test at 5% level)
FPE: Final Prediction Error
AIC: Akaike Information Criterion
SC: Schwarz Information Criterion
HQ: Hannan Quinn Information Criterion

From the above table it can be observe that majority of the lag length criterion consistently reported 0 days lag length criterion as the optimum lag length, by considering this lag length we have examined the VAR decomposition test among the variables.

Variance Decomposition

After carrying out the Granger Causality test, the study trying to estimate the dynamic causality relationship between growth of energy consumption demand and growth rate of GDP through variance decomposition analysis of vector auto regression (VAR) technique.

$$\pi_t = \begin{bmatrix} x_t \\ y_t \end{bmatrix} = \beta + \beta_1 t + \sum_{i=1}^{k+1} A_t + \pi_{t-1} + u_t$$

$$A_t = \begin{bmatrix} \delta_{11} & \delta_{12} \\ \delta_{21} & \delta_{23} \end{bmatrix}$$

The variance decomposition is computed for 10 period lags for all the energy consumption.

Table:6 Variance Decmpostion of Growth of Eletricity

Variance Decomposition of Electricity Growth		
Periods	**Electricity**	**GDP**
1	100.0000	0.000000
2	92.61089	7.389115
3	92.24030	7.759701
4	92.22640	7.773598
5	92.19723	7.802770
6	92.20679	7.793210
7	92.19494	7.805055
8	92.19508	7.804924
9	92.19606	7.803935
10	92.19585	7.804150
Variance Decomposition of GDP Growth		
Periods	**Electricity**	**GDP**
1	7.149685	92.85032
2	15.02581	84.97419
3	18.48674	81.51326
4	18.14719	81.85281
5	18.15081	81.84919
6	18.31321	81.68679
7	18.31083	81.68917
8	18.32404	81.67596
9	18.32690	81.67310
10	18.32700	81.67300

The variance decompocition of growth rate of elcetricity consumption is presented in Table 6 shows that the variation in the elctricity growth rate is initially being explained by in its own shock, but from the second period on words, the growth rate of GDP to a certain sinificant degree explains the variation in growth rate of elctricity consumption demand. This states that the growth rate of GDP leads to increasing the demand for electricity consumption in India. In the same table, we find the decomposition result for the growth rate of GDP shows that growth rate besides being explained by its own shock, it is also significantly being explained by the shocks in electricity consumption and this almost through out the periods. At the first period 7 percent of the variance in growth rate is being explained by the shocks in elctricity consmption and the second period it is 15 percent and in the third period until the 10^{th} period around 18 percent of variation in growth rate of GDP is being explained by the variation in growth rate of electricityconsumption. This implises that there is a bidirectional causal relationship between growth of electriicty consumption and economic growth in the context of India. This result is divergent to the Granger causality test reported above as Granger causality shows there is no causal relationship between elctricity consumption and GDP growth.

Table:7 Variance Decmpostion of Growth of Lignite

Variance Decomposition of Lignite Growth		
Periods	**Lignite**	**GDP**
1	100.0000	0.000000
2	79.07768	20.92232
3	77.87450	22.12550
4	77.85001	22.14999
5	77.60339	22.39661
6	77.36212	22.63788
7	77.26905	22.73095
8	77.27464	22.72536
9	77.27016	22.72984
10	77.26116	22.73884
Variance Decomposition of GDP Growth		
Periods	**Lignite**	**GDP**
1	14.99069	85.00931
2	14.97917	85.02083
3	15.81473	84.18527
4	15.96902	84.03098
5	16.09301	83.90699
6	16.09656	83.90344
7	16.09527	83.90473
8	16.09654	83.90346
9	16.09644	83.90356
10	16.09642	83.90358

The variance decomposition of growth rate of Lignite consumption is explained in Table 7 shows that the variation in the lignite growth rate is intially being explained by its own shock, but from first period on words, the growth rate of GDP to a certain significant degree explaines the variations in the growth rate of lignite consumption demand. This implises that with the rise in GDP growth, there is an increasing demand for lignite consumption in the economy. In the same table we have seen the variance decomposition result for growth of GDP besides being explained by its own shock, it is also significantly being explaied by the shock in lignite consumption and this almost through out the periods. This also indicates that there is a bidirectional causal relationship between the growth of lignite consumption and economic growth in India. This result is also contrary to the result obtained from the Granger causality test reported above as Granger causality shows there is unidirectional causality runs from GDP to lignite.

The variance decomposition analysis of natural gas consumption explained in Table 8 shows that 1 percent variation in the second period, a 13 percent variation in the 3 and 4 period and 14 percent variation in the growth rate of natural growth is being explained by the growth rate of GDP respectively to the 10 period. That means it is growth of income which causes more demand for natural gas consumption in the economy. This result conformed from the above Granger causality test. However, when one considers the variance decomposition of growth rate of GDP presented in the same table, it shows that the variation in growth rate of GDP is not being explained by the consumption of natural gas. Relatively, it is nearly unconditionally being explicated by its own shocks. This implies that the growth rate of consumption of natural gas is driven by growth of GDP in the economy.

The Table 9 presents the variance decomposition results growth rate of petroleum in relation n to the growth rate of GDP. It shows that the petroleum energy consumption is marginally is being explained by its own variation and shocks. This result is relatively similar to Granger causality, wherever, the study found the growth rate of GDP have no influence on the petroleum consumption. However, the variance decomposition of the growth rate of GDP produced in the same table shows that the growth rate of GDP is not significantly being explained by the shocks in the petroleum consumption. Which suggest that petroleum consumption is not a key to the growth rate of GDP in the economy or it is insignificant to the economic growth for India. This result is reliable with the Granger causality obtained previously.

Table: 8 Variance Decmpostion of Growth of Natural Gas

Variance Decomposition of Natrual gas Growth		
Periods	**Natrural Gas**	**GDP**
1	100.0000	0.000000
2	98.80035	1.199655
3	86.96455	13.03545
4	86.03242	13.96758
5	85.60908	14.39092
6	85.52588	14.47412
7	85.49595	14.50405
8	85.48822	14.51178
9	85.48586	14.51414
10	85.48521	14.51479
Variance Decomposition of GDP Growth		
Periods	**Natural Gas**	**GDP**
1	0.491649	99.50835
2	1.461220	98.53878
3	1.411612	98.58839
4	1.410781	98.58922
5	1.407707	98.59229
6	1.407283	98.59272
7	1.407082	98.59292
8	1.407036	98.59296
9	1.407021	98.59298
10	1.407017	98.59298

Table:9 Variance Decmpostion of Growth of Petroleum

Variance Decomposition of Petroleum Growth		
Periods	**Petroleum**	**GDP**
1	100.0000	0.000000
2	96.41870	3.581301
3	96.16087	3.839126
4	96.06012	3.939885
5	96.05169	3.948308
6	96.04652	3.953475
7	96.04605	3.953951
8	96.04581	3.954188
9	96.04579	3.954211
10	96.04578	3.954222
Variance Decomposition of GDP Growth		
Periods	**Petroleum**	**GDP**
1	5.656649	94.34335
2	5.951384	94.04862
3	5.702478	94.29752
4	5.710188	94.28981
5	5.699370	94.30063
6	5.699688	94.30031
7	5.699202	94.30080
8	5.699214	94.30079
9	5.699192	94.30081
10	5.699192	94.30081

VI. Concluding Remarks

The present study examined the linkage between different forms of energy consumption and economic growth in the context of India. The relationship is examined by using the annual data covering the period from 1970 to 2011. The study investigated the relationship by employing the sophisticated econometric techniques like

Granger causality test and variance decomposition analysis of VAR technique. As we know Granger causality method is used to examine whether the information contained in a variable is correctly predict the other variables and vice versa, whereas the variance decomposition VAR analysis, discussed an out of sample forecast explains the variation in one variable how much is being explained due to its own shock as against the shock to the other variables in a system. The empirical result of Granger causality suggests that it is the growth rate of GDP, which leads to more demand of natural gas and lignite energy consumption, and none of the energy growth variables have an influence on GDP growth rate. In contrast, variance decomposition analysis suggests that there could be two way causality between electricity consumption and economic growth and Lignite consumption and economic growth in the future. The result also suggests that there could be unidirectional influence from an economic growth to natural gas consumption. Thus, the study identified inconsistent and diverse result on the relationship between energy consumption and economic growth as compared to the previous studies carried out in the Indian context.

Given the fact that the GDP growth fuels rate of energy consumption, but the reverse does not hold good in the context of India. The energy policy in India should curb conventional and non-renewable energy consumption, such as crude oil, natural gas as import of these forms of energies expensive. The government acquires large amount of expenditure in importing and distributing these energies of the subsided rates, which has got more implications for maintaining a sound macroeconomic environment. However, limited consumption of these energies can keep the environment clean and financial position of the macroeconomic stable. Therefore, there should be an effort to exploit the renewable sources of energy for efficient use, as a result of which it would economies the use of these natural resources in India. Moreover, since electricity and lignite contributes to economic growth, the study suggests that the policymaker of the country should give importance for efficient Sectoral allocation on energy as industry, which is the major driven of economic growth consumes the heavy amount of these forms of energies.

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