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Impact of Clean Energy on Economic Growth: An Empirical Investigation

Dr. Anugu Anil Reddy

Abstract

The purpose of this paper is to empirically investigate the impact of clean energy, gross capital formation (capital), Labour force (Labour) on Economic growth, particularly in relation to India. The study utilizes annual data from 1990 to 2014. GDP constant prices of 2010 denominated in US Dollar, alternative and nuclear energy (% of total energy use), Gross Fixed Capital Formation (% of GDP) proxy for Capital and Labour force total were obtained from World Bank, World Development Indicators. The study employed descriptive statistics, Correlations, Johansen cointegration test and Pairwise Granger Causality test. Empirical results confirmed the existence of a long-term equilibrium relationship among the variables and showed that clean energy consumption using Granger causality test causes economic growth. We can infer crucial policy implications from the findings. Consumption of clean energy has a favourable impact on economic growth and cuts CO_2 emissions significantly. As a result, policymakers should focus on and encourage the development of clean energy.

Keywords: Clean Energy, Economic Growth, Capital, Labour, Correlations, Cointegration Relationship, Pairwise Granger Causality

Department of Economics, Email: anilanugu@gmail.com

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1. Introduction

According to the United Nations sustainability goal, clean growth can be defined as economic growth that is linked to improving energy efficiency and utilizing renewable (clean) energy to reduce or eliminate the negative impact of economic growth on the environment. The Indian government has recognized the importance of clean growth and has enacted stringent environmental regulations to address the issue of environmental damage. However, as previously stated, the country's energy consumption has increased in recent years, implying that its energy structure, which is primarily based on non-clean consumption, continues to place enormous strain on the environment, and improving energy efficiency individually (by decreasing energy intensity) is insufficient.

India, as a developing country with the world's second largest population, is experiencing a nationwide power supply shortage. It is critical to maximise the use of all available power resources within the country, and it has been discovered that New and Renewable Sources of Energy (NRSE) can contribute significantly to power generation in the coming years. The commercialization of numerous NRSE technologies has resulted from the development of new technology and advancement in this sector. This industry also has the advantage of reducing pollution and raising awareness about the need to reduce carbon emissions in order to protect the environment.

2. Review of Literature

There are seldom studies focusing on the relationship amongst clean energy consumption and economic growth. Jung (2005) support unidirectional causality running from nuclear energy consumption to economic growth in both short- and long-run for Korea.Ozturk (2017) indicate unidirectional causality running from economic growth to renewable energy

consumption in the short-run and bidirectional causality supporting feedback hypothesis in the long-run.

Mulali (2014) investigates the influence of nuclear energy consumption on GDP growth and CO_2 emission in 30 major nuclear energy consuming countries. The panel mode was used taking the period 1990 to 2010. Their results of the study indicated that nuclear energy consumption has a positive long run effect on GDP growth while it has no long run effect on CO_2 emission. The Granger causality test results also revealed that nuclear energy consumption has a positive short run causal relationship with GDP growth while it has a negative short run causal relationship with CO_2 emission.

Cai et al. (2018) find no cointegration among real GDP per capita, clean energy consumption and CO_2 emissions in Canada, France, Italy, the US and the UK. However, cointegration exists in Germany when LRPGDP and LCO_2 serve as dependent variables and in Japan when LCO_2 is the dependent variable. Regarding the causality test results that they find clean energy consumption causes real GDP per capita for Canada, Germany and the US. CO_2 emissions cause clean energy consumption for Germany. Besides, they find feedbacks between clean energy consumption and CO_2 emissions for Germany, and unidirectional causality running from clean energy consumption to CO_2 emissions for the US.

Korhan and Mohamad (2018) empirically observed the nexus between nuclear energy consumption and economic growth in the country of Spain. Unit root and stationarity tests, Johansen cointegration tests, vector error correction models (VECM), and Granger causality tests were applied to annual data for the years 1968 to 2014. Empirical results revealed the existence of a long-term equilibrium relationship between two variables and showed that nuclear energy consumption using Granger causality tests causes economic growth.

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Iwata et al. (2010) examines the environmental Kuznets curve (EKC) in the case of France by taking the role of nuclear energy in electricity production into account. They employed the autoregressive distributed lag (ARDL) approach to cointegration as the estimation method. Additionally, they examine the stability of the estimated models and investigate the Granger causality relationships between the variables in the system. The results from our estimation provide evidence supporting the EKC hypothesis, and the estimated models are shown to be stable over the sample period. The uni-direction running from other variables to CO_2 emissions are confirmed from the casualty tests. Specifically, the uni-directional causality relationship running from nuclear energy to CO_2 emissions statistically provides evidence on the important role of nuclear energy in reducing CO_2 emissions.

3. Data and Methodology

The study utilizes annual data from 1990 to 2014. GDP constant prices of 2010 denominated in US Dollar, alternative and nuclear energy (% of total energy use), Gross Fixed Capital Formation (% of GDP) proxy for Capital and Labour force total were obtained from World Bank, World Development Indicators. The study employed descriptive statistics, Correlations, Johansen cointegration test and Pairwise Granger Causality test.

Econometric model:

$$Ln\,(\boldsymbol{EG_t}) = \boldsymbol{\beta_o} + \boldsymbol{\beta_1}\, \boldsymbol{ln}(\,\boldsymbol{CLEAN}_{\,t}) + \boldsymbol{\beta_t}\, \boldsymbol{ln}(\,\boldsymbol{CAP_t}) + \boldsymbol{\beta_3}\, \boldsymbol{ln}(\,\boldsymbol{LF_t}) + \boldsymbol{\varepsilon_t}$$

Where

EG = Economic Growth

$CLEAN$ = Clean energy consumption

LF = Labour Force

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CAP = Capital

ε_t = Error Term

Where, $\beta_0, \beta_1, \beta_2, \beta_3,$ are the respective parameters.

4. Empirical Findings

Table 1
Descriptive Statistics

Variable	*lnGDP*	*lnCLEAN*	*lnCAPITAL*	*lnLABOUR*
Mean	27.63010	0.741855	3.361215	19.81955
Std. Dev.	0.453576	0.129680	0.138808	0.133178
Skewness	0.077650	0.756361	0.039325	-0.446865
Kurtosis	1.763067	2.498557	1.527583	1.772434
Jarque-Bera	1.618876	2.645599	2.264790	2.401741

The descriptive statistics results portrayed in table 1. The results shows that all the variables are having positive mean. Here the skewness values of all the variables are positive (except labour) which indicates that the frequency curve of all the sharing isnon-symmetric bell-shaped curve. Kurtosis is concentrated with the flatness or peakedness of frequency curve. Here, the kurtosis values of economic growth, clean energy consumption, capital and labour were less than 3, which indicate that these variables have normal kurtosis.The Jarque-Bera test marker reveals the typical non-normality quality of high frequency.

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Table 2
Correlation Results

Variable	*LGDP*	*LCLEAN*	*LCAPITAL*	*LLABOUR*
lnGDP	1.000000	0.849799	0.870470	0.968926
lnCLEAN	0.849799	1.000000	0.720306	0.754879
lnCAPITAL	0.870470	0.720306	1.000000	0.895423
lnLABOUR	0.968926	0.754879	0.895423	1.000000

The correlation between GDP, clean energy consumption, capital and labour are presented in Table2. This table reflects that labour has the highest correlation with GDP by 0.9689, capital 0.8704, and clean energy consumption 0.8497. This therefore indicates that these three variables have a significant relationship with respect GDP in India.

Table 3
Cointegration Test Results

Unrestricted Cointegration Rank Test (Trace)				
Hypothesized		***Trace***	***0.05***	
No. of CE(s)	***Eigenvalue***	***Statistic***	***Critical Value***	***Prob.*****
None *	0.743749	59.71628	47.85613	0.0026
At most 1	0.609601	29.76117	29.79707	0.0505
At most 2	0.337179	9.068300	15.49471	0.3591
At most 3	0.000945	0.020797	3.841466	0.8852
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)				
Hypothesized		Max-Eigen	0.05	
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None *	0.743749	29.95511	27.58434	0.0243
At most 1	0.609601	20.69287	21.13162	0.0575
At most 2	0.337179	9.047502	14.26460	0.2822
At most 3	0.000945	0.020797	3.841466	0.8852
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				

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The results for the Johansen cointegration test divulged in Table 3. The Johansen cointegration technique was applied to investigate the existence of a long run equilibrium relationship among the variables. The estimated results supported the existence of one cointegration equation at 5 % level, which means that economic growth, clean energy consumption, capital and labour have the tendency to move together in the long run.

Pairwise Granger causality Test results

Table 4 displays the results of the pairwise Granger causality test. The null hypothesis of no causality was rejected, as evidenced by the results. More specifically, the findings show that clean energy consumption granger causes economic growth, indicating that it adheres to the growth hypothesis, implying that clean energy consumption influences economic growth in India.

Table 4: Pairwise Granger Causality Tests

Pairwise Granger Causality Tests			
Null Hypothesis:	Obs	F-Statistic	Prob.
lnGDP does not Granger Cause lnCLEAN	22	0.97353	0.3978
lnCLEAN does not Granger Cause lnGDP		6.18621	0.0235*

5. CONCLUSION

The purpose of this paper is to empirically investigate the impact of clean energy, gross capital formation (capital), Labour force (Labour) on Economic growth, particularly in relation to India. The study utilizes annual data from 1990 to 2014. GDP constant prices of 2010 denominated in US Dollar, alternative and nuclear energy (% of total energy use), Gross Fixed Capital Formation (% of GDP) proxy for Capital and Labour force total were obtained from World Bank, World Development Indicators. The study employed

descriptive statistics, Correlations, Johansen cointegration test and Pairwise Granger Causality test. Empirical results confirmed the existence of a long-term equilibrium relationship among the variables and showed that clean energy consumption using Granger causality test causes economic growth. We can infer crucial policy implications from the findings. Consumption of clean energy has a favourable impact on economic growth and cuts CO2 emissions significantly. As a result, policymakers should focus on and encourage the development of clean energy.

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