

## A Review of Causality between Energy Consumption and Economic Growth

Regeenamma Joseph

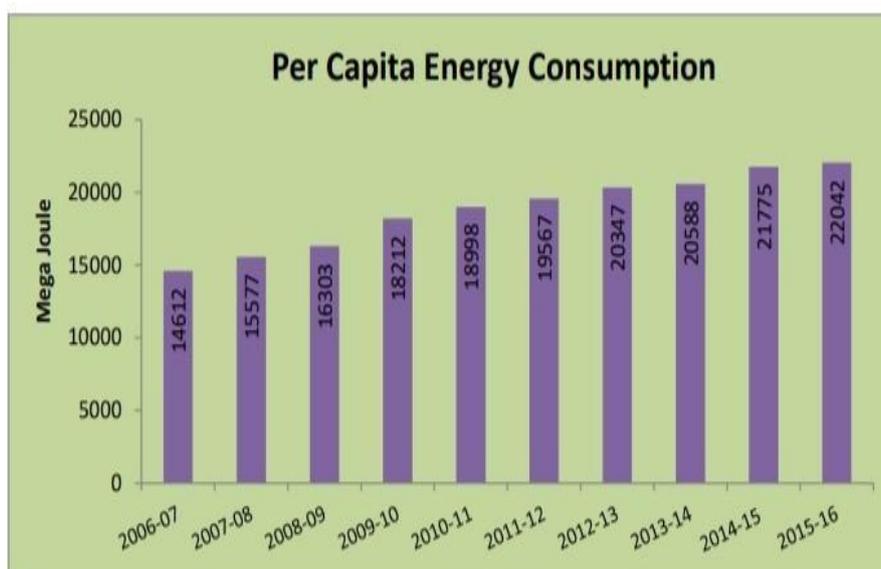
Alphonsa College Pala & Krishna Nair J, Junior Research Fellow, IIT, Kharagpur

### Abstract

All production and many consumption activities involve energy as an essential input. It is a critical source of economic growth, industrialization, and urbanization. For the proper functioning of an economy, energy is necessary and vital. When analysing the existing literature regarding the causal nexus between economic growth and energy consumption, there exist four different hypotheses, such as growth hypothesis, conservation hypothesis, feedback hypothesis, and neutral hypothesis. Finding the relationship between these two variables is essential in order to formulate energy-efficient policies according to the needs of the nation that will ultimately lead to economic growth. The results of the literature prove that in order to help the government to come up with a stable energy policy, causal nexus should analyse and the limitations which are existing in the present studies should be solved.

### I. Introduction

Since independence, high and sustainable economic growth has been an issue of concern for the policymakers of the Indian economy. Several studies have emphasised on the focal role of the agriculture and industry linkages, industrialisation and development of the service sector, in the growth of the economy. Although these policy initiatives have benefited the economy in numerous ways, there is still a rising concern about the sustainability of high economic growth potentials of the economy due to the increasing significance of the issue of environmental protection. The main target of every nation is to attain sustainable and stable economic growth; this will happen only with the integration of many sectors in the economy, and energy is one such significant factor that is necessary for the proper functioning of an economy. Energy is a vital factor in raising the standard of living of people and thereby the development of a nation. Energy can be used both for commercial as well as non-commercial purposes. India is the fourth-largest energy consumer in the world. As the fastest growing as well as the second-largest populous nation, energy needs are also proliferating. Data from various sources pointed out that primary energy consumption got more than doubled between 1990 and 2011.



Source: Energy statistics, 2017

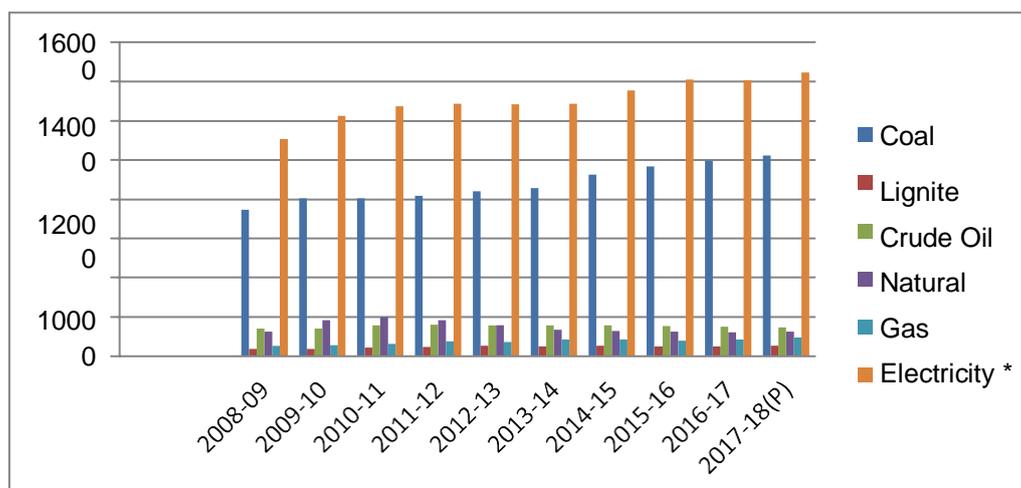
Energy demand in rural and urban areas is on a steady rise. The maximum energy-intensive sector is the industrial sector accounting for about 56% of total energy consumption. Per Capita consumption of Energy showed a CAGR of 2.54% for the period 2011-12 to 2017-18 (Energy Statistics, 2019). India's energy basket has a mix of all the resources available, including renewable sources. The largest energy source is coal, followed

by petroleum and traditional biomass. As per the energy statistics, in the case of Crude Oil and Natural Gas, during the period 2008-09 to 2017- 18, the Production increased by 0.63% and (-) 0.06% whereas Consumption increased by 4.59% & 4.82%.

According to the 2011 Census, about one-fourth of the population lacking access to electricity and energy security. So the country is relying on imports for a considerable amount of its energy use, particularly for crude petroleum. During 2008-09 to 2017-18, imports of the Coal increased at a CAGR of 13.44%, Natural Gas and Crude Oil at CAGR of 9.44% and 5.20% respectively, and the imports of petroleum products increased at CAGR of

6.67 % ( MOSPI, 2019). Figure 1 shows the trends in Production of Energy by Commercial Sources in India from 2008-09 to 2017-18.

**FIGURE 1**



Source: Energy statistics, 2019

The wide disparity in energy use pattern between the haves and have-nots, urban and rural and men and women are also a cause of concern. Energy availability to the population is very poor in India. Nation's share with the world population is 17%, but its shares in gas, oil, and coal reserves together are 1.7% only. It can be the main reason behind India's heavy dependence on imported energy resources. India's energy policy mainly focused on securing adequate energy resources to meet the growing demands of its economy. By keeping the main agenda as eradication of poverty, energy-related policies intend to increase per capita energy consumption. With nearly 304 million Indians without access to electricity and about 500 million people still dependent on solid biomass for cooking, it has to be noted that the country has to still go a long way on securing its energy security objectives [National Energy Policy, 2017]. Till the date main focus of our energy policies were covering up supply constraints only. However, the new policies are concentrated on demand-side interventions also mainly through the methods of Energy conservation and energy efficiency. So the four main objectives of new National Energy Policy are:

- Access at affordable price
- Improved security and independence
- Greater sustainability
- Economic growth.

The empirical investigations to find the nexus between energy consumption and economic growth can trace back to the 1970s. The inquiry is still valid because of its dynamic nature. In the global context of growing energy demands, finding the relationship between these two variables is essential in order to formulate energy-efficient policies according to the needs of the nation that will ultimately lead to economic growth. The existence of the causality between economic growth and energy consumption is a fact, and it has significant implications. However, the dissension about the direction of causality is a reason for debate. The lack of consensus on whether economic growth results in energy consumption or is energy consumption the stimulant of economic growth has aroused the curiosity and interest among economists and analysis to investigate the direction of causality between these variables (P. Jacovac, 2018).

## II. Review Of Literature

The causal nexus between economic growth and energy consumption can trace from the following hypotheses:

- 1) Unidirectional causality from economic growth to energy consumption (The conservation hypothesis)
- 2) Unidirectional causality from energy consumption to economic growth (The growth hypothesis)
- 3) Bi-directional causality from energy consumption to economic growth (The feedback hypothesis)
- 4) The absence of causality between these two variables (Neutrality hypothesis).

### \*The conservation Hypothesis

This hypothesis focuses on the unidirectional causality from economic growth to energy consumption. The validation of this hypothesis in a country implies that a country may implement energy conservation policies without hurting its economic growth. This hypothesis also indicates that the economy is least energy-dependent.

Kraft and Kraft (1978) studied the causality between economic growth and energy consumption in the US during the period 1947-1974. With the help of the Sims Causality test, it proves that there exists a unidirectional relationship from GNP to energy consumption.

Yu and Choi (1985) investigated the nexus between energy consumption and economic growth using the Granger causality test for five countries such as the US, UK, Korea, Poland, and the Philippines for the period 1950-1976 and prove the existence of unidirectional causality from GDP to energy consumption in those countries. Erol and Yu (1988) have employed the same test to conduct an empirical analysis to prove the causality in six developed countries such as West Germany, Canada, Italy, France, UK, and Japan during the period 1952-1980. They proved the presence of all four hypotheses in their study. That is, in Italy and Germany, there exists unidirectional relationship from GDP to energy consumption; data sets from Canada has proven the existence of Growth hypothesis; in Japan, there exists a bi-directional relationship between economic growth and energy consumption and empirical testing in France and UK proves the existence of neutrality hypothesis. Masih and Masih (1996) also proved the existence of all four hypotheses in their study but with the help of the data from six developing countries, including India and Pakistan. With the help of Johansen-Juselius model and Vector Correction Model using the data from 1955- 1990, the study has proved the existence of growth hypothesis in India, conservation hypothesis in Indonesia, feedback hypothesis in Pakistan, and neutrality hypothesis in Philippines, Malaysia, and Singapore.

Author(s)	Country	Study Period	Variables Used	Methodology Employed	Result
Fatai et al. (2002)	New Zealand	1960–1999	Economic Growth, Electricity Consumption and Oil	Granger causality test Toda-Yamamoto causality test and (ARDL) technique	GDP→Electricity GDP→Oil
Soytas and Sari (2003)	Germany, France, Japan, Italy, Turkey, Argentina, Korea	1950–1997	Economic Growth And Energy consumption	Johansen- Juselius Co-integration and Granger causality	GDP→Energy (Italy Korea)
Narayan and Smyth (2005)	Australia	1966–1999	Energy Consumption and Economic Growth	Multivariate Granger causality test	GDP → EC

### \*The Growth hypothesis

The growth hypothesis postulates that there exists a unidirectional relationship from energy consumption to economic growth, inferring that an increase in energy consumption would result in increased economic growth. The policy implication of the presence of unidirectional causality is that if energy conservation policies aimed at reducing energy consumption are adopted, it may slow down the economic growth of the country. Stern (2000) conducted a study to analyse the relationship between energy consumption and economic growth in the US using the data from 1948-1994 with the help of the granger causality test and proves that there exists a unidirectional relationship from energy consumption to economic growth. With the help of the same methodology, Soytas et al. (2001) conducted another study in the context of Turkey for the period 1960-1995. This study also concluded with the acceptance of the growth hypothesis. A recent study by Tsani (2010) in the context of Greece has also given the same results. The study conducted using the Toda-Yamamoto causality test for 46 years from 1960-2006.

Author(s)	Country	Study Period	Variables Used	Methodology Employed	Result
Lee and Chang (2005)	Taiwan	1954-2003	Energy consumption and economic growth	Cointegration and causality, Hansen parameter stability test and Gregory and Hansen structural break	EC → GDP
Nain et.al. (2012)	India	1970-2009	Economic growth and electricity consumption	ARDL, MWALD	ELC → Y
Apergis and Payne(2009)	6 countries	1980-2004	GDP and Energy consumption	Cointegration an VEC	EC → GDP

**\*The Feedback hypothesis**

This hypothesis postulates that there exists a bi-directional relationship between economic growth and energy consumption. An increase in the consumption of energy will lead to economic growth and vice versa. So there should be more investments in energy-efficient technologies rather than energy-conserving technologies. Paul and Bhattacharya (2004) conducted a study in the Indian context for the period 1950- 1996 by using different methods such as Johansen-Juselius cointegration method, Granger causality test, and VEC in order to check the causality between energy consumption and economic growth. The study proves that there exists a bi-directional relationship between the studied variables. Yoo (2005) also gets the same results in the Korean context for 32 years from 1970 till 2002. The study mainly depends upon Granger causality and Error Correction Model to get the results.

Author(s)	Country	Study Period	Variables Used	Methodology Employed	Result
Jumbe (2004)	Malawi	1970–1999	Energy Consumption and Economic Growth	Granger causality (GC) and error correction (ECM) techniques	EC ↔ GDP
Yildirim and Aslan (2012)	17 highly developed OECD countries	1971–2009	Economic Growth and Energy consumption	Toda Yamamoto and Granger causality methods.	Y ↔ E
Ahmad et al. (2014)	India	1970-71 to 2009-10	Economic Growth and Electricity Consumption	ARDL, ECM	Y ↔ ELC

**\*The Neutrality hypothesis**

The absence of the relationship between economic growth and energy consumption is the crux of the neutrality hypothesis. This hypothesis implies that energy plays a relatively small role in economic growth, and energy conservation policies can implement without hurting economic growth. Akarca and Long (1980) conducted an empirical analysis in the US context for the years starting from 1950 till 1980. They employed Sims technique to find the nexus between economic growth and energy consumption and prove that there exists no relationship between variables. Oh and Lee (2004) conducted a study from 1970-1999 in the context of South Korea. By employing techniques like Johansen-Juselius Cointegration and VEC, they proved the same results. Karanfil (2008) conducted a study in Turkey from 1970 till 2005, with the help of the Granger causality test, which also proves the same result in line with the hypothesis.

Author(s)	Country	Study Period	Variables Used	Methodology Employed	Result
Cheng (1997)	Mexico	1949–1993	Economic Growth and Energy consumption	Hsiao's version of Granger causality	No Causality
Soytas and Sari (2009)	Turkey	1960–2000	Economic Growth and Energy consumption	Toda– Yamamoto procedure	No Causality
Gurgul and Lach (2012)	Poland	2000–2009	Economic Growth and Electricity consumption	Granger causality, VECM and Toda-Yamamoto	No Causality

**III. Conclusion**

The importance and vitality of the topic can be detected from the growing number of literature that has come up from 1970 onwards. However, there exist some limitations and research gaps. Most of the existing literature has concentrated on bivariate analysis, rather than multivariate analysis, by omitting many of the influencing factors. So in order to have an efficient and accurate result, more factors should be included in the study. For example, the population contributes a significant role in the energy consumption of the nation. So the

inclusion of this factor will give better results. In the context of global commitments towards environmental protection, reducing the emission is a significant duty that every nation has to take up. Since the energy sector is a major contributor to the emission of pollutants, it is better to consider carbon emission as a representing variable. Another gap that exists in the current literature is the failure to look after the intensity or magnitude of the causality between economic growth and energy consumption. Most of the existing studies are using the same methods with the same variables but different periods. It results in the generation of more conflicting results for the same nation. Future research must sort out these limitations; then the government can make up new, efficient, and precise policies according to the needs of the nation.

### References

- [1]. Akarca, A.T., Long, T.V. (1980). "On the relationship between energy and GNP: a re-examination". *Journal of Energy Development*, 5, 326-331.
- [2]. Apergis, Nicholas and Payne, James E. (2009). "CO2 emissions, energy usage, and output in Central America," *Energy Policy*, 37(8), 3282-3286.
- [3]. Cheng, B.S. and Lai, T.W. (1997). "An investigation of co-integration and causality between energy consumption and economic activity in Taiwan". *Energy Economics*, 19(4), 435-444.
- [4]. Erol, U and Yu, E.S.H. (1987). "On the Causal Relationship between Energy and Income for Industrialized Countries". *Journal of Energy and Development*, 13, 113- 122.
- [5]. Fatai, K, L. Oxley and F.G. Scrimgeour (2003). "Modeling and forecasting the demand for electricity in New Zealand: A comparison of alternative approaches". *Energy Journal*, 24(1): 75-102.
- [6]. Gurgul, H. and Lach, L. (2012). "The electricity consumption versus economic growth of the Polish economy," *Energy Economics*, 34(2), 500-510.
- [7]. Jumbe, C.B. L. 2004. "Cointegration and causality between electricity consumption and GDP: empirical evidence from Malawi". *Energy Economics*, 26(1), 61-68.
- [8]. Karanfil, F. (2008). "Energy consumption and economic growth revisited: does the size of unrecorded economy matter?". *Energy Policy*, 36 (8), 3019-3025.
- [9]. Kraft, J. and Kraft, A. (1978). "On the Relationship between Energy and GNP", *Journal of Energy and Development*, 3, 401-403.
- [10]. Lee, Chien-Chiang. (2005). "Energy Consumption and GDP in Developing Countries: A Cointegrated Panel Analysis". *Energy Economics*, 27(3), 415-427.
- [11]. Masih, A.M.M. and Masih, R. (1996). "Energy Consumption, Real Income and Temporal Causality: Results from a Multi-Country Study Based on Cointegration and Error-correction Modeling Techniques". *Energy Economics*, 18 (3), 165-183.
- [12]. Nain, M.Z., Ahmad, W. and Kamiah, B. (2017). "Economic growth, energy consumption and CO2 emissions in India: a disaggregated causal analysis". *International Journal of Sustainable Energy*, 36(8), 807-824.
- [13]. Narayan, P.K. and Smyth, R. (2005). "Electricity consumption, employment and real income in Australia evidence from multivariate Granger causality tests". *Energy Policy*, 33(9), 1109-1116.
- [14]. Oh, W. and K. Lee (2004). "Causal relationship between energy consumption and GDP revisited: The case of Korea 1970-1999". *Energy Economics*, 26(1), 51-59.
- [15]. Paul, S. and Bhattacharya, R. N. (2004). "Causality between energy consumption and economic growth in India: a note on conflicting results". *Energy economics*, 26(6), 977-983.
- [16]. Soytaş, U., Sari, R., and Ozdemir, O. (2001). "Energy Consumption and GDP Relations in Turkey: A Cointegration and Vector Error Correction Analysis". *Economics and Business in Transition: Facilitating Competitiveness and Change in the Global Environment Proceedings*, 838-844.
- [17]. Soytaş, U. & Sari, R. (2003). "Energy consumption and GDP: causality relationship in G-7 countries and emerging markets". *Energy Economics*, 25(1), 33-37.
- [18]. Soytaş, U. and Sari, R. (2009). "Energy Consumption, Economic Growth, and Carbon Emissions: Challenges Faced by an EU Candidate Member". *Ecological Economics*, 68, 1667-1675.
- [19]. Stern, D.I. (2000). "A multivariate Cointegration analysis of the role of energy in the US macro economy". *Energy Economics*, 22(2), 267-28.
- [20]. Tsani, S.Z. (2010). "Energy consumption and economic growth: A causality analysis for Greece", *Energy Economics*, 32(3), 582-590.
- [21]. Yildirim, E. and Aslan, A. (2012). "Energy consumption and economic growth nexus for 17 highly developed OECD countries: Further evidence based on bootstrap-corrected causality tests". *Energy Policy*, 51 (1), 985-993.
- [22]. Yoo, S.H. (2005). "Electricity consumption and economic growth: Evidence from Korea". *Energy Policy*, 33(12), 1627-1632.
- [23]. Yu, E.S.H. and Choi, J.Y. (1985). "The Causal Relationship between Energy and GNP: An International Comparison", *Journal of Energy and Development*, 10(2), 249-272.