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EXAMINING THE EFFECT OF GEOPOLITICAL RISKS ON RENEWABLE ENERGY CONSUMPTION IN OECD COUNTRIES

Abstract

As urgent actions are required to accelerate the transition to a more environmentally friendly energy sector and global economy, the rising geopolitical risks defined as any tensions that disrupt the peace of local and international relations pose greater uncertainty to the rapid renewable energy deployment in supporting the carbon-neutrality ambitions. Thus, this paper investigates the influence of geopolitical risks on renewable energy consumption in OECD countries over the period 1970–2022 to address potential estimation biases from ignoring recent events such as COVID-19 and the ongoing Russia-Ukraine war. The paper applies a system GMM to a cross-country panel dataset while controlling for per capita income, carbon dioxide (CO2) emissions, economic globalization, and natural resource rents to deal with all possible sources of endogeneity. The results show that geopolitical risks reduce the consumption of renewable energy, with a magnitude of 0.22 percentage points. In addition, CO2 emissions and natural resource rents adversely affect the amount of renewable energy consumption. However, economic growth and globalization promote the demand for renewable energy. Therefore, the empirical findings suggest that geopolitical risks play a crucial role in the consumption of renewable energy.

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INTRODUCTION

Climate change poses not only a significant challenge to economic activities and human life but also acts as a driver of instability and conflict. These adverse effects of climate change call for urgent global efforts to address human-induced climate change that is attributed to an increasing use of fossil fuels for socioeconomic activities. The fossil-based activities have significantly contributed to a rise in CO2 emissions that drive climate change, which leads to global warming (Zhao et al., 2023; Nordhaus, 2019). Therefore, the transition from fossil fuels to renewable energy, which emits almost zero CO2 emissions, is considered a pragmatic step to mitigate and adapt to climate change (Shang et al., 2022; Ji & Zhang, 2019). This calls for adequate renewable energy investment to achieve the carbon-free energy transition. An effective and efficient response to fulfill this investment need requires a better understanding of potential drivers of renewable energy use.

While extensive studies have been conducted to examine the determinants of renewable energy consumption, scanty research that considers the role of geopolitical risk remains inconclusive. In addition, the recently heightened geopolitical tensions are increasingly relevant to addressing energy security issues, especially among OECD countries

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that are heavily energy-import dependent. Thus, the need to fill this research vacuum becomes critical to understand whether these energy security issues might be prioritized at the expense of rapid renewable energy deployment required to achieve the carbon-neutrality target or emphasize the security benefits of renewables.

1. LITERATURE REVIEW

The literature takes two broad views on the influence of geopolitical risks on renewable energy. The first view focuses on the supply-side effects of geopolitical risk, while the second view relies on its demand-side effects. From the supply-side perspective, geopolitical risks such as conflicts, terrorism, and wars, raise renewable investment costs for both private and government sectors (Gozgor et al., 2022; Bilgin et al., 2020) and also reduce the management efficiency of public sources (Wang et al., 2022). On the other hand, the demand-side perspective states that geopolitical risk increases living costs, invariably leading to spending reductions on renewable energy to meet the necessities of life (Alsagr & Van Hemmen, 2021).

The Russia-Ukraine war has caused high fossil fuel prices, thus stimulating renewable energy investments, especially for advanced economies to reduce fossil fuel consumption in the long run (Song et al., 2019). Thus, this reality contradicts the above-mentioned theoretical views. In addition, empirical literature remains inconclusive about the reality. For instance, Alsagr and Van Hemmen (2021) found a positive effect of geopolitical risk on renewable energy use when applying a dynamic panel technique to a dataset of 19 developing economies over the period 1996–2015. In the same vein, Sweiden (2021a) established the positive relationship between geopolitical risks and renewable energy deployment using a panel dataset of 10 net crude oil importer developing countries for the period 1985–2017 and quarterly data for the US context from 1973 to 2020 (Sweiden, 2021b).

However, Flouros et al. (2022) found a negative impact on renewable energy production between 1985 and 2018. A negative effect on renewable energy demand is also found for the sample of 20 OECD countries using a system generalized method of moments (GMM) approach (Zhao et al., 2023). Furthermore, Liu et al. (2023) found a negative influence of increased geopolitical risks on the US renewable energy projects while implementing a vector autoregressive (VAR) technique on a monthly dataset. Combining the sample of developed and emerging economies for the period from 1990 to 2018 into a panel regime switching estimation setting, Cheikh and Zaied (2023) found that the magnitude of the influence of geopolitical risks on renewable energy deployment depends on the stage of economic development. Implementing an instrumental variable method in a bilateral trade framework, Hille (2023) established that geopolitical risks in fossil fuel exporting countries promote renewable energy development in Europe from 1991 to 2021. However, Sarker et al. (2023) found an increased influence of geopolitical risks on the returns of clean energy prices in the short run while turning to a negative impact in the long run.

In summary, the literature provides mixed results on how geopolitical risks influence renewable energy. In addition, sample periods in the literature do not cover the most recent events, such as COVID-19 and the 2022 Russia-Ukraine war. Thus, this paper contributes to the prior research by testing the following hypotheses:

H1: *Geopolitical risk affects renewable energy consumption either positively or negatively.*

H2: *Recent events such as COVID-19 and the Russia-Ukraine war have influenced the magnitude of geopolitical risk effects on the demand for renewable energy.*

2. METHOD

This paper examines the effect of geopolitical risk on renewable energy consumption while allowing for per capita income, CO2 emissions, economic globalization, and natural resource rents as the control variables. It develops a cross-country panel model for 20 OECD countries over the sample period from 1970 to 2022. In addition, it choos-

Table 1. Description of variables

Variable	Acronym	Unit	Data source
Renewable Energy Consumption	REC	Exajoules	British Petroleum (2023)
Geopolitical Risks	GPRI	Index	Caldara and Iacoviello (2022)
Carbon Dioxide Emissions	CO2	Million Tonnes	British Petroleum (2022)
Economic Globalization	EGI	Index from 0 to 100	Gygli et al. (2019)
Natural Resources Rents	NATRES	Percentage of GDP	World Bank (n.d.)
GDP per Capita	GDPC	Current US Dollar	World Bank (n.d.)

es these countries to ensure a better comparison with the prior research (Zhao et al., 2023). In the cross-country panel renewable energy use model, the study utilizes renewable energy consumption as a dependent variable, retrieving data from British Petroleum (2023) as presented in Table 1. This variable is measured in exajoules. The key independent variable is geopolitical risk proxied by the geopolitical risk index of Caldara and Iacoviello (2022).

GDP per capita is proxied by GDP per capita in constant 2015 US dollar. Natural resource rents, defined as a percentage of gross domestic product, are taken as a proxy for the contribution of natural resources (i.e., coal, oil, natural gas, minerals, and forest) to economic output. The data are obtained from the World Development Indicators (WDI) datasets of the World Bank (n.d.). Environmental degradation is captured by carbon dioxide emissions in a million tons (CO2), which is collected from British Petroleum (2022), while economic globalization is proxied by Gygli et al. (2019)'s economic globalization index. These variables are also included as control variables. The summary of these variables and their data sources are shown in Table 1.

The study transforms CO2 emissions, economic globalization, and GDP per capita into a natural logarithm (*LN*) form to reduce the scale effect and heterogeneity in the data series. This logarithmic transformation is not applied to renewable energy consumption, geopolitical risks, and natural resource rent because of their small values and percentage forms (Zhao et al., 2023). Therefore, the panel regression model of renewable energy consumption is expressed in a semi-logarithm.

Before the model specification, the study checks the potential existence of multicollinearity through correlation analysis. As can be observed in Table 3, the results show a high correlation between geopolitical risk and CO2 emissions and between GDP per capita and economic globalization. Thus, the paper addresses the problem of multicollinearity by constructing four models. Model 1 includes all variables while estimating the OECD countries' renewable energy consumption. Then, the paper excludes GDP per capita in Model 2, economic globalization in Model 3, and CO2 emissions in Model 4 while implementing the estimation.

Model 1:

$$REC_{it} = \beta_{1,0} + \beta_{1,1}GPRI_{it} + \beta_{1,2}LNCO2_{it} + \beta_{1,3}LNEGI_{it} + \beta_{1,4}NATRES_{it} + \beta_{1,5}LNGDP_{it} + \varepsilon_{it}, \quad (1)$$

Model 2:

$$REC_{it} = \beta_{2,0} + \beta_{2,1}GPRI_{it} + \beta_{2,2}LNCO2_{it} + \beta_{2,3}LNEGI_{it} + \beta_{2,4}NATRES_{it} + \mu_{it}, \quad (2)$$

Model 3:

$$REC_{it} = \beta_{3,0} + \beta_{3,1}GPRI_{it} + \beta_{3,2}LNCO2_{it} + \beta_{3,3}LNGDP_{it} + \beta_{3,4}NATRES_{it} + \omega_{it}, \quad (3)$$

Model 4:

$$REC_{it} = \beta_{4,0} + \beta_{4,1}GPRI_{it} + \beta_{4,2}LNEGI_{it} + \beta_{4,3}LNGDP_{it} + \beta_{4,4}NATRES_{it} + \xi_{it}, \quad (4)$$

where β_s denotes regression parameter coefficients, while subscripts *i* and *t* represent the cross-section country and year, respectively. ε_{it}, μ_{it}, ω_{it}, and ξ_{it} are error terms in Model 1, Model 2, Model 3, and Model 4. These errors are assumed to be normally distributed (i.e., the zero mean and the constant variance).

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2.1. Estimation procedures

2.1.1. *Cross-sectional dependence tests*

The assumption of cross-sectional independence among the error terms is empirically found to be invalid, especially in a panel data set (Chudik & Pesaran, 2015; Sarafidis & Wansbeek, 2012). This is due to the global connections among countries. For instance, economic uncertainty in one country can influence the economic activities of other countries. Given this fact and potentially unreliable estimates from ignoring the cross-sectional dependence (CD), the study performs cross-sectional dependence tests such as Lagrange Multiplier (Breusch & Pagan, 1980), Scaled Lagrange Multiplier and Cross-Dependence (Pesaran, 2021), and Bias-corrected Scaled Lagrange Multiplier (Baltagi et al., 2016).

2.1.2. *Cross-sectionally dependent panel unit root test*

The paper utilizes the cross-sectional augmented Im-Pesaran-Shin (CIPS) test proposed by Pesaran (2007) to provide more reliable and consistent results for its panel data. Given the presence of cross-sectional dependencies across the panel, it investigates the integrating characteristics of the chosen variables. Using cross-sectional augmented Dickey-Fuller (CADF) test statistics specified in (5), it obtains the CIPS results following the approach of Zhao et al. (2023):

$$\Delta y_{it} = \alpha_i + \beta_1 y_{i,t-1} + \delta_i \bar{y}_{t-1} + \sum_{j=0}^{p} \theta_{ij} \Delta \bar{y}_{t-j} + \sum_{j=1}^{p} \mu_{ij} \Delta y_{i,t-j} + \varepsilon_{it}, \quad (5)$$

where y_t represents the cross-section average. Then, it presents the CIPS statistics as follows:

$$CIPS = \frac{1}{N} \sum_{i=1}^{n} CADF_i. \quad (6)$$

2.1.3. *Tests for cointegration*

Owing to the presence of a mixed integration order, the paper performs a cointegration test as a necessary condition for implementing long-run panel econometric techniques. Using the second-generation cointegration test, the paper provides reliable long-run relationships between the explained and the explanatory variables even in the presence of cross-sectional dependence. Then, it implements different cointegration tests introduced by Kao (1999), Pedroni (2002, 2004), and Westerlund (2008), with the null hypothesis of no cointegration.

2.1.4. *Long-run panel system GMM*

Having established the presence of the long-run relationship, the paper applies the panel system GMM to examine the link between renewable energy consumption, geopolitical risks, per capita income, CO2 emissions, natural resource rents, and economic globalization. Its panel GMM provides the direction and size of estimated coefficients related to this link, as common in different long-run estimation techniques. The significance of these estimated coefficients is known through their probability values and is expected to be less than the probability of 5%. Unlike the standard panel estimation techniques, such as fixed effects and random effects, the GMM system helps address the issue of endogeneity while allowing for country-specific effects in the renewable energy consumption model. Given these advantages, the panel system of GMM is implemented using the standard econometric specification of Arellano and Bover (1995) and the orthogonal deviations of Blundell and Bond (1998).

3. RESULTS

3.1. Preliminary analyses

Table 2 presents descriptive statistics for the concerned variables. The distributions of these variables, except for economic globalization, are positively skewed. In addition, all the variables, except for economic globalization and per capita income, have a mean that exceeds the median. The highest volatility is attributed to per capita income, while renewable energy consumption has the second lowest volatility, as measured by their standard deviations. Geopolitical risk has the lowest standard deviation among the independent variables, followed by natural resource rent. The observed heterogeneous scale for these variables provides justification for transforming them into a natural logarithm (*LN*) to reduce the scale effect on its coefficient estimates.

Table 2. Descriptive statistics

Statistic	REC	GPRI	CO2	EGI	NATRES	GDPC
Mean	0.225	0.287	530.6	61.89	1.842	28,824
Median	0.033	0.088	211.2	64.74	0.520	29,232
Maximum	8.427	4.679	5884	89.71	17.24	79,638
Minimum	0.000	0.000	14.89	25.63	0.011	2,410
Std. Dev.	0.670	0.628	1083	15.93	2.750	16,247
Skewness	7.125	4.004	3.731	–0.292	2.191	0.365
Observations	1060	1060	1060	1040	1040	1049

Note: REC: Renewable energy consumption, GPRI: Geopolitical risk index, CO2: Carbon dioxide emissions, EGI: Economic globalization index, NATRES: Natural resources rents, and GDPC: Per capita income.

Table 3. Pairwise correlations

Variable	REC	GPRI	CO2	EGI	NATRES	GDPC
REC	1					
GPRI	0.512***	1				
CO2	0.580***	0.929***	1			
EGI	0.149***	–0.073**	–0.094***	1		
NATRES	–0.118***	–0.098***	–0.101***	–0.223***	1	
GDPC	0.310***	0.197***	0.226***	0.686***	–0.061*	1

Note: **p*-value < 0.10, ***p*-value < 0.05, ****p*-value < 0.00. REC: Renewable energy consumption, GPRI: Geopolitical risk index, CO2: Carbon dioxide emissions, EGI: Economic globalization index, NATRES: Natural resources rents, and GDPC: Per capita income.

Table 3 reports a highly significant correlation between the independent variables and renewable energy consumption. With the exception of natural resource rent, all other explanatory variables are positively correlated with renewable energy demand. The magnitude of their correlations is below 0.6 except for the correlation between geopolitical risk and CO2 emission and between per capita income and economic globalization. These high correlations between these variables indicate the possible problem of multicollinearity. Thus, this multicollinearity issue is addressed by estimating three additional restricted models that exclude per capita income, economic globalization, or CO2 emissions.

3.2. Cross-sectional dependence and panel unit root test

The result of the cross-sectional dependence tests in Table 4 reveals that the implemented four tests' statistics are statistically significant, thus suggesting cross-sectionally dependence for each of the variables. This indicates that a geopolitical conflict in one member of these 20 OECD countries affects the geopolitical positions of its peers. This finding is not surprising because of the strong connections among the countries. Therefore, the study employs second-generation unit root tests, such as the CIPS panel unit root test, that allow for cross-sectional dependence while testing the stationarity of each variable.

Table 4. Cross-sectional dependence (CD) tests

Variable	Breusch-Pagan LM	Pesaran Scaled LM	Bias-corrected Scaled LM	Pesaran CD
REC	8877***	445.6***	445.4***	94.10***
LNGDPC	9446***	474.8***	474.7***	97.16***
LNCO2	4378***	214.9***	214.7***	15.98***
LNEGI	8729***	438.1***	437.9***	93.34***
NATRES	2870***	137.5***	137.3***	35.62***
GPRI	1261***	54.96***	54.77***	26.04***

Note: ****p*-value < 0.01. REC: Renewable energy consumption, GPRI: Geopolitical risk index, CO2: Carbon dioxide emissions, EGI: Economic globalization index, NATRES: Natural resources rents, and GDPC: Per capita income.

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The CIPS test statistics in Table 5 reveal the mixed integrating order (i.e., I(0) or I(1)) among the variables. While geopolitical risks, per capita income, and economic globalization are stationary at I(0), renewable energy consumption, CO2 emissions, and natural resource rents are stationary after taking their first differences, i.e., I(1). This implies that any shock to the long-run value for each variable will not lead to another permanent value in the long-run.

Table 5. CIPS unit root test

Variable	I(0)	I(1)
REC	–1.859	–3.625***
LNGDPC	–2.679***	
LNCO2	–1.670	–6.068***
LNEGI	–2.607***	
NATRES	–1.829	–5.791***
GPRI	–3.884***	

Note: ****p*-value < 0.01. REC: Renewable energy consumption, GPRI: Geopolitical risk index, CO2: Carbon dioxide emissions, EGI: Economic globalization index, NATRES: Natural resources rents, and GDPC: Per capita income.

3.3. Panel cointegration tests and baseline panel system GMM estimations

The study tests the assumption of a long-run relationship by checking the presence of cointegration. The cointegration results in Table 6 reject the null hypothesis of no cointegration in all the models. Therefore, a long-run relationship is established among the variables. Then, the study proceeds to estimate its long-run panel system GMM renewable energy consumption model to identify the directions and magnitude of the relationships between the variables.

Table 7 reports the estimated regression coefficients for the four models. The coefficient of geopolitical risk is statistically significant and negative, suggesting that increased geopolitical risk in 20 OECD countries over the period 1970–2022 reduces renewable energy consumption in all the models. This finding confirms renewable energy literature with a higher magnitude of about –0.384 in Model 1, compared to –0.027 and –0.167 found by Wang et al. (2024) and Zhao et al. (2023), respectively. In the same vein, the results show a significant negative impact of carbon dioxide emissions on renewable energy consumption. This implies that degrading environmental quality through emitting more carbon lowers renewable energy consumption. For instance, a 1% rise in carbon dioxide emissions leads to a 0.35% drop in renewable energy consumption on a sample average, holding other factors constant. Put differently, the more polluted a country is, the less renewable energy is consumed.

However, a positive significant influence of economic globalization on the demand for renewable energy is established in the estimated long-run models. For example, a 1% increase in economic globalization stimulates renewable energy consumption by about 0.75% on a sample average, while other factors remain unchanged. As economic globalization encourages more economic cooperation, this would support technical know-how and investment for faster renewable energy deployment. Similarly, the result indicates a significant and positive impact of per capita income on renewable energy consumption. This implies that a 1% rise in GDP per capita promotes demand for renewable energy by 0.10% on a sample average, holding other factors constant. This finding is

Table 6. Panel cointegration tests

Test	Model 1	Model 2	Model 3	Model 4
Westerlund test (Westerlund, 2008)				
Variance Ratio	6.824***	4.038***	4.946***	5.652***
Pedroni test (Pedroni, 2002, 2004)				
Modified Phillips-Perron t	6.849***	6.103***	6.611***	8.106***
Phillips-Perron t	9.018***	8.560***	9.412***	12.726***
Augmented Dickey-Fuller t	9.683***	9.603***	10.026***	14.116***
Kao test (Kao, 1999)				
Modified Dickey-Fuller t	9.585***	9.605***	9.452***	9.636***
Dickey-Fuller t	15.156***	14.196***	14.389***	15.709***
Augmented Dickey-Fuller t	12.449***	11.634***	11.932***	12.821***
Unadjusted Modified Dickey-Fuller t	8.963***	8.891***	8.823***	8.994***
Unadjusted Dickey-Fuller t	17.099***	16.578***	16.460***	17.746***

Note: *** *p*-value < 0.01.

Table 7. Results from panel system GMM estimations

Variable	Model 1	Model 2	Model 3	Model 4
GPRI	−0.384***	−0.377***	−0.410***	−0.409***
	(0.083)	(0.084)	(0.084)	(0.085)
LNCO2	−0.350***	−0.348***	−0.281***	
	(0.056)	(0.056)	(0.054)	
LNEGI	0.749***	1.134***		0.491***
	(0.158)	(0.084)		(0.156)
NATRES	−0.027***	−0.023**	−0.033***	−0.029***
	(0.010)	(0.009)	(0.010)	(0.010)
LNGDPC	0.101***		0.242***	0.099***
	(0.035)		(0.019)	(0.036)

Note: * *p*-value < 0.10, ***p*-value < 0.05, ****p*-value < 0.01. GPRI: Geopolitical risk index, CO2: Carbon dioxide emissions, EGI: Economic globalization index, NATRES: Natural resources rents, and GDPC: Per capita income.

theoretically expected because OECD governments are relatively rich in providing huge investments in renewable energy. In addition, their excessive dependence on fossil fuels poses a climate change threat, thus providing incentives for adopting renewable energy in their production and consumption.

However, a negative significant impact of natural resource rent on renewable energy consumption is found as theoretically expected. This indicates that a 1% increase in natural resource rent retards renewable energy demand by 0.03% on a sample average, holding other factors constant. Thus, it suggests the more a country depends on natural resources (i.e., oil, coal, and minerals) to drive its economic activities, the less the country shifts its consumption toward renewable energy.

Overall, the empirical results provide consistent and reliable geopolitical risk estimates and directions that are robust to all different specifications. Therefore, these findings suggest evidence-based recommendations for the policymakers and governments in OECD countries to develop effective strategies for mitigating geopolitical risks.

The results indicate that geopolitical risks negatively affect renewable energy consumption, with the higher size effect due to recent events such as COVID-19 and the Russia-Ukraine war.

4. DISCUSSION

The empirical findings indicate that geopolitical risks reduce renewable energy consumption. This is consistent with prior research that established the severe influence of geopolitical conflicts on renewable consumption (Wang et al., 2024; Zhao et al., 2023) but contrasts the positive influence found in the context of net oil-importing countries (Sweidan, 2021a), the United States (Sweidan, 2021b), and emerging economies (Alsagr & van Hemmen, 2021). Reasons for this evidence might be a result of the following. First, most of these OECD countries face the challenges of high energy import and limited renewable energy technology; thus, these issues amplify geopolitical tensions and retaliations. In the presence of high geopolitical tensions, technology collaboration to support domestic production of renewable energy is hindered. Second, increasing geopolitical tensions constrain countries from using their financial resources on readily available fossil fuels to satisfy their immediate needs rather than spending on renewable energy innovation, which requires massive investment.

In the same vein, CO2 emissions show a significant negative impact on renewable energy consumption. This finding points to the literature fact that more polluting economies deploy less renewable energy (Zhao et al., 2023). The negative effect of natural resource rent is also consistent with the empirical literature (Wang et al., 2024) that an increase in the natural resource rent promotes more extraction of fossil fuels in order to boost the economic output. However, the positive influences from GDP per capita and economic globalization align with Zhao et al. (2023) and Gozgor et al. (2020), who reinforce the positive influence of economic development and globalization on the demand for renewable energy in OECD countries.

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CONCLUSION

This paper extends the existing research on how geopolitical risks influence renewable energy consumption, which is needed to address climate change resulting from the rising fossil-based CO2 emissions. The study applies a panel system GMM for 20 OECD countries over the sample period 1970–2022 to address inappropriate policy recommendations from ignoring recent events such as the ongoing Russia-Ukraine war and omitting relevant drivers of renewable energy consumption. The results reveal the higher effect of geopolitical risk on reducing renewable energy consumption compared to the prior research, thus posing a great challenge to climate change mitigation policies. CO2 emissions retards renewable energy deployment as the OECD countries depend more on fossil fuels. However, economic development and globalization promote demand for renewable energy, compared to the negative influence of natural resource rents. Therefore, addressing climate change through renewable energy consumption calls for boosting economic development and economic globalization, mitigating the rising CO2 emissions, and diverting natural resource rents to support renewable energy investment.

The following crucial and timely policy recommendations can be drawn from the empirical findings. First, the OECD countries' actions complementary to the global efforts should focus on encouraging peaceful existence among countries, groups, and regions. This harmony would fast-track the required pace of renewable energy to meet the ambitions of decarbonization. Second, OECD governments should ensure appropriate strategies to curtail rising pollution and CO2 emissions in order to promote the rapid deployment of renewable energy. Third, the stimulation of economic development and economic globalization in OECD countries would substantially drive renewable energy consumption. This suggests a growth-oriented open economy is a quick stimulus for the clean energy transition.

This study can be extended further to include both developed and developing economies. Future research can also use this suggested global dataset to allow for heterogeneity across countries over the periods. It is also interesting to examine the short and long-run impact of geopolitical risks on demand for renewable energy.

AUTHOR CONTRIBUTIONS

Conceptualization: Saheed Bello, Yusuf Hassan.
Data curation: Saheed Bello.
Formal analysis: Saheed Bello.
Investigation: Saheed Bello, Yusuf Hassan.
Methodology: Saheed Bello, Yusuf Hassan.
Project administration: Saheed Bello, Yusuf Hassan.
Supervision: Saheed Bello.
Validation: Saheed Bello, Yusuf Hassan.
Visualization: Saheed Bello, Yusuf Hassan.
Writing – original draft: Saheed Bello, Yusuf Hassan.
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