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Energy Consumption and Sustainable Economic Development in India

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ABSTRACT

It is evidently found that energy has become inevitable for the economic development of any nation. In the 21st century the demand for energy has escalated since the emphasis on achieving economic development is being realized worldwide. It is interesting to note that the majority of the developing countries have rich resources of renewable energy, which includes solar, wind, thermal and bio energies. By exploiting resources of renewable energies developing nations can decrease their dependency on fossil fuels and achieve economic development without destroying environment. As we know that energy is the basic necessity for the economic development of any country. Having a population of more than a billion, a fifth of the total populace in the worldwide, India retains its position in the third on the planet regarding demand for energy. Inadequacy of energy supply would obviously affect very adversely on the quality of service in the fields of education, health and in fact, even food security which is a vital and essential requirement of any society. India's strategy towards energy development and energy security plays a vital role in economic development. There are causal factors which influence energy crisis in terms of supply and demand factors viz. supply shortage with respect to demand; transmission bottlenecks; natural factors; defects in deregulation; imperfect market; financial concerns, geopolitical pressures and the global energy landscape. The choices we as a whole make today whether they include putting resources into a multibillion dollar oil task or obtaining the family vehicle may have long haul suggestions pertaining to energy. It is important that we face the challenges and embrace the opportunities because energy both its production and its use in an environmentally safe manner is a platform for broader discussion.

Keywords

Energy Consumption, Sustainable Development, Energy Security.

INTRODUCTION

Energy is the important engine of an economy and has a critical place in the development of the country. It has been accepted worldwide as one of the main significant variable of the economic and individual growth. The energy sector is the largest universally common and thriving industry with the biggest impact on other sectors of the economy. This sector is counted among the basic infrastructure sectors.The demand for energy has risen enormously and has exerted enormous

pressure on resources. The availability of energy is a prerequisite for the working of an economy.An adequate and continuous supply of energy sources helps the prosperity of a country. The Indian economy faces momentous challenges is to meet the requirements of the energy. The estimated relationship between total primary energy consumption and economic growth is used to predict future energy consumption. The correlation existing between energy consumption and economic growth points to a two-way causality within them. Increased use of energy improves production, spurs economicdevelopment and develops standards of life. These are all signs of growth, which in their return lead to more energy consumption. Furthermore, energy consumption andgeneration also proves a vital role in different sustainability concerns, like any climatechange, reduction in the natural assets and local internal and external air pollution (Ruijven 2008). Energy has become the central function for any country's economic development, improving the efficiency and productivity of the country. Widespread industrialization, urbanization and rising population size have scaled up the energy consumption in India. This direction of causality has considerable political implications. Empirically, in this study, attempts have been made to find the area of causality between total primary energy consumption and economic growth in India through the use of Granger techniques. World energy consumption is growing continuously, especially in developing countries like India and China, which are the two most populated countries. These areamong the top ten energy consumers in the world.

Objectives of the Study

1. To discuss the strategies towards energy security and sustainable development
2. To elucidate on energy security and sustainable development in India
3. To analyse the growth and composition of energy sector in India

Energy Security in terms of Coal Production, Consumption and Imports

Table 1.Production, Consumption and Imports of Coal in India

Variables	1991-2000	2001-10	2011 -20
Production	5.23	5.49	5.73
Consumption	5.21	5.49	3.87
Imports	5.73	5.79	4.92

Source: Author's Calculations

Compound growth rate formula in term of linear regression equation show R-square is 0.879 and adjusted R-square is 0.872 with very small Std. Error of the Estimate is 0.079 in terms of production. In case of consumption the value of R-square is 0.870 and the adjusted R-squared is 0.862. More over the table shows that growth rate co-efficient is statistically noteworthy because the p-value is less than level of significance. And coefficients D1 and D2 are significant with 0.0001 values. Energy security equations are Yt = 5.234 + 0.252D1 + 0.493D2, Yt = 5.214 + 0.272D1 + 0.576D2 and Yt = 2.772 + 1.098D1 + 2.143D2 in terms of production, consumption and imports respectively. In order to estimate energy security for the period of 1991 – 2000, D1 = 0, D2 = 1, for the period of 2001 – 2010, D2 = 0, D1 = 1, for the period of 2011 – 2020, D1 = 0 and D2 = 1, Yt
= energy security.

Energy Security in Oil: Production, Consumption and Imports

Crude oil is particularly significant in view of its critical role in the transportation sector, mainly for a large country like India. The oil shortage in the system indicates the inability to meet the increasing demand. India's energy security is indomitable byincreasing dependence on imported fuels, which is tremendously vital to support India's large energy needs. India is exposed to bigger geopolitical risks and international price instability due to increased import addiction.

Energy Production, Consumption and Imports

The main challenge for developing countries is to balance their needs in terms of energy security, access to energy at reasonable prices and more sustainability in terms of energy consumption. The Indian population is suppose to exceed China to hold the position of first as most populated country around the world by 2022, reaching around 1.4 billion People, generating larger energy demand. India has the potential to be a much bigger producer and consumer of natural gas. As the Indian economy continuesto grow, its energy needs, including natural gas, will probably also grow. Although natural gas has historically been part of the Indian energy mix, it has never played a leading role. Natural gas usage differs majorly depending on the region of India. The regions of Gujarat and Maharashtra in west and UP in the north uses over 65 per cent of Indian natural gas, whereas they represent only 31 per cent of the population. Theexpansion of natural gas use in India is confined because of improper process and structure, especially gas pipelines to enable movement of the resource throughout the country. In the Paris Climate negotiations in 2015 (COP-21), India was seen as a recalcitrant country, but the contribution was considered vital to achieve its emission reduction targets. India's planned national contribution (INDC), unconfined by considering of the Paris contract, describes India's purpose to achieve a lessening in carbon concentration from 33 per cent to 35 per cent as a proportion of the GDP from2005 levels by 2030.

Production, Consumption and Imports of Natural Gas: Regression Model with Dummy Variables

In the present study the researcher has used regression modal with dummy variables to analyze the energy security. First starts with model summary:

Table 2 Model Summary of Key Variables for Natural Gas

Variables	Model	R	R Square	AdjustedR Square	Std. Error of the Estimate	F	Sig.
Production	1	.856[a]	.732	.716	.26484	45.153	.0001**
Consumption	1	.880[a]	.774	.761	.26619	45.153	.0001**

Source: Author's Calculations.

Table 2 shows the strong link between the model and the dependent variable. The multiple correlation coefficients (R) are the linear correlation between both observed values and those values which are predicted by the dependent variable model. The value 0.856 indicates a close relationship. R Square, the coefficient of determination,is the squared value of the multiple correlation coefficients. It shows that the model explains 0.732 per cent of the change in production and 0.774 per cent of consumption. The adjusted R square is a 'corrected' R square statistic that penalizes models with a large number of parameters. These statistics, together with the standard
error of the estimate, are employed as relative measures to choose between two or more models. The value of the standard error of the estimate is respectively 0.26484 and 0.26619 for production and consumption, shows the minimum values. Systematic factors and random factors. The former factors have a statistical influence on the given data set, while random factors do not. The researcherused the value F and sig. value to determine the influence that the independent variables have on the dependent variable in a regression study. ANOVA is also known as Fisher's analysis of variance and is popular as it is the extension of the t and z tests. The ANOVA test is the preliminary step to analyze the factors that cast their influence over a given set of data. The researcher tested the methodical factors that contribute measurably to the inconsistency of the data set. And she used the results of ANOVA test in an f-test. The researcher used the ANOVA test to compare more than two groups simultaneously to determine if there is a relationship between them.The total of the squares is a statistical technique that is used

in regression analysis toestablish the dispersion of data points. This refers to how close the data is to the fittedregression line. It is also termed the coefficient of determination or coefficient of multiple determinations for multiple regressions. The model shows significant values at all levels, with 0.0001 per cent for both production and consumption.

Table3. Coefficients of Variables

Variables	Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
			B	Std. Error	Beta		
Production	1	(Constant)	2.055	.084		24.533	.0001**
		D1	.711	.118	.650	6.003	.0001**
		D2	1.010	.107	1.024	9.459	.0001**
Consumption	1	(Constant)	2.025	.084		24.062	.0001**
		D1	.735	.119	.614	6.176	.0001**
		D2	1.142	.107	1.057	10.639	.0001**

Source: Author's Calculations

Linear regression analysis calculates the coefficients of a linear equation, which involves one or more independent variables. This enables the prediction of the best value of the dependent variable. It is the numerical index used to quantify the reduction percentage of the investigated parameter with the consideration of the interaction of the variable factors and the effect on the adsorption process. The regression coefficient is the stable in the regression equation that refers to the change in the value of dependent variable. This correspondsto the unit change in the independent variable. The regression coefficient is also termed slope coefficient because it determines the slope of the line. The change in thedependent variable for the unit change in the independent variable. It is a statistical measure of the average functional relationship between two or more variables. The model is significant at all levels, shows the 0.0001 values. The value of standard error is minimum for production and consumption in the model.

Energy Security In Terms Of Production And Consumption Of Natural Gas

Table 4 Production and Consumption of Natural Gas

Variables	1991-2000	2001-10	2011 -20
Production	2.05	2.77	3.06
Consumption	2.03	2.76	3.17

Source: Author's Calculations

Compound growth rate formula in term of linear regression equation shows R-Square is 0.732 and Adjusted R-Square is 0.716 with very small Std. Error of the Estimate is 0.265. More over analysis of variation of table shows that growth rate co-efficient are statistically significant as the p-value is lesser to the stages of consequence. Energy security equation in terms of the production, Yt = 2.055 + 0.711D1 + 1.010D2and Energy security equation in terms of the total consumption, Yt = 2.025 + 0.735D1 + 1.142D2. In order to estimate energy security for the period of 1991 – 2000, D1 = 0, D2 = 1, for the period of 2000 – 10, D2 = 0, D1 = 1, for the period of 2011 – 2020, D1 = 0 and D2 = 1, Yt = energy security.

Table 5. Lag Order Selection for Co-Integration Analyses using

VARIABLE	D (TOTAL)	D(GDP)
D(TOTAL(-1))	-0.207737	-0.788998
	(0.13945)	(0.54782)
	[-1.48965]	[-1.44024]
0.016005	.246995	-0.355982
	(0.13811)	(0.54253)
	[3.12695]	[-0.65615]
D(GDP(-1))	.071880	.025455
	(.04025)	(.15814)
	[1.78562]	[.16097]
D(GDP(-2))	0.065824	0.138073
	(0.04036)	(0.15855)
	[1.63087]	[0.87083]
C	0.030853	0.127579
	(0.01337)	(0.05253)
	[2.30733]	[2.42871]
R-squared	.343945	.063272
Adj. R-squared	.276657	-.032802
Sum sq. resides		

S.E. equation	.020258	.079581
F-statistic	5.111559	0.658574
Log likelihood	111.7851	51.58336
Akaike AIC	-4.853870	-2.117426
Schwarz SC	-4.651121	-1.914677
Mean dependent	.053720	.078944
S.D. dependent	.023819	.078308
Determinant resid covariance (dof adj.)		2.58E-06
Determinant resid covariance		2.02E-06
Log likelihood		163.5612
Akaike information criterion		- 6.980053
Schwarz criterion		-6.574555

Note: *, **, *** represents significant at 10%, 5%, 1% stages of significance.Source: Author's Calculations.

Table 6.Lag length Selection for Co-integration Analyses Using VAR

Lag	Log L	LR	FPE	AIC	SBC	HQ
0	123.3392	NA	2.72e-06	-7.137601	-7.047815*	-7.106982*
1	124.3617	1.864575	3.25e-06	-6.962455	-6.693097	-6.870596
2	129.2682	8.369897	3.09e-06	-7.015778	-6.566848	-6.862680
3	133.2327	6.296551	3.12e-06	-7.013689	-6.385188	-6.799352
4	140.2451	10.31229*	2.65e-06*	-7.190887*	-6.382813	-6.915310
5	141.4508	1.631336	3.19e-06	-7.026520	-6.038875	-6.689705
6	142.6080	1.429379	3.91e-06	-6.859292	-5.692075	-6.461237
7	145.4328	3.157126	4.39e-06	-6.790162	-5.443373	-6.330869
8	150.3704	4.937654	4.44e-06	-6.845318	-5.318958	-6.324786
9	151.5613	1.050814	5.75e-06	-6.680078	-4.974146	-6.098307
10	156.6369	3.881317	6.11e-06	-6.743347	-4.857843	-6.100336
11	156.8771	0.155437	9.04e-06	-6.522184	-4.457108	-5.817934
12	160.7645	2.058017	1.15e-05	-6.515558	-4.270910	-5.750069

Note: *, **, *** represents significant at 10%, 5%, 1% stages of significance, correspondingly.
Source: Author's Calculations.

Outcomes of Lag Order Selection for Co-integration Analyses Using VAR Model

Table 6 provides SBC and AIC values of the models. As quoted in the econometricsliterature, the lag length corresponding to minimum SBC and AIC values is optimum lag length. However, any clash emerges between the two criterions then one must settle on the optimum lag length based on SBC criteria. The AIC is minimum with 2-5lag length and SBC is minimum with 1-2 lag length. Hence, the researcher goes with 1-3 lag length and decides the lag length 1-3 for testing the presence of co-integration relationships. As total energy consumption variable is dependent, the p-value is 0.0000, 0.0014 and 0.0161 with 1, 2 and 3 lags respectively. When the GDP is a dependent variable, the p-value is 0.0000 with 1 lag. This shows the significant level with a 5% level of significance. The lag length has been selected 4 lags automatically. The next step is to ascertain whether energy consumption and economic growth have a long-term relationship or not. Aimed at this reason, the Autoregressive Distributed Lag (ARDL)

Bounds test has been selected. The Autoregressive Distributed Lag (ARDL) Boundstest is a co-integration method.

Table 7. Causality between Energy Consumption and Economic Growth: Using Vector Autoregressive (var) Granger Causality/ Block Exogeneity Wald Tests

Dependent variable: D(TOTAL)			
Excluded	**Chi-sq**	**Df**	**Prob.**
D(GDP)	7.848001	3	0.0493**
All	7.848001	3	0.0493**
Dependent variable: D(GDP)			
Excluded	**Chi-sq**	**Df**	**Prob.**
D (TOTAL)	3.930494	3	0.2691
All	3.930494	3	0.2691

Note: *, **, *** represents significant at 10%, 5%, 1% stages of significance. Source: Author's Calculations.

Outcomes of the Granger Causality Test

Granger Causality (1969) analyzed that if the variables are co-integrated, it implies that there should be at least one direction of causality between two variables and this causality has been demonstrated by p-statistics. The importance of the adjustment parameters can be used as a first guide to determine the co-integration ratio. Causalityin economics is quite different from the concept in everyday use, it indicates more the ability of one variable to forecast (and therefore cause) the other. Table 7 shows the results of the Granger Causality between the variables. The table provides Chi-squaretest statistics to test the null hypothesis that test the causality along with the p-values. The researcher used the unidirectional and bidirectional causality test. First, GDP (economic growth) has been used as a cause variable. And, for the second time, total primary energy consumption was used as a cause variable. The result shows that D (GDP), i.e. economic growth, Granger Cause D (TOTAL), i.e. the total primary energy consumption, since the p-value (0.0493) is less than 5% level of significance.And the D (TOTAL), i.e. the total primary energy consumption does not Granger Cause D (GDP), i.e. economic growth, since the p-value (0.2691) is more than 5% level of significance.

Energy Security in Oil Production: Regression Model with DummyVariables

Table 8. Model Summaries of Variables for Oil

Variables	**Model**	**R**	**R Square**	**Adjusted R Square**	**Std. Error of the Estimate**	**F**	**Sig.**
Production	1	.898[a]	.806	.794	.03799	68.526	.0001**
Consumption	1	.939a	.883	.876	.08679	124.103	.0001**
Imports	1	.931a	.868	.858	.16895	88.439	.0001**

Source: Author's Calculations

The R square value is 0.806, 0.883 and 0.868 for production, consumption and imports. This shows the higher value of R square and indicates the better fitted the model. The value 0.898, 0.939 and 0.931 indicates a strong relationship. Standard error is minimum 0.03799, 0.08679 and 0.16895 for production, consumption and imports respectively.
The researcher has used the F and significant values for the comparison of more thantwo groups simultaneously to decide whether a relationship exists between them. Total of squares is a statistical technique which is used in regression analysis to resolve the dispersion of data points, means how close the data are to the fitted regression line.

It is also known as the coefficient of determination, or the coefficient of multiple determinations for multiple regressions. The model shows the significant values at all levels, with 0.0001 per cent for both production and consumption.

CONCLUSION

It is a well known fact that India is one of the fastest growing and emerging economies in the world. This growth is inspite of many challenges such as expanding population of over 1.30 billion people India's energy demand has kept pace with this increase in population at an alarming rate, the pace that led to its emergence as one of the world's leading energy importers, particularly in fossil fuels. India depends unprecedented on oil imports, resulting in economic instability and energy insecurity. To encourage India's production and reduce dependence on imports with a sustainable approach, it is essential to boost the use of renewable energy. India needs a reliable availability of energy. The rate of population growth and urbanizationof the nation have undoubtedly led to a sharp increase in its energy demands (WDI 2015).

The limited reserves of fossil fuels and the capacity for local static production are the fundamental features of India's developing energy insecurity, which leads to a strong dependence on foreign energy sources. The demand for Indian oil has risen sharply inthe last decade, while local production is comparatively stagnant. The country's national production can satisfy about 25 per cent of the national oil requirement, which makes it a leading net oil importer. Thanks to its rapid growth in fossil fuel consumption and low energy efficiency, India is now ranked third in the list of the world's largest energy producers. The vast majority of greenhouse gases such as carbon dioxide, methane and sulphur oxides emitted by India emerged from their energy sources mainly through the consumption of solid, liquid and gaseous fuels andthe combustion of gas. Coal clearly stands out as the greatest source of increased carbon dioxide emissions in India. The increasing combustion of fossil fuels causes the amount of sulphur dioxide released in the atmosphere which also reacts with atmospheric oxygen to form acid rain and causes global warming. Fossil fuels represent more than three quarters of the world's main energy consumption and, consequently, this strong hydrocarbon domination poses greenhouse gas emissions and climate change threats around the world. The condition is further exacerbated byenergy-consuming countries, such as China and India, which use fossil fuels to meettheir hiking energy needs. As a result, most Indian cities and countries now are facing various forms of environmental degradation. This is an indication of a global warming danger for India and the world at large (WDI 2016).

Energy shortages, dependence on imports, supply disruptions and energy consumption have become obstacles to energy surplus in India. The growing domination of coal in the basic supply mix of the country includes an increasing environmental risk for the nation and the world in general.Effective energy governance is the need of the hour in India to find solutions and methods to control growing energy needs and demands. It is extremely essential to understand energy goals and perspective policies to understand the dynamics of energy policy structure that governs India's energy sector. The rising economic growth, the growing demand for energy, the lack of cumulative supply, the increase inoil imports and the growing environmental threat have increased the need for a lastingsolution to India's energy problem. In the search for energy security in the future, a huge and strategic construction of energy reserve structures is required to protect against the risk of supply disruption and energy market instability in India. Furthermore, the expansion of renewable and non-conventional technologies should have the greatest priority, since in the end this will produce surprising economic benefits and reduce environmental degradation. There is a big gap between energy consumption and energy production, energy consumption is more than energy production, which leads to energy insecurity in India.

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