



Renewable Energy, Trade and Economic Growth on Nitrous Oxide Emission in G-7 Countries Using Panel ARDL Approach

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Abstract: This study's objective is to evaluate the influences of numerous variables, including trade openness, renewable energy, and gross domestic product, on nitrous oxide emissions from 1990 to 2022. The Kao and Pedroni result demonstrates that the variables are cointegrated. This study the relationships between renewable energy, GDP, and trade openness on CO₂ emission in G-7 nations. Using the Panel ARDL approach, the results show that, in the long run, there is a positive and significant correlation between GDP and trade openness on nitrous oxide emission in G-7 countries. Additionally, there is an insignificant but positive link between renewable energy and N₂O emissions. Our proposal to political leaders and government officials is that they should strongly encourage foreign investors to participate in the production of clean and renewable energy, such as green energy, rather than conventional energy, in order to both support the activities of our economy and promote environmental stability. The government has to impose rigorous environmental laws and regulations, as well as come up with incentives for people to follow those policies, in order to enhance the overall quality of the environment.

Introduction

The actions of humans put the environment, as well as our sources of food, clean water, and energy, as well as our opportunities for leisure and fresh air, in jeopardy. Wackernagel and Rees (1996) determined the amount of bio-effective land that is necessary to keep a population stable by employing nitrous oxide (EF). Nitrous oxide is the factor that decides both the amount of waste that is produced as a result of human resource utilization and the number of herbal sources that are consumed by humans. The nitrous oxide indicator, which measures the availability of

resources, looks at how speedily nature can consume fecal matter and produce new ones. It achieves this by predicting how rapidly nature can generate fresh resources. Statistically speaking, nitrous oxide is used to track the environmental effects of producing goods and services that are required to maintain a certain standard of living, encompassing both goods and services (Hassan et al. 2019b; Rashid et al. 2018).

Nitrous oxide takes a more holistic approach to the problem of global warming by examining

the ways in which carbon emissions, land usage, and deforestation are all contributing to climate change (Bilgili et al. 2019). Nitrous oxide will be used in order to evaluate and assess the management of resources, as well as environmental sustainability. Nitrous oxide is a method for accounting for resources, but it may also be used in the process of evaluating the natural resources of a nation (Solarin et al., 2019). Many nations are confronting an increasingly difficult problem as a consequence of the observation that the amount of energy needed to satisfy the world's requirements has exceeded the amount that the earth can produce. An insufficient supply of gas affects just 0.080% of the world's population. The pursuit of sustainable development requires governments to respect the natural limits that exist on their territories (GFN 2018). Nitrous oxide emissions provide a more accurate and insightful picture of the state of the environment than carbon dioxide emissions do (Danish et al. 2019; Ulucak and Bilgili 2018).

Because of its heavy reliance on agriculture, Pakistan is a leading exporter of many agricultural products. Consumption of agricultural goods, together with exports of coal and natural gas, have all played important roles in the expansion and prosperity of the United States economy. For instance, the gross domestic product of the United States of America increased by more than four times between the years 1965 and 2016, going from 665 USD to 3974 USD. (2018) (Kurniawan and Managi) (Kurniawan and Managi). Because more than half of Asians make their homes in urban areas, the urbanization rate in this region has increased at a rate that is unmatched by any other (UNDP 2017). The industrialization process is accelerated by the acceleration of monetary growth, which also accelerates the depletion of natural resources. In addition, the extraction of natural assets for purposes like industrialization, mining, farming, and deforestation could harm the environment (Danish et al., 2019). While a decrease in the natural resource base will result

in an increase in nitrous oxide emissions, it is possible to anticipate an increase in coal mining and electricity generation revenues (Panayotou 1993).

The methods of sustainable management are used in the production and consumption of products and services, and then it may be possible to allow assets to regenerate. This will help prevent the exhaustion of natural resources. Oil, gasoline, and coal were the primary contributors to Asia's growth in the area of nonrenewable energy sources. It is anticipated that coal will eventually replace natural gas as Asia's preferred gas source owing to the abundant deposits of coal, its relatively low price, and its relative ease of use (Kurniawan and Managi 2018). Urbanization is helped forward by economic development as well. On the other hand, urbanization raises not only the demand for transportation and production but also the amount of energy that is used from sources that are not renewable and the levels of nitrous oxide (Ulucak and Khan, 2022). Urbanization is associated with a decrease in physical fitness, yet, it is also associated with improved profitability, economies of scale, and positive externalities.

The goal of urbanization may be to increase the purchasing power of city people so that they may make use of renewable energy sources and so reduce the amount of nitrogen oxide emissions they produce (Danish and Wang 2019). The biosphere may suffer from changes made to environmental assets like charcoal and petroleum products, among others, and nitrous oxide levels may rise as a result. The Asia region became the region that accounted for the majority of the planet's total biocapacity in the year 2010, as reported by the Living Planet Report (LPR) 2014. This information was gathered from 2010. (WWF 2014). According to the biannual file (LPR), In Asia, nitrogen dioxide levels are extremely close to the average biocapacity of the region, according to a scientific analysis of how urbanization affects the health of our planet. This

should serve as a wake-up call to Asia to reform its manufacturing and consumption patterns, which are the root cause of the continent's rising nitrous oxide emissions, which have now surpassed the biocapacity of its individual countries (China, Russia, India, Pakistan, and Bangladesh). In order to avoid leaving an imprint that is not sustainable and that puts both human health and herbal systems in jeopardy, there is an immediate and critical need to reduce environmental stress in that area. Long-term development is a goal that Asia, along with the other G7 nations and emerging economies, aspires to achieve. When compared on a per capita basis, a nation's biocapacity per inhabitant must be higher than its nitrous oxide capacity per inhabitant while yet preserving an adequate standard of living in order to achieve sustainable development (WWF 2014). There is not a single economic system anywhere in the world that is now capable of functioning without the use of energy. Power is the engine that propels the economy on numerous levels. It is advantageous for both development and production. (Ali et al. 2022; Shahbaz et al. 2017b, 2019b; Nathaniel 2019). (Shahbaz et al. 2017a). On the other hand, a scarcity of it makes a boom more difficult to achieve (Shahbaz 2015). The use of energy contributes to the degradation of the environment, especially when it comes to sources of energy that are not renewable (Nathaniel al. 2022) (Ghazali and Ali 2019).

Due to the fact that the majority of Asian nations largely depend on natural assets for their energy requirements, such as fossil energy, charcoal, natural gas, and petroleum products, the Asian area continues to struggle to meet both its residential and commercial energy requirements (Sambodo and Novandra 2019). The use of coal, which is not a sustainable source of energy, is harmful to the environment. The results of numerous studies show that using coal has a negative impact on the ecology in many nations (Tacconi and Muttaqin 2019). In all three of these nations: Pakistan, India, and Bangladesh, coal consumption has been

gradually increasing. This is the first study to utilize nitrous oxide (nitrous oxide) to capture environmental excellence within the power-environment nexus for G7 economics. Previous studies have used emissions of nitrous oxide, but this study is the first to use nitrous oxide. This is due to the fact that nitrous oxide is a more mixed signal than other pollutants, and as a result, it more accurately indicates the degradation of the ecosystem (Wang and Dong 2019). (Hassan et al. 2019a; Nathaniel et al., 2019).

Literature

Our world is at risk of extinction as a consequence of the widespread interest in environmental preservation issues that have grown as a result of the desire to preserve biological diversity. The outcomes of the many studies on urbanization, commerce, energy use, and environmental quality are not totally obvious. A further in-depth examination of the relevant studies discovered that nitrous oxide emissions induced by the usage of non-renewable energy sources contribute to the destruction of the environment (See, as an example, Vo et al. 2019; Bekun et al. 2019a, b; Nathaniel and Iheonu 2019; Valadkhani et al. 2019). Ahmed et al. (2019a) examined the non-linear relationship between urbanization and nitrous oxide emissions in Asia from 1971 to 2014. They modified their results to account for the amount of energy utilized and the rate of economic development. According to the research, Asia's urbanization, increased power usage, and the financial boom are all contributing contributors to the growth in nitrous oxide emissions.

Kurniawan and Managi (2018) examined data from Pakistan, India, and Bangladesh between 1970 and 2015 to evaluate how urbanization and the usage of alternative energy affected coal consumption in those countries. They observed that these components, together with increased economic activity, led to a rise in the usage of coal, hastening environmental damage. The scientists stated that in order to preserve a

healthy environment in Asia, the quantity of coal utilized should be reduced. According to Shahbaz et al. (2019a), environmental sustainability and urbanization both lead to an increase in emissions, while change and environmental sustainability work to enhance environmental quality.

Li et al. 2019, Azizalrahman 2019, Wang et al. 2019a,b, Wang and Zhao 2018, Fan and Zhou 2019, Hafiza, Manzoor, Fatima, Sheikh, Rahman, Qureshi, 2022, Shahid, Muhammed, Abbasi, Gurmani, & Rahman 2022, Rahman, & Bakar, 2018. In contrast to economic growth, which contributes significantly to nitrous oxide emissions, the findings of Shahbaz et al. (2019a) contradict those of Adams and Klobodu (2018) and Lin et al. (2017), who discovered that urbanization had no significant impact on emissions in Africa and occasionally-income countries, respectively. This was in contrast to the fact that urbanization had a major influence on emissions in low-income countries. Waheed et al. (2019), Shahbaz and Sinha (2019), and Mardani et al. (2019) each gave their own distinct viewpoint on the link between growth in strength and the surrounding environment. Furthermore, nitrous oxide was used in a number of research to assess the degree of environmental damage.

Alola et al. (2019b) studied the impact of trade, fertility fees, and non-renewable energy on the quantity of nitrous oxide in Europe's atmosphere from 1997 to 2014. The Panel ARDL technique demonstrated that non-renewable energy, alternative energy, and fertility all had a negative impact on the surrounding ecology. Baloch et al. (2019b) investigated the impact of urbanization on nitrous oxide from 1990 to 2016 in 59 Belt and Road Initiative countries. It has been shown that urbanization, economic advancement, and the use of non-renewable energy sources are hazardous to the environment since they raise nitrous oxide levels. According to Hassan et al. (2019b), nitrous oxide levels will rise in unison with economic growth. It was discovered that there is a link between nitrous

oxide and not just biocapacity but also nitrous oxide and herbal sources. This relationship is bidirectional. Hassan et al. (2019a) conducted research using the ARDL technique that was quite comparable to this one. From 1971 to 2014, their research focused on the effects of economic growth, biocapacity, and human capital on nitrous oxide in Asia. Each of the aforementioned factors promotes the creation of nitrous oxide. In the medium term, however, the rise of the financial sector decreases nitrous oxide levels by around 0.60 percent.

Doga et al. (2019) evaluated the factors responsible for observed variations in nitrous oxide levels in MINT countries from 1971 to 2013. According to their findings, the major drivers were export, urbanization, financial advancement, and the use of fossil fuels. They also concluded that urbanization is the major factor in environmental stress in MINT countries. Bello et al. (2018) concluded that urbanization in Malaysia had no negative impact on the surrounding natural environment. Destek and Sarkodie (2019) used the AMG estimator to examine the effect of alcohol use on nitrous oxide levels in 11 industrialized (N-eleven) nations from 1977 to 2013. Their investigation included the years 1977 through 2013. The usage of energy was shown to be a substantial contribution to the degradation of the environment in (N-11) countries.

Destek et al. (2018) had earlier completed a study for European countries that was quite similar to this one. They came to the conclusion that RE contributes to environmental degradation by increasing nitrous oxide levels in the atmosphere. Furthermore, it has been shown that change increases the quality of the environment. Ahmed et al. (2022) examined the relationship between nitrous oxide emissions and urbanization in the G7 countries, taking into consideration the impact of human capital on the relationship. Urbanization, power usage, and economic expansion should all contribute to an increase in nitrous oxide levels, according to the

results of continuously updated, absolutely modified (CUP-FM), and continuously updated bias-corrected (CUP-BC) estimators. These results support Destek et al. (2018)'s findings for the European population, Dogan et al. (2019) for the MINT population, and Hassan et al. (2019b) for the Pakistani population.

Using the AMG estimator, Nathaniel et al. (2022) investigated the factors that influence nitrous oxide levels in MENA countries. They concluded, as have the bulk of prior research for developing countries, that urbanization and economic development do not improve environmental quality. The causality result supported a one-way causal link between nitrous oxide and nonrenewable energy, urbanization, and economic development. In contrast to Nathaniel et al. (2022), Destek and Sinha (2022) used the common correlated results, which hint at the need for an organization estimator to analyze the impacts of trade, financial development, and energy consumption on nitrous oxide in 24 OECD nations between 1980 and 2014. According to their results, non-RE uploads to environmental damage are required. [Citation required] Wang and Dong (2019) for Sub-Saharan Africa, Zafar et al. (2019) for the United States of America, Fakher (2019) for OPEC, He et al. (2019) for Malaysia, and Solarin and Al-Mulali (2018) for 20 unique sites throughout the world.

Ahmed et al. (2019b) conducted ARDL limitations research to explore the association between Malaysia's nitrous oxide emissions and the status of the environment from 1971 to 2014. They observed that, whereas economic expansion and energy usage both increase the synthesis of carbon and nitrous oxide, environmental sustainability is not necessarily a main determinant in nitrous oxide production.

Ahmed and Wang (2019) discovered an inverted U-shaped link between economic growth and nitrous oxide in India. Human capital, on the other hand, has been demonstrated to minimize nitrous oxide, while

energy consumption has been shown to enhance it. Finally, experts are divided on the relationship between energy expansion and environmental degradation. The capacity of cities to govern their populations, people's earnings, and the stage of urbanization itself are all aspects that contribute to the different results about how urbanization affects the natural environment. Despite this, there seems to be universal agreement that the generation of nonrenewable energy has a negative impact on the surrounding ecology.

Furthermore, the great majority of previous research used nitrous oxide emissions as a proxy for environmental impact. Rather than employing the more all-encompassing nitrous oxide, this was done. The great majority of study results indicate that the use of strong drinks, the adoption of alternative lifestyles, and the increase of economic activity are not ecologically helpful in rising nations. However, it has not been possible to determine how these factors influence nitrous oxide levels in Pakistan because the majority of studies, particularly those that relied on nitrous oxide emissions to quantify environmental damage, have not yet investigated how urbanization, trade, energy consumption, and financial growth affect nitrous oxide levels.

Data source and variable section

The primary objective of this practice is to use panel data for the G7 countries from 1990 to 2022 to examine the effect of renewable energy, trade openness, and GDP on environmental deterioration. The use of GHG emissions as a proxy for the measurement of environmental degradation was established in the earliest literature for variables (Khan et al. 2019a, b, 2022a). Gross domestic product is utilized as the inflow of raw materials for industrial production (Paramati et al. 2016; Shahbaz et al. 2018); solar power indicates the consumption of renewable power (Sarkodie et al. 2022; Destek and Aslan 2022); greenhouse gas emissions indicate the consumption of renewable energy from distinct sources (Hamdi et al. 2014; Hdom 2019; Liddle and Sadorsky 2017; Ridhosari and Rahman 2022);

(Khan et al. 2019a; Mishkin 2009; Shahbaz et al. 2017)

Econometric approach for panel ARDL

Focus on panel data-set with time periods $t = 1, 2, 3, \dots, T$ and $G7$ countries $i = 1, 2, 3, \dots, N$, the following panel ARDL ($P, Q, Q, \dots, Q_i$) model is estimated:

$$N_2O_{it} = \sum_{j=1}^p \lambda_{ij} N_2O_{it-j} + \sum_{j=0}^Q \delta'_{ij} X_{it-j} + \mu_i + \varepsilon_{it} \quad (1)$$

In the ARDL (P, Q, Q, Q, Q, Q_1) model, the repressor organization vectors are shown by X_{it} ($k \times 1$). I stands for the fixed effect, or the coefficients of delayed regression, which is CO_2 . ij stands for the scalars in the equation, and ij stands for the ($ok \times 1$) vector coefficient. If regressors and regressors are cointegrated, the error correction term is used for all of the countries. Cointegrations between the regressed and the regressors are responses to the change that long-term equilibrium brings about. The regressand and regressors show that the deviation from equilibrium has an effect on the ECM. The ECM describes the short-term behavior of the regressand and regressors inside the device. The following error-correction equation is different because it is based only on the PMG (P, Q, Q, Q, Q, Q_1) equation that was already given:

$$\Delta N_2O_{it} = \phi_i(N_2O_{it-1} - \theta'_i X_{it-1}) + \sum_{j=1}^{p-1} \lambda_{ij} \Delta N_2O_{it-j} + \sum_{j=0}^{Q-1} \delta_{ij} \Delta X_{it-j} + \mu_i + \varepsilon_{it} \quad (2)$$

In the Above Equation $\phi_i = -(1 - \sum_{j=1}^p \lambda_{ij})$, $\theta_i = \sum_{j=0}^Q \frac{\delta_{ij}}{1 - \sum_k \lambda_{ik}} \lambda_{ik}$, $\lambda_{ij} = -\sum_{m=j}^p \lambda_{im}$

Reflect the rate of the adjustment to its equilibrium. This is called the error correction pace. There is no meaningful romantic relationship between regressors and regressands over the long term. When the observer's error

correction speed is equal to zero (also written as $I = 0$), this condition is met. On the basis of the hypothesis that the used variables in the equation reveal a return to long-run equilibrium, it is anticipated that the error correction time period will be full-size and negative. The time period oi in the preceding equation demonstrates the long-run affiliation between the regressors and the regressand. The following equation, which is based on Eq. (2), uses all variables that are relevant to the problem:

$$\Delta N_2O_{it} = \beta_0 + \phi_{1,i} [N_2O_{it-1} - \theta'_{2,i} (RENG_{it}, TP_{it}, GDP_{it})'] + \sum_{j=1}^{p-1} \lambda_{ij} \Delta N_2O_{it-j} + \sum_{j=0}^{Q-1} \delta_{ij} \Delta RENG_{it-j} + \sum_{j=0}^{Q-1} \delta_{ij} \Delta TP_{it-j} + \sum_{j=0}^{Q-1} \delta_{ij} \Delta GDP_{it-j} + \mu_i + \varepsilon_{it} \quad (3)$$

Pesaran and Smith (1995) made the pooling method group (PMG) estimator. All of the used intercepts, slopes of the confidence of the variables, and the final error version are unique across enterprises of different countries. This was done with the help of the group pooling method (PMG). Pesaran et al. (1997, 1999) improved the PMG for panel data that was related to both the common and pool characteristics in every other case. Even if the coefficients of regressors are the same across countries, the Pooled way organization technique lets the intercepts, coefficients of short-run variables, and error models be different for each country. Even though the coefficients of the regressors are the same, this is still possible.

Findings and Discussion

This part of our consequences and discussion specifies the findings of descriptive records. The descriptive records are employed to demonstrate the overall description of the used information set in detail. We illustrated that the implication of the logarithmic of nitrous oxide emission in the mean is 3.880.

Table 1

Descriptive Statistics

	N ₂ O	GDP	RNE	TP
Mean	3.880	1.546	3.807	3.711
Median	3.742	1.861	1.357	4.486
Maximum	4.826	6.868	16.448	15.353
Minimum	3.526	-9.693	0.577	-16.765
Std. Dev.	0.362	2.375	3.750	5.855
Skewness	1.609	-1.801	1.464	-1.036
Kurtosis	1.609	-1.801	1.464	-1.036
Jarque-Bera	109.634	353.599	97.160	58.733
Probability	0.000	0.000	0.000	0.000

The largest and bottom values of nitous oxide are 4.826 and 3.526, respectively. The gross domestic product average price is 1.546, with a maximum and minimum value are 6.868 and -9.693, respectively. The average implies the price of the renewable strength is 3.807, and maximum and minimum values are 16.448 and 0.577, respectively. The common value of environmental sustainability is 1.188, and the widespread deviation is 2.169, whereas the most and the minimum values are 7.587 and -7.369, respectively. The average price of greenhouse gases is 5.978, and the most and minimal values are 6.836 and 5.600, respectively, while the same old deviation is zero.367. The average fee for renewable power is 3.807, while the deviation is 3.750. Subsequently, the mean fee of the trade openness is three.7110, and the most and minimum values are 15.353 and -16.7650, respectively.

The effects of unit root exams are indexed in Table 2. It is mandatory to analyze the unit root of every variable earlier than making use of the ARDL version if any of the utilized variables isn't always desk-bound at the second difference I(2); otherwise, the findings will result in suspicious effects. Similarly, greater findings of the Levin– Lin–Chu unit root check illustrate that decline of surroundings, GDP, Environmental sustainability, and trade openness have unit roots at degree while other variables are desk-bound at first distinction. The investigated findings of the Harris–Tzavalis unit root check illustrate that Environmental sustainability and exchange openness are unit root at stage whilst the Nitous oxide, GDP, greenhouse gases, and renewable power are at the start difference I(1).

Table 2

Panel Unit Root Test

			GDP	N ₂ O	RNE	TP
LLC	At Level	Intercept	0.83967 (0.7995)	0.67241 (0.7493)	3.88771 (0.9999)	-2.65739 (0.0039)
		Inter and Trend	0.62875 (0.7352)	-2.29549 (0.0109)	0.08022 (0.5320)	-4.00281 (0.0000)
	First Difference	Intercept	-1.13966 (0.1272)	-2.64763 (0.0041)	-5.23089 (0.0000)	-6.90591 (0.0000)

IPS	At Level	Inter and Trend	-0.69876 (0.2424)	-1.95697 (0.0252)	-6.03860 (0.0000)	-4.80726 (0.0000)
		intercept	-3.91365 (0.0000)	0.85961 (0.8050)	6.23183 (1.0000)	-5.18874 (0.0000)
	First difference	Inter and Trend	-4.31408 (0.0000)	-0.46860 (0.3197)	1.91714 (0.9724)	-5.42633 (0.0000)
		intercept	-8.51254 (0.0000)	-3.82756 (0.0001)	-5.53686 (0.0000)	-10.8285 (0.0000)
ADF	At Level	Inter and Trend	-7.01712 (0.0000)	-2.53466 (0.0056)	-6.45813 (0.0000)	-9.52465 (0.0000)
		intercept	43.1101 (0.0001)	11.0172 (0.6847)	2.05402 (0.9999)	55.1091 (0.0000)
	First Difference	Inter and Trend	45.0605 (0.0000)	16.2903 (0.2960)	8.66021 (0.8522)	54.1450 (0.0000)
		Intercept	93.0613 (0.0000)	41.1787 (0.0002)	59.9394 (0.0000)	120.579 (0.0000)
PP	At Level	Inter and Trend	70.2483 (0.0000)	30.0120 (0.0076)	64.9551 (0.0000)	96.9061 (0.0000)
		Intercept	46.2186 (0.0000)	14.2525 (0.4311)	4.75163 (0.9890)	79.3014 (0.0000)
	First difference	Inter and Trend	44.0868 (0.0001)	17.5723 (0.2270)	8.75768 (0.8463)	84.2741 (0.0000)
		Intercept	148.560 (0.0000)	90.1411 (0.0000)	119.777 (0.0000)	235.878 (0.0000)
		Inter and Trend	242.056 (0.0000)	79.7347 (0.0000)	595.384 (0.0000)	1203.15 (0.0000)

Furthermore, desk five indicates the findings of the Kao and Pedroni cointegration exams, respectively. The investigated findings of Kao cointegration take a look at and illustrate that cointegration exists among the regressand and regressors throughout G7 nations. The findings show that both test values of Kao and Pedroni cointegration are extensive and endorse that cointegration exists between the chosen variables.

Table 3 demonstrates the findings of Panel cointegration tests to investigate the effect of renewable energy, GDP, and trade openness on N₂O emission in G-7 countries. The outcomes of GDP display a statistical impact on the environmental decline in the end, whilst, within the brief run, the investigated outcomes display that it has a fantastic and non-extensive effect on environmental pollution.

Table 3

Panel co-integration tests

	Statistic	P value
Kao cointegration test		
Modified Dickey-Fuller t	- 2.6355	0.0019
Dickey-Fuller t	- 3.1473	0.0067

Augmented Dickey-Fuller t	- 3.6593	0.0101
Unadjusted modified Dickey-Fuller t	- 4.7359	0.0092
Unadjusted Dickey-Fuller t	- 4.1748	0.0017
Pedroni cointegration test		
Modified Phillips-Perron t	2.8462	0.0501
Phillips-Perron t	- 3.9536	0.0014
Augmented Dickey-Fuller t	- 3.9938	0.0105

The investigated outcomes show that, ultimately, a 1% boom in renewable energy inflow in the above-cited G-7 countries helps to reduce the environmental decline by about 0.0049% in the end. It is suggested that nations promote the use of renewable energy by offering tax exemptions and other financial incentives to encourage local and foreign investors to invest in modern power projects, such as solar energy, and to slow the

environmental deterioration within the host nations, namely the G7 countries. Our conclusions differ from those of (Paramati et al. 2016) in terms of their implications. In another study by (Shahbaz et al. 2018), Hafiza, Rahman, Sadiq, Manzoor, Shoukat, & Ali (2023), Zahra, Nasir, Rahman, & Idress. (2023) and (Khan et al. 2022b) revealed that the environmental decline is unquestionably influenced by GDP.

Table 5

Results for PMG estimator

Variable	Coef.	Std. Err.	t value	P value
Long-run coefficients				
GDP	0.25004*	0.07868	3.17796	0.0019
RNE	0.7593**	0.10534	0.720781	0.4726
TP	0.6713***	0.02891	2.32157	0.0221
Short-run coefficients				
ECT	-0.165424	0.076752	-2.155293	0.0334
d(N2O(-1))	0.106172	0.077684	1.366707	0.1746
d(N2O(-2))	0.247285	0.074143	3.335266	0.0012
d(N2O(-3))	0.084626	0.106262	0.796391	0.4276
d(GDP)	-0.005338	0.002699	-1.977806	0.0505
d(GDP(-1))	-0.004593	0.003296	-1.393452	0.1664
d(RNE)	-0.003441	0.099173	-0.034702	0.9724
d(RNE(-1))	-0.004149	0.034796	-0.119241	0.9053
d(TP)	0.001039	0.000413	2.516681	0.0133
d(TP(-1))	2.429432	0.000192	0.126341	0.8997

In Table 5, the findings of the panel ARDL confirm that a significant and positive relationship exists between economic growth (GDP) and Nitrous oxide (N₂O) emission in G-7 countries in the long run and short run. These are aligned with studies by Ahmed, Wang, Mahmood, Hafeez, & Ali (2019); Sinha, Gupta, Shahbaz, and Sengupta (2019). Khan, Afridi, Shad, Rahman, (2022); Bilal, Shah, Rahman, Jehangir, (2022);

Khoula, Rahman, Idress, (2022); Zulfiqar, Ansar, Ali, Hassan, Bilal, & Rahman, (2022).

A panel of G7 nations' ecological emissions is reduced by the use of renewable energy. The results show that in the long run, nitrous oxide (N₂O) emissions will increase by around 0.7593% for every 1% increase in renewable energy use. The results demonstrate that the impact of using renewable energy, in the long run, is significant.

However, in the short run, the impact is considerably less than in the long run. In the short run, the utilization of renewable energy reduces nitrous oxide emissions by about 0.1061%. These are aligned with the previous studies of Sharma, Sinha, & Kautish (2021); Munir & Riaz (2022); Salahuddin, Alam, Ozturk, Sohag, (2018); Wang, Wang, Wei, & Li (2018). Rahman, & Bakar, (2019); Rahman, & Bakar, (2019); Rahman, Bakar, & Idrees, S. (2019). Younas, Idrees, & Rahman (2021); Li, Bai, Yu, Meo, Anees, & Rahman, (2022); Zhu, Fang, Rahman, & Khan, (2021);

These results are consistent with those found by Dogan and Seker (2016), who studied environmental decline in advanced economies. It has been demonstrated that using renewable sources of energy has a favorable effect on the environment. At the same time, the adoption of non-renewable sources of energy was found to increase pollution. Researchers Jebli et al. (2016) found that whereas using conventional energy sources was associated with worsening environmental conditions, switching to renewable energy sources had the opposite effect. Similar findings were found by (Shafiei et al. 2014), who all demonstrated that using renewable energy lessens negative ecological impacts in specific economies. (Usman et al. 2022; Chaudhary, Nasir, Rahman, & Sheikh, 2023; Shahzadi, Sheikh, Sadiq, & Rahman, 2023) did a recent study in Pakistan that looked at the uneven impacts of energy usage on environmental degradation. The study's authors concluded that Pakistan's transition to renewable energy sources had slowed the country's environmental degradation.

Furth more, the outcomes show that trade openness (TP) in the G-7 countries has a favorable and significant impact on nitrous oxide (N₂O) in the long run as well as in the short run. The results indicate that a 1% increase in trade openness (TP) will lead to a rise in nitrous oxide (N₂O) emissions in the long run, about 0.6713%. These are consistent with earlier research of Ali,

Rahman, & Anser (2020); Sarwar, Ali, Bhatti, & Rahman (2021); Rahman, Chaudhry, Meo, Sheikh, & Idrees, (2021); Shafique, Rahman, Khizar, Zulfiqar, (2021); Hassan, Sheikh, & Rahman, (2022);

Conclusion

Energy consumption increases gradually, which results from our environment declining day by day due to the increase of harmful gasses. This study the relationships between renewable energy, GDP, and trade openness on CO₂ emission in G-7 nations. Using the Panel ARDL technique, the outcomes of the study affirm that trade openness and GDP have a positive and significant relationship with N₂O emissions in a group of seven economies. However, the coefficient of renewable sources of energy (RNE) exhibited a positive and insignificant association with N₂O emission in the long run. Based entirely on the research studies, it has been found that trade openness and economic growth in the form of GDP are the main causes of the environmental decrease in the examined countries. When compared to conventional electricity production, which involves using fuel, coal, and gasoline oil, effective smooth power resources for strength production, such as biomass, wind energy, hydropower, and solar energy, can more effectively meet environmental regulations and guidelines. Additionally, policymakers and the government should encourage foreign investors to fund projects related to smooth power generation in order to improve their relationships with advanced and knowledgeable nations that offer such resources.

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