The 3rd International Conference on Japan–Bangladesh Research and Practice (JBRP2024)
November 29–30, 2024
Online, Coordinated from The University of the Ryukyus, Okinawa, Japan
Organized by the Network of Bangladeshi Researchers in Japan (NBRJ)
Submission Number: 10

Disaggregated Impact of Non-Renewable Energy Consumption on the Environmental Sustainability of the United States: A Novel Dynamic ARDL Approach

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Track: Natural Sciences, Engineering, and ICT

Keywords: Non-renewable Energy, Environmental Sustainability, Dynamic ARDL, Coal, Petroleum.

Extended Abstract

The load capacity factor (LCF) represents the ratio of biocapacity to the ecological footprint and it is one of the most appropriate measures of environmental sustainability [1,2]. In the United States (U.S.), the LCF has consistently remained below 0.5 from 1970 to 2022, indicating that the country's resource supply is insufficient to meet current levels of consumption and production [3]. Despite extensive research on environmental sustainability, the disaggregated effects of major non-renewable energy (NRE) sources on U.S. environmental health are not well understood, particularly through the lens of the LCF. Given that approximately 90% of the U.S. energy consumption comes from four major NRE sources—coal, natural gas, petroleum, and nuclear energy [4]—this study seeks to fill that gap by examining the heterogeneous impacts of these energy sources on environmental sustainability from 1961 to 2022. Using a dynamic autoregressive distributed lag (DYNARDL) model, we examined the short- and long-term impacts of NRE consumption on the U.S. environment.

The findings reveal that every one-unit increase in coal, natural gas, and petroleum consumption reduces environmental sustainability by 0.007, 0.006, and 0.008 units in the short run and 0.006, 0.004, and 0.005 units in the long run, respectively (Table 1). In contrast, nuclear energy contributes positively to sustainability, with a 0.007-unit increase for each additional unit consumed in the long run. Furthermore, kernel-based regularized least squares (KRLS) analysis confirms that coal and petroleum have significantly negative causal links to environmental health, while nuclear energy shows a strong positive impact (Table 2). This research underscores the need to expand nuclear energy use in the U.S. while

gradually phasing out coal and petroleum, followed by natural gas, to achieve greater environmental sustainability. Policymakers must also consider the social and economic implications of transitioning away from fossil fuels, ensuring a balanced approach that promotes both environmental health and economic stability.

Table 1: Dynamic ARDL simulation result.

Variable(s)	Coefficient	Std. Err.
Δ COAL	-0.007***	0.0024
COAL	-0.006***	0.0013
Δ NG	-0.006***	0.0021
NG	-0.004***	0.0011
Δ PETRO	-0.008***	0.0016
PETRO	-0.005***	0.0014
Δ NUC	-0.011	0.0075
NUC	0.007***	0.0018
ECT(-1)	-0.521***	0.1101
Constant	0.546	0.1122
R-squared	0.7275	

Note: *** represents a 1% level of significance.

Table 2: KRLS Result.

Variable	Avg.	SE	t	P>|t|	P25	P50	P75
COAL	-0.004	0.001	-3.992	0.000	-0.008	-0.004	-0.001
NATURAL GAS	-0.001	0.001	-1.334	0.187	-0.002	0.000	0.001
PETROLEUM	-0.008	0.001	-13.071	0.000	-0.012	-0.009	-0.006
NUCLEAR	0.004	0.001	2.588	0.012	0.002	0.004	0.005
Lamda	0.086	Sigma	4	R-sq.	0.977	Tolerance	0.062
Eff. df.	4	Looloss	0.17				

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