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CONTENTS

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AN ECONOMETRIC ANALYSIS OF ENERGY CONSUMPTION IN INDIA

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ABSTRACT

This paper attempts to explore the causal nexus between energy consumption and economic growth in India using Granger (1969) Causality framework. The analysis was carried out for the period 1970-71 to 2011-12. The empirical results showed a unidirectional causal flow from energy consumption to economic growth. This result in the Indian context is quite contrast to the findings of Ghosh (2005), that consumption demand for energy is driven by higher rate of economic growth in the economy. Therefore, the present study suggests that India should conserve energy or consume more energy for attaining higher growth rate in the economy. There is an urgent need to conserve energy and reduce energy requirements by demand-side management and by adopting more efficient technologies in all sectors of the economy.

KEYWORDS

Energy Consumption, Economic Growth, Unit root test, Causality test.

INTRODUCTION

Energy is one of the most important building blocks in human development, and, as such, acts as a key factor in determining the economic development of all countries. In an effort to meet the demands of a developing nation, the Indian energy sector has witnessed a rapid growth. Areas like the resource exploration and exploitation, capacity additions, and energy sector reforms have been revolutionized. However, resource augmentation and growth in energy supply have failed to meet the ever increasing demands exerted by the multiplying population, rapid urbanization and progressing economy. Hence, serious energy shortages continue to plague India, forcing it to rely heavily on imports.

Energy has been universally recognized as one of the most important inputs for economic growth and human development. 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 benign energy sources, and on the other hand, the level of economic development has been observed to be reliant on the energy demand. Energy intensity is an indicator to show how efficiently energy is used in the economy. The energy intensity of India is over twice that of the matured economies, which are represented by the OECD (Organization of Economic Co-operation and Development) member countries. India's energy intensity is also much higher than the emerging economies—the Asian countries, which include the ASEAN member countries as well as China. However, since 1999, India's energy intensity has been decreasing and is expected to continue to decrease.

The indicator of energy–GDP (gross domestic product) elasticity, that is, the ratio of growth rate of energy to the growth rate GDP, captures both the structure of the economy as well as the efficiency. The energy–GDP elasticity during 1953–2001 has been above unity. However, the elasticity for primary commercial energy consumption for 1991–2000 was less than unity (Planning Commission 2002). This could be attributed to several factors, some of them being demographic shifts from rural to urban areas, structural economic changes towards lesser energy industry, impressive growth of services, improvement in efficiency of energy use, and inter-fuel substitution.

The energy sector in India has been receiving high priority in the planning process. The total outlay on energy in the Tenth Five-year Plan has been projected to be 4.03 trillion rupees at 2001/02 prices, which is 26.7% of the total outlay. An increase of 84.2% is projected over the Ninth Five-year Plan in terms of the total plan outlay on energy sector. The Government of India in the mid-term review of the Tenth Plan recognized the fact that under-performance of the energy sector can be a major constraint in delivering a growth rate of 8% GDP during the plan period. It has, therefore, called for acceleration of the reforms process and adoption of an integrated energy policy. In the recent years, the government has rightly recognized the energy security concerns of the nation and more importance is being placed on energy independence.

DEMAND AND SUPPLY SCENARIO

India's energy consumption has been increasing at one of the fastest rates in the world due to population growth and economic development. Primary commercial energy demand grew at the rate of six per cent between 1981 and 2001 (Planning Commission 2002). India ranks fifth in the world in terms of primary energy consumption, accounting for about 3.5% of the world commercial energy demand in the year 2003. Despite the overall increase in energy demand, per capita energy consumption in India is still very low compared to other developing countries.

India is well-endowed with both exhaustible and renewable energy resources. Coal, oil, and natural gas are the three primary commercial energy sources. India's energy policy, till the end of the 1980s, was mainly based on availability of indigenous resources. Coal was by far the largest source of energy. However, India's primary energy mix has been changing over a period of time.

Despite increasing dependency on commercial fuels, a sizeable quantum of energy requirements (40% of total energy requirement), especially in the rural household sector, is met by non-commercial energy sources, which include fuel wood, crop residue, and animal waste, including human and draught animal power. However, other forms of commercial energy of a much higher quality and efficiency are steadily replacing the traditional energy resources being consumed in the rural sector. Resource augmentation and growth in energy supply has not kept pace with increasing demand and, therefore, India continues to face serious energy shortages. This has led to increased reliance on imports to meet the energy demand.

COAL

India now ranks third amongst the coal producing countries in the world. Being the most abundant fossil fuel in India till date, it continues to be one of the most important sources for meeting the domestic energy needs. It accounts for 55% of the country's total energy supplies. Through sustained increase in investment, production of coal increased from about 70 MT (million tonnes) (MoC 2005) in early 1970s to 382 MT in 2004-05. Most of the coal production in India comes from open pit mines contributing to over 81% of the total production while underground mining accounts for rest of the national output (MoC 2005). Despite this increase in production, the existing demand exceeds the supply. India currently faces coal shortage of 23.96 MT. This shortage is likely to be met through imports mainly by steel, power, and cement sector (MoC 2005). India exports insignificant quantity of coal to the neighbouring countries. The traditional buyers of Indian coal are Bangladesh, Bhutan, and Nepal. The development of core infrastructure sectors like power, steel, and cement are dependent on coal. About 75% of the coal in the country is consumed in the power sector (MoC 2005).

POWER

Access to affordable and reliable electricity is critical to a country's growth and prosperity. The country has made significant progress towards the augmentation of its power infrastructure. In absolute terms, the installed power capacity has increased from only 1713 MW (megawatts) as on 31 December 1950 to 118 419 MW as on March 2005 (CEA 2005). The all India gross electricity generation, excluding that from the captive generating plants, was 5107 GWh (gigawatt-hours) in 1950 and increased to 565 102 GWh in 2003-04 (CEA 2005).

Energy requirement increased from 390 BkWh (billion kilowatt-hours) during 1995/96 to 591 BkWh (energy) by the year 2004-05, and peak demand increased from 61 GW (gigawatts) to 88 GW over the same time period. The country experienced energy shortage of 7.3% and peak shortage of 11.7% during 2003/04. Though, the growth in electricity consumption over the past decade has been slower than the GDP's growth, this increase could be due to high growth of the service sector and efficient use of electricity.

Per capita electricity consumption rose from merely 15.6 kWh (kilowatt-hours) in 1950 to 592 kWh in 2003-04 (CEA 2005). However, it is a matter of concern that per capita consumption of electricity is among the lowest in the world. Moreover, poor quality of power supply and frequent power cuts and shortages impose a heavy burden on India's fast-growing trade and industry.

OIL AND NATURAL GAS

The latest estimates indicate that India has around 0.4% of the world's proven reserves of crude oil. The production of crude oil in the country has increased from 6.82 MT in 1970-71 to 33.38 MT in 2003-04 (MoPNG 2004b). The production of natural gas increased from 1.4 BCM (billion cubic metres) to 31.96 BCM during the same period. The quantity of crude oil imported increased from 11.66 MT during 1970-71 to 81 MT by 2003-04. Besides, imports of other petroleum products increased from 1 MT to 7.3 MT during the same period. The exports of petroleum products went up from around 0.5 MT during 1970-71 to 14 MT by 2003-04. The refining capacity, as on 1 April 2004, was 125.97 MTPA (million tonnes per annum). The production of petroleum products increased from 5.7 MT during 1970-71 to 110 MT in 2003-04.

India's consumption of natural gas has risen faster than any other fuel in the recent years. Natural gas demand has been growing at the rate of about 6.5% during the last 10 years. Industries such as power generation, fertilizer, and petrochemical production are shifting towards natural gas. India's natural gas consumption has been met entirely through domestic production in the past. However, in the last 4 to 5 years, there has been a huge unmet demand of natural gas in the country, mainly required for the core sectors of the economy. To bridge this gap, apart from encouraging domestic production, the import of LNG (liquefied natural gas) is being considered as one of the possible solutions for India's expected gas shortages. Several LNG terminals have been planned in the country. Two LNG terminals have already been commissioned: (1) Petronet LNG Terminal of 5 MTPA (million tonnes per annum) at Dahej, and (2) LNG import terminal at Hazira. In addition, an in-principle agreement has been reached with Iran for import of 5 MTPA of LNG.

RENEWABLE ENERGY SOURCES

Renewable energy sources offer viable option to address the energy security concerns of a country. Today, India has one of the highest potentials for the effective use of renewable energy. India is the world's fifth largest producer of wind power after Denmark, Germany, Spain, and the USA. There is a significant potential in India for generation of power from renewable energy sources—small hydro, biomass, and solar energy. The country has an estimated SHP (small-hydro power) potential of about 15 000 MW. Installed combined electricity generation capacity of hydro and wind has increased from 19,194 MW in 1991-92 to 31,995 MW in 2003-04, with a compound growth rate of 4.35% during this period (MoF 2005). Other renewable energy technologies, including solar photovoltaic, solar thermal, small hydro and biomass power are also spreading. Greater reliance on renewable energy sources offers enormous economic, social, and environmental benefits.

The potential for power production from captive and field-based biomass resources, using technologies for distributed power generation, is currently assessed at 19,500 MW including 3500 MW of exportable surplus power from bagasse-based cogeneration in sugar mills (MNES 2005).

ENERGY CONSUMPTION-GROWTH NEXUS

Increasing pressure of population and increasing use of energy in different sectors of the economy is an area of concern for India. As regard the relative consumption of various sources of energy as percent of the world total, India occupies the third place following China and Japan among the emerging Asian economies. This raises the question whether India's energy consumption levels commensurate with levels of economic growth similar to other high as well as low energy consuming economies of the Asian region. In this context, this paper attempts to investigate the impact of energy consumption on economic growth rate in India. The prime motivation of the study relates to addressing the puzzle of the increasing levels of energy consumption to induce economic growth in the event of the increasing cost associated with it as well as apprehensions regarding its sustained supply in future. 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.

METHODOLOGY AND DATA

Augmented Dickey-Fuller (1979) test was employed to verify the stationarity of the data series. Further, the necessary lag length of the data series was selected on the basis of Akaike (1974) Information Criterion (AIC). Besides, the Granger (1969) causality test was employed to examine the short-run relationship between energy consumption and gross domestic product. Granger (1969) causality test regresses a variable y on a lagged value of itself and another variable x. If x is significant; it means that it explains some of the variance of y that is not explained by lagged values of y itself. This indicates that x is causally prior to y and said to dynamically cause or Granger cause y. The model can be specified as follows:

$$y_t = \sum_{j=1}^{m} \alpha_j y_{t-j} + \sum_{j=1}^{m} \beta_j x_{t-j} + u_t \quad \text{..... (1)}$$

The model specification for the study is presented below:

$$\Delta lnEC_t = c_1 + \sum_{k=1}^{n} \alpha_{1i} \Delta lnEC_{t-k} + \sum_{k=1}^{n} \beta_{2i} \Delta lnGDP_{t-k} + u_{1t} \quad \text{.....(2)}$$

$$\Delta lnGDP_t = c_2 + \sum_{k=1}^{n} \beta_{1i} \Delta lnGDP_{t-k} + \sum_{k=1}^{n} \alpha_{2i} \Delta lnEC_{t-k} + u_{2t} \quad \text{.....(3)}$$

where, Δ is the first difference operator and u_{1t} and u_{2t} are white noise disturbance terms. EC_t and GDP_t represents energy consumption and gross domestic product at time t, respectively.

The time series database on energy consumption and real gross domestic product (GDP) were on annual basis and it covers from the period 1970-71 to 2011-12. The study considers aggregate energy consumption that comprises coal, natural gas, crude petroleum and electricity. The energy consumption variable is expressed as a ratio to GDP in order to measure them as per unit of output. Growth rate of GDP is defined as the change in the GDP in two consecutive periods divided by its initial period value. The necessary information on aggregate energy consumption and GDP were collected from the various issues of www.indiastat.com and Central Statistical Organisation (CSO).

EMPIRICAL RESULTS AND DISCUSSION

As for the preliminary steps of the analysis, the present study tested the underlying stochastic process that generated the series assumed to be invariant with respect to time. If the stochastic process is stationary then one can model the process with an Ordinary Least Square (OLS) regression and the fixed coefficient can be estimated from the present data. The investigation of stationary in a time series is closely related to the unit roots test. For that the study employed Augmented Dickey Fuller (1979) test for unit roots. The results of the unit root are shown in Table 1. According to the Augmented Dickey Fuller test results shown in Table 1, the null hypothesis of a unit root for all the variables is not rejected in the case of levels. However, when the series are first differenced, the coefficient of all the variables is significant at one per cent level. Further, the optimal lags for unit root test are selected through Akaike (1974) Information Criterion (AIC). From the above Augmented Dickey Fuller test result we conclude that both the series are found to be stationary.

TABLE 1: AUGMENTED DICKEY-FULLER TEST FOR UNIT ROOTS

Sr. No.	Variables	Constant	Constant & Trend	Without Constant & Trend
I Levels	**EC_t**	-0.353	-0.348	0.002
		(3.100)	(3.032)	(0.192)
	GDP_t	-0.021	-0.640	0.001
		(1.143)	(1.305)	(1.813)
II First Difference	**EC_t**	-1.692	-2.698	-2.689
		(13.004)*	(12.985)*	(13.031)*
	GDP_t	-1.879	-1.877	-1.742
		(7.967)*	(7.930)	(7.509)*

Note: Parenthesis shows t-value, * (**) – indicates statistical significance at the one and five per cent level respectively, Critical values for t-statistics are followed from Dickey and Fuller (1979), optimal lag-length, is determined by the Akaike (1974) Information Criterion (AIC). EC_t and GDP_t represents energy consumption and gross domestic product at time t, respectively.

Source: Author's own computation.

The Granger (1969) causality test was employed to examine the short-run relationship between energy consumption and gross domestic product and its results are presented in Table-2. The Granger causality test result showed that there is a causal influence of energy consumption to GDP growth rate. This result in the Indian context is quite contrast to the findings of Ghosh (2005), that consumption demand for energy is driven by higher rate of economic growth in the economy. Therefore, the present study suggests that India should conserve energy or consume more energy for attaining higher growth rate in the economy. There is an urgent need to conserve energy and reduce energy requirements by demand-side management and by adopting more efficient technologies in all sectors of the economy.

TABLE 2: PAIR-WISE GRANGER CAUSALITY TESTS

Null Hypothesis:	F-Statistic	Probability
GDP does not Granger Cause EC	1.86397	0.11395
EC does not Granger Cause GDP	.46769*	0.00133

Source: Author's own computation.

Notes: EC_t and GDP_t represent energy consumption and gross domestic product at time t, respectively. *-significance at one percent level.

CONCLUDING REMARKS

This paper attempts to explore the causal nexus between energy consumption and economic growth in India using Granger (1969) Causality framework. The analysis was carried out for the period 1970-71 to 2011-12. The empirical results showed a unidirectional causal flow from energy consumption to economic growth. This result in the Indian context is quite contrast to the findings of Ghosh (2005), that consumption demand for energy is driven by higher rate of economic growth in the economy. Therefore, the present study suggests that India should conserve energy or consume more energy for attaining higher growth rate in the economy. There is an urgent need to conserve energy and reduce energy requirements by demand-side management and by adopting more efficient technologies in all sectors of the economy.

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