The Impact of Renewable & Non-renewable Energy Consumption on Economic Growth in India

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ABSTRACT

The present study investigates the impact of renewable energy consumption (REC) Non-renewable energy consumption (NREC) on economic growth in India, The Renewable and Non-renewable energy consumption and GDP using yearly time series data from 1980 to 2021, using Unit Root Test, The Johanson Cointegration Test, FMOLS Test. The Johansen trace test determines the overall presence of cointegration relationships in a system of variables. It helps answer whether there is any cointegration among the variables being analysed. FMOLS aims to estimate the long-term equilibrium relationship between the cointegrated variables. The FMOLS model indicates that Log renewable energy consumption (LREC) and Log Gross fixed capital formation (LGFCF) statistically and significantly impact Log Gross Domestic product. (LGDP). They impacted India's GDP positively and significantly during the study period.

Keywords: *Renewable energy consumption; Non-renewable energy consumption; Economic growth; Unit Root Test; Johansson Cointegration Test; FMOLS Test.*

INTRODUCTION

As one of the world's fastest-growing economies, India has been working to meet its rising energy demands while addressing environmental concerns. This research essay explores the relationship between renewable and non-renewable energy consumption and economic growth in India, examining this complex interaction's opportunities, challenges, and policy implications. Energy is an essential component of human needs and plays a determining role in the development of the economy. Due to rapid industrialization, urbanization, and high economic growth targets, energy demand has increased significantly during the last few decades.

India's energy environment comprises a combination of non-renewable and renewable energy sources. The energy sector has traditionally been dominated by non-renewable resources, primarily coal, oil, and natural gas. On the other hand, renewable energy sources, including solar, wind, hydro, and biomass, are receiving more attention due to the government's emphasis on sustainable development.

Historically, India's economic growth has been driven by non-renewable energy sources. In particular, coal has been the primary source of the nation's energy generation. However, the widespread usage of coal has led to severe air pollution and detrimental health effects, impacting everyone's well-being. Incorporating renewable energy sources into India's energy mix can mitigate environmental damage and promote financial growth. The government creates jobs and attracts foreign investment by funding renewable energy initiatives. Additionally, less reliance on imported fossil fuels improves trade balance and energy security, supporting economic expansion.

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LITERATURE REVIEW

Bilal Khan et al. (2022) this study examines the relationship between globalization, energy use, and economic growth in a few South Asian nations. The study included a yearly time series analysis from 1972 to 2017. The World Development Indicator (WDI) was utilized to compile data collection compilation. The result of a fully modified ordinary least squares (FMOLS) method characterizes the South Asian environment as considerably deteriorating. Bangladesh is among the nations that positively influence the globalization index, nonrenewable energy, CO2 emissions, and environmental degradation. Nonetheless, GDP squared, and both positive and negative GDP growth rates in this area are consistent with the EKC theory. This study proved a bidirectional causal relationship between economic growth and energy consumption and a causal relationship between GDP growth and carbon emissions.

Pandey, K.K., and Rastogi (2019) Examine empirically how economic development (determined in terms of real GDP) and energy consumption specifically, electricity consumption affect carbon dioxide (CO2) emissions, which are an indicator of degradation of the environment. The study aims to determine how closely three variables real GDP, energy use, and CO2 emissions are related. Annual time series data from 1971 to 2017 served as the basis for the analysis. The variables' stationary was assessed using the Dicky Fuller test, and the short- and long-term causal linkages between electricity consumption, real GDP, and CO2 emissions were examined using the Granger Causality and Johansen Cointegration techniques. The Johansen cointegration test is used to establish if certain combinations of the two variables are cointegrated a sign that the defined variables have a long-term relationship. The results also suggest that India's energy consumption, economic expansion, and CO2 emissions are causally related in the near term.

Sultan, Z. A. (2019) they have shown a steady, long-term correlation between energy usage and actual production. After analyzing data from 1971 to 2014, the study found a consistent correlation between India's existing production and energy usage. The study also found that, in the short term, Energy Granger drives economic activity in India; however, over time, it also found that Energy and India's economic prosperity have a bidirectional connection.

Bahram Shakouri & Soheila Khoshnevis Yazdi (2017) investigated the connections between CO2 emissions, economic growth, and renewable and nonrenewable energy use in ten MENA nations empirically. The years 1980 through 2009 were included in the study. They used the Granger causality test, panel cointegration, dynamic ordinary least square (DOLS), and panel fully modified ordinary least square (FMOLS). According to the estimated findings, output and CO2 emissions show an inverse U-shaped relationship. Their research validated the Environmental Kuznets Curve (EKC) theory. The empirical findings support the bidirectional causal relationship between CO2 emissions and electricity use.

Chandra Kanta Sharma (1991) Population, economic development, natural resources, and the environment are closely linked. Rapid population growth and lack of supply of indigenous energy resources in Nepal have caused the extensive use of traditional energy resources, resulting in environmental degradation. Conventional energy sources like fuel, wood, and agricultural residues supply about 95% of the total energy demand in Nepal. Nepal has an enormous economic potential for hydropower generation (42,000 MW), but only about 0.5% of this potential has been harnessed. Without economically feasible fossil-fuel reserves, Nepal will, in the long term, require proper forest management and an extended development plan for a hydroelectric generation if the Nepalese energy demand is to be met. Hydropower, however, should be exploited in ways that will maintain the environmental balance on a sustainable basis and result in economic progress.

Farhani and Shahbaz (2014) investigated the connections between CO2 emissions, economic growth, and renewable and nonrenewable energy use in ten MENA nations empirically. The years 1980 through 2009 were included in the study. They used the Granger causality test, panel cointegration, dynamic ordinary least square (DOLS), and panel fully modified ordinary least square (FMOLS). According to the estimated findings, output and CO2 emissions show an inverse U-shaped relationship. Their research validated the Environmental Kuznets Curve (EKC) theory. The empirical findings support the bidirectional causal relationship between CO2 emissions and electricity use.

DATA AND METHODOLOGY

Date and Sources

The present research study is based on secondary data. Secondary data is usually Published and unpublished information sources, such as concerned departments' annual reports, thesis, books, journals, articles, newspapers and web sources, electronic CDs, or the internet; some government or research body has already gathered this data.

The secondary data is based on time series data. To meet our study objectives, we collected renewable and non-renewable energy consumption data from the US Energy Information Administration (EIA), while GDP, Population, and Capital from World Development Indicators (WDI), World Bank, 2022.

Time

The study uses yearly data. The selection of the sample period is based on the availability of data. Data has been collected for the last 42 years on renewable energy consumption, Non-renewable energy consumption, GDP, Capital, and Population from 1980 to 2021.

Main Objective of this study: To analyse the impact of renewable and non-renewable energy consumption on economic growth in India.

MODEL

The econometric model is given below:

$LGDP_t = Q0 + Q1LREC_t + Q2LTNREC_t + Q3LGFCF_t + Q4LPOP_t + \varepsilon_t$… (1)

In this model, the dependent variable is LGDP (Log GDP), and the independent variables are LREC (Log Renewable Energy Consumption), LTNREC (Log Total Nonrenewable Energy Consumption), LGFCF (Log Gross Fixed Capital Formation), and LPOP (Log Population) εt stochastic error term and were Q0, Q1, Q2, Q3, Q4 are the respective parameters. All variables are in log form Transferred.

STATISTICAL TOOLS

Variables Chosen for the Study

The present study has collected data from secondary sources. The past empirical literature reviews have used EC (Energy consumption), Renewable and Nonrenewable Energy Consumption, Capital, Population, and GDP variables. However, this study tries to use a time series of energy scenarios relating to secondary data between 1980 and 2021 for India, based on econometric tools like Cointegration and FMOLS Tests; all the variables are also transformed into a natural log.

Johansen Cointegration Test

Danish econometrician Soren Johansen developed the Johansen cointegration test in the late 1980s and early 1990s. He created this approach as a bivariate version of the Engle-Granger cointegration test. The Engle-Granger test has drawbacks addressed by the Johansen test, allowing researchers to investigate cointegration among numerous variables at once.

To assess the null hypothesis that there is no cointegration, the test uses statistics such as the maximum eigenvalue and trace tests. The area of econometrics has dramatically benefited from Soren Johansen's contributions to cointegration analysis, including creating the Johansen cointegration test. His work has improved our knowledge of long-term equilibrium and interdependencies in economic and financial data by giving scholars a reliable instrument to examine complex interactions among many time series variables.

FMOLS Test

The FMOLS examination considers serial correlation and endogeneity of the variables while evaluating the coefficients of a cointegrated regression model. Cointegration suggests that although the variables may not be individually stable, they have a long-term equilibrium connection. A cointegrated regression model's parameters can be estimated using an econometric technique called Fully Modified Ordinary Least Squares (FMOLS). In 1996, Philip C. B. Phillips and Jin Seo Cho presented it in their work "Estimation of Long-Run Relationships in Dynamic Heterogeneous Panels." FMOLS aims to offer reliable and effective estimates of the coefficients describing this connection of long-term equilibrium.

EMPIRICAL FINDINGS AND DISCUSSION

Unit Root Test Results

Before estimating Johansen cointegration in this study, we verified the stationarity of the variables using ADF and PP unit-root tests. For this purpose, we have checked the stationarity at the levels of variables and with the first difference variables. Both tests indicated that all the variables are nonstationary at the levels as the probability level of the test statistics is more than 0.05. However, as noted in both tests, these variables have become stationary in their first differences. The results are presented in the following tables:

Table No: 1

Unit Root Test Outcomes					
Augmented Dickey-Fuller Test Statistic			***Phillips Perron Test Statistic***		
Level					
Variable	***t- statistic***	***Prob.***	***t- statistic***	***Prob.***	***Inference***
LGDP	0.002586	0.9533	0.024916	0.9554	1(0)
LREC	0.530005	0.9858	1.811944	0.9996	1(0)
LTNREC	-2.059843	0.1377	-3.153693	0.0303	1(0)
LGFCF	0.006358	0.9537	0.062495	0.9588	1(0)
LPOP	0.277578	0.9741	-2.517352	0.2800	1(0)
Augmented Dickey-Fuller Test Statistic			***Phillips Perron Test Statistic***		
First Difference					
Variable	***t- statistic***	***Prob.***	***t- statistic***	***Prob.***	***Inference***
LGDP	-6.077405	0.0000	-6.072385	0.0000	1(1)
LREC	-6.93655	0.0000	-7.270401	0.0000	1(1)
LTNREC	-5.970731	0.0000	-5.971809	0.0000	1(1)
LGFCF	-7.721501	0.0000	-7.721501	0.0000	1(1)
LPOP	4.028642	0.04598	3.884149	0.0500	1(1)

The study is based on secondary data. We used a two-step procedure to verify the study objective, i.e., the relationship between energy consumption and GDP in India. In the first stage, we tested the cointegration between the dependent and independent variables using Johansen cointegration tests. Before this, we verified stationarity in the series using ADF and Philips Perron tests. The tests indicated the variables LGDP, LREC, LNREC, and LGFCF. LPOPs are non-stationary but stationary at their first difference level. They are integrated into order 1. e. I (1). This means there is non-stationarity in the level variables. Thus, we tested for cointegration between these variables using Johansen cointegration tests, i.e., Trace and Rank tests. Both tests indicate that these variables are cointegrated.

Johansen Cointegration Test Results

The Johansen trace test determines the overall presence of cointegration relationships in a system of variables. It helps answer whether there is any cointegration among the variables being analysed. This test generates a set of test statistics and critical values. By comparing the test statistics to the critical values, we can assess whether cointegration exists and how many cointegration relationships might be present in the dataset.

Table: 2: Johansen Cointegration Test

Unrestricted Cointegration Rank Test (Trace)				
Hypothesised		***Trace***	***0.05***	
No. of CE(s)	***Eigenvalue***	***Statistic***	***Critical Value***	***Prob.*****
None *	0.710031	87.75353	69.81889	0.0010
At most 1	0.378045	39.47224	47.85613	0.2419
At most 2	0.310973	20.95164	29.79707	0.3607

At most 3	0.140344	6.425123	15.49471	0.6453
At most 4	0.013432	0.527410	3.841466	0.4677
Trace test indicates 1 cointegrating eqn(s) at the 0.05 level.				
* denotes rejection of the hypothesis at the 0.05 level **MacKinnon-Haug-Michelis (1999) p-values				
Unrestricted Cointegration Rank Test (Maximum Eigenvalue)				
Hypothesised		***Max-Eigen***	***0.05***	
No. of CE(s)	***Eigenvalue***	***Statistic***	***Critical Value***	***Prob.*****
None *	0.710031	48.28128	33.87687	0.0005
At most 1	0.378045	18.52060	27.58434	0.4524
At most 2	0.310973	14.52652	21.13162	0.3234
At most 3	0.140344	5.897713	14.26460	0.6264
At most 4	0.013432	0.527410	3.841466	0.4677
Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level * denotes rejection of the hypothesis at the 0.05 level **MacKinnon-Haug-Michelis (1999) p-values				

Both tests indicate that cointegration exists between these variables, which mean there is a long-run relationship between these variables.

In the second stage. We have estimated the FMOLS cointegration equation to estimate the relationship between variables. The Fully Modified Ordinary Least Squares (FMOLS) cointegration model analyses and evaluates the long-term relationship between two or more cointegrated non-stationary time series variables. Cointegration is when two or more time series move together over the long run, even though they may have short-term fluctuations that are not directly correlated. Cointegration suggests that although individual variables are non-stationary, a linear combination is stationary, implying a stable equilibrium relationship.

Fully Modified Least Squares (FMOLS) Test Results

FMOLS aims to estimate the long-term equilibrium relationship between the cointegrated variables. This is important because short-term fluctuations and shocks can obscure the proper relationship between variables. FMOLS incorporates lagged values of the variables in the regression to capture any potential dynamics in the relationship. FMOLS provides more accurate estimates of the underlying relationships between variables in the presence of non-stationarity. The results of the FMOLS model are presented below.

Table No: 6.3: Fully Modified Least Squares (FMOLS)

Dependent Variable: LGDP				
Method: Fully Modified Least Squares (FMOLS)				
Variable	***Coefficient***	***Std. Error***	***t-Statistic***	***Prob.***
LREC	0.284824	0.087606	3.251177	0.0025
LTNREC	-0.014387	0.245858	-0.058517	0.9537
LGFCF	0.495710	0.104301	4.752683	0.0000

LPOP	0.566399	0.558100	1.014869	0.3169
C	2.838488	11.54262	0.245914	0.8071
R-squared	0.996812	***Mean dependent var***		27.50131
Adjusted R-squared	0.996458	***SD dependent var***		0.711622
SE of regression	0.042354	***Sum squared resid***		0.064580
Long-run variance	0.003245			

CONCLUSION

The FMOLS model indicates that Log renewable energy consumption (LREC) and Log Gross fixed capital formation (LGFCF) statistically and significantly impact Log Gross Domestic product. (LGDP). They impacted India's GDP positively and significantly during the study period. However, Log population (LPOP) and Log total nonrenewable energy consumption (LTNREC) have no significant impact on Log Gross Domestic Product (LGDP). The coefficients in the model indicate the elasticities of GDP concerning the given independent variable, such as REC.

India's economic growth and using renewable and non-renewable energy sources are closely connected. The country is at a turning point in its history when decisions made about energy will significantly impact the sustainability of the environment and economic growth. India can solve urgent environmental issues and promote sustainable economic growth by systematically shifting to a more significant percentage of renewable energy. But achieving this vision of a greener, wealthier future will need thoughtful policy planning, technical innovation, and international cooperation.

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