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RESEARCH ARTICLE

Does the potency of economic globalization and political instability reshape renewable energy usage in the face of environmental degradation?

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Abstract

Since renewable energy is essentially non-carbohydrate in nature, it can generate little or no pollutants and can therefore help in achieving both sustainable development and environmental quality. In this regard, the question that continues to persist is whether economic growth, economic globalization, and political risk can potentially affect renewable energy in the presence of environmental deterioration. In this context, the current research provides evidence to support this theoretical context by investigating the impact of economic globalization, economic growth environmental degradation, and political risk, on the usage of renewable energy in Vietnam using a dataset spanning the period between 1984 and 2019. For empirical analysis, the dynamic autoregressive distributed lag approach is utilized. Based on our analysis, economic growth positively impacts renewable energy in the long and short term. Economic globalization also positively affects renewable energy in the long term, but a neutral impact is uncovered in the short term. Political risk and environmental degradation are adversely related to renewable energy in the short and long run. The findings from the frequency domain approach reveal a causal interaction from political risk to renewable energy, and from renewable energy to economic globalization, whereas a feedback causal interaction is discovered between renewable energy and environment degradation, as well as between economic growth and renewable energy. From a policy standpoint, we propose that the Vietnamese policymakers need to consider economic globalization as a renewable energy promotion tool via capital inflow, foreign direct investment, and technological transfer.

Keywords Economic globalization · Political instability · Economic growth · Sustainable energy · Environmental degradation · Renewable energy

Abbreviations

SDG	Sustainable Development Goal
REN	Renewable energy
DARDL	Dynamic autoregressive distributed lag
FDI	Foreign direct investment
ED	Environmental degradation
LCV	Lower critical values
UCV	Upper critical values

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Introduction

The Sustainable Development Goal 8 (SDG 8), which is to attain sustainable growth, is considered crucial for enhancing and preserving global environmental and socioeconomic wellbeing, especially in the modern era. It is considered that the quantity and form of energy used to create national productivity commonly impact the potential to achieve SDG 8 (Anwar et al. 2021; Pan et al. 2022; Wu et al. 2022). The consequences of enhancing energy productivity are associated with significantly improved economic growth without causing a boost in energy-related issues like climate change (Akinsola et al. 2022; Adedoyin et al. 2021; Wang et al. 2023; Caglar et al. 2022). Concurrently, it is deemed that switching from fossil fuel energy to renewable energy is crucial for mitigating these energy-related issues as well as maintaining sustainable growth (He et al. 2021). The capacity of global renewable energy is predicted to expand by 50% between 2019 and 2024 (IEA 2019). Also, it is estimated that the percentage of renewable energy in the global electricity mix reached over 26.2% in 2019 (Ranalder and Gibb 2020). Meanwhile, the importance of promoting energy productivity and implementing renewable energy transitions for achieving sustainable growth has been widely discussed in the literature (Akadiri et al. 2022a; Al-Faryan et al. 2022; Alam and Murad 2020; Miao et al. 2022; Sunday Adebayo et al. 2022; Wu et al. 2022).

Strengthening the usage of renewable energy is also important in terms of achieving environmental protection obligations, particularly the Paris Agreement and SDGs. Obviously, energy is seen as a critical component of the UN's SDG roadmap (Adebayo 2022a, 2022b; Agyekum et al. 2022; Akadiri et al. 2022a, b; Kirikkaleli et al. 2022; Murshed et al. 2022a, b; Ojekemi et al. 2022). As a result, appropriate usage of energy sources is required to achieve various SDGs. For example, SDG 7 aims to attain ubiquitous accessibility to clean, cheap, and sustainable energy by 2030 (Shahzad et al. 2021) by expanding renewable energy usage into the global energy mix. Increasing the usage of renewable energy is therefore in line with attaining SDG 7. Likewise, increasing the usage of renewable energy can minimize emissions and assist in achieving SDG 13, which concentrates on taking holistic action to address environmental concerns. Recently, the United Nations Climate Change Conference (COP26) in Glasgow exposed some of the crucial issues relating to global warming and provided recommendations on how to make outstanding progress towards establishing a sustainable environment. One of such recommendation entails increasing renewable energy usage can help countries accomplish their obligations to reduce emissions in order to address global warming issues.

Given that renewable energy is anticipated to be the only sustainable solution in the future, it is important to identify the major drivers of renewable energy in order to provide direction to energy policy. However, beyond economic expansion and environmental deterioration as a determinant of renewable energy usage, the relevance of globalization for renewable energy consumption has also been found (Ibrahiem and Hanafy 2021; Rahman and Miah 2017; Irfan et al. 2022; Urom et al. 2022). Over time, the globalization process has accelerated, which has impacted the social, political, and economic aspect of any country. Meanwhile, there is conflicting evidence regarding the association between globalization and renewable energy, such that the impacts of globalization on renewable energy usage can be both beneficial and detrimental. Through the conduits of foreign trade, capital flows, and foreign direct investment (FDI), the increased economic globalization greatly improves the open economy's welfare (Adebayo 2022a; Ali and Malik 2021; Goyibnazarov et al. 2022; Alola et al. 2021; Du et al. 2022; Onifade et al. 2022; Ramzan et al. 2022). In essence, the pathway and intensity of the impacts of economic globalization on renewable energy are critical because they may have repercussions on environmental and foreign trade policy in developing economies.

The development of renewable energy necessitates high-level technology, while high-level technology requires large financial resources whereby multinational corporations may help to reshape renewable energy investments in a country via capital flow or foreign direct investment (FDI). The supply of input for the development or production of renewable energy technologies can be provided by trade. Hence, through the conduits of capital flow, foreign trade, and FDI, the process of economic globalization is a critical determinant of renewable energy development (Gozgor et al. 2020; Padhan et al. 2020). Hence, we anticipate that economic globalization is positively related with renewable energy. In the same vein, economic globalization can indirectly achieve sustainable economy and environmental quality through its crucial role in the development of renewable energy. The seminal work of Gozgor et al. (2020) investigated economies that have higher levels of economic globalization and economic performance. They concluded that economic globalization plays a critical role in enhancing renewable energy in these economies. Another study conducted by Padhan et al. (2020) established a different opinion regarding the effect of economic globalization on renewable energy for the same economies, thus generating conflicting outcomes. On the other hand, this raises an important question for both governments and policymakers in developing economies: how crucial is economic globalization for the development of renewable energy consumption in the twenty-first century? Inspired by our research question, we try to investigate the effect of economic globalization on renewable energy usage in Vietnam by researching the linkage between renewable energy usage and the extent of economic globalization. This is an important and current research challenge for developing nations, especially given the fact that the role of economic globalization towards economic development is vital.

Furthermore, apart from economic growth, environmental degradation, and economic globalization, the relevance of political risk on the usage of renewable energy needs to be determined, which has only been investigated in a limited number of studies such as Su et al. (2021). Other studies (such as (Appiah et al. 2022; Uzar 2020; Zhao et al. 2022)) have employed institutional quality, corruption, external and internal conflict, and investigated the effects of these indicators on renewable energy usage. For instance, a positive connection between institutional quality and renewable energy was found by Appiah et al. (2022), whereas the study of Uzar (2020) detected that institutional quality mitigates renewable energy. Furthermore, the work of (Zhao et al. 2022) established that the effect of external and internal conflict is adversely related to renewable energy. These studies only focused on a specific aspect of the political environment, while our investigation tries to bridge this gap by employing the political risk index, similar to Su et al. (2021). The political risk index includes 12 elements, which highlight the political context of an economy. These elements entail institutional quality, control of corruption, external and internal conflict, law and order, investment profile, democratic accountability, military in politics, quality of bureaucracy, religious tension, socio-economic conditions, ethnic tensions, and government stability. However, while the study of Su et al. (2021) employed a panel dataset, the effect of political risk on renewable energy in the case of a specific country was limited. This study attempts to bridge this gap in the literature by investigating the effect of political risk on renewable energy usage in Vietnam.

Against the backdrop of prior studies, which have ignored the effect of economic globalization and economic growth on renewable energy usage, and most interestingly, the role of political risk in shaping the consumption of renewable energy, this research's main objective is to determine the impact of economic globalization, political risk, environmental degradation, and economic expansion on renewable energy and fills a research gap by: 1) evaluating the impact of environmental degradation on renewable energy; 2) considering the effect of political risk and economic globalization as possible drivers of renewable energy; and 3) identifying the impact of economic growth on renewable energy. To achieve this aim, Vietnam has been selected and an annual dataset from 1984 to 2019 (36 observations) is employed. For the methodological perspective of the study, we employ the novel dynamic Autoregressive Distributed Lag (DARDL) to uncover the long and short-term impacts. As opposed to other econometric techniques, the DARDL technique can detect counterfactual changes in the regressors on the dependent variable. Furthermore, the causality pathway among the variables used is detected using the frequency domain approach proposed by Breitung and Candelon (2006). In contrast to the standard Granger causality test, this approach could predict the behavior of these variables at various time horizons. The findings of this study are intended to assist the Vietnamese' policymakers in adopting and implementing appropriate measures to enhance the usage of renewable energy production. As a result, these policies can be an effective approach for Vietnam to reshape its energy mix towards expanding the usage of renewable energy (SDG 7) and achieving sustainable growth and environmental quality (SDGs 8 and 13). The Fig. 1 presents the energy mix for Vietnam in 2019.

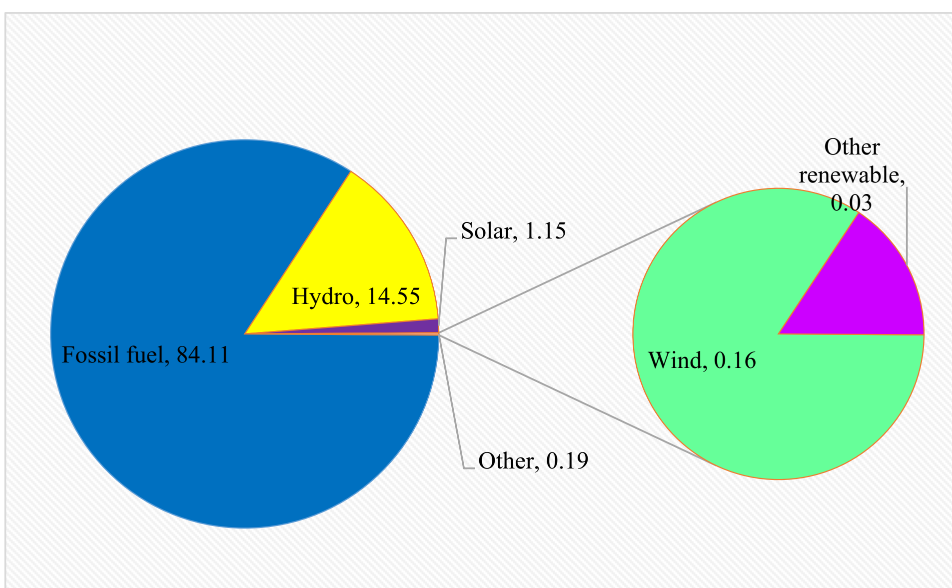


Fig. 1 Vietnam energy mix for 2019

The next section comprises a synopsis of the research. The "Model framework and data" section outlines the model construction and data. The "Methodology" section entails the methodology aspect of this study. The findings and discussion are presented in the "Result and discussions" section. The sixth section includes concluding remarks.

Literature review

Some extant research has emphasized some determinants that often boost renewable energy demand. As a result, this segment examines relevant research that has addressed the influence of economic globalization, political risk, economic growth, and environmental degradation on renewable energy in chronological order.

Economic globalization and renewable energy

Prior literature on renewable energy and economic globalization nexus are scant. For instance, Gozgor et al. (2020) probed into the association between renewable energy (REN) and economic globalization in OECD nations for the period between 1970 and 2015. The authors reported that economic globalization enhances REN in OECD economies. Conversely, the research of Padhan et al. (2020) applied the panel quantile regression of Machado and Santos Silva (2019) to investigate the connection between economic globalization and REN in OECD nations for the period between 1970 and 2015. They detected that economic globalization mitigates the usage of REN. However, several studies probed into the effect of globalization, FDI, and trade openness on REN usage. For instance, the study done in Bangladesh by Murshed et al. (2022a, b) looked into the influence of FDI on REN using the timeline spanning from 1972 to 2015. The authors detected that FDI helps to promote the growth in REN usage. However, Elheddad et al. (2022) found a conflicting outcome in Bangladesh using the quantile regression approach. Zhang et al. (2022) utilized the panel dataset of Belt and Road initiative economies; they examined the connection between globalization and REN for the period between 2001 and 2018. They detected that globalization accelerates REN usage in these economies. In another investigation on the globalization and renewable energy nexus, the study of Urom et al. (2022) utilized the non-linear ARDL approach using the dataset of the G-7 nations for the period from 1970 to 2015. Their empirical findings reported that the negative and positive shock in globalization increases REN in Japan and Italy, whereas, in the USA, Germany, and Canada, the positive and negative variation in globalization contributes to and mitigates REN usage, respectively. Samour et al. (2022) studied the connection between FDI and renewable energy in the United Arab Emirates for the period between 1989 and 2019. They found that the increasing usage and development of REN causes by FDI. Tiwari et al. (2022) inspected the effect of FDI and trade openness on REN in Asian economies for the timeframe from 2001 to 2019. Their findings concluded that trade openness mitigates REN while FDI increases REN.

Political risk and renewable energy

The research of Su et al. (2021) in OECD economies probed into the connection between political risk and REN for the period between 1990 and 2018. The authors employed the second-generation econometric approach such as CADF, CIPS, and CS-ARDL, which reported that political risk improves REN. Appiah et al. (2022) inspected the impact of institutional quality on REN in Sub-Saharan African economies for the period between 1990 and 2020. The authors' empirical outcome reported that the institutional quality of these economies negatively impacts REN. Conversely, the research of Uzar (2020) reported a different result. The authors confirmed that the institutional quality of thirty-eight economies plays a key role in improving the usage of REN. They employed the PMG-ARDL to analyze the dataset spanning between 1990 and 2015. Zhao et al. (2022) looked at the effect of external and internal conflict on REN in OECD nations for the period spanning between 1990 and 2019. The authors established that the effect of external and internal conflict is adversely related to REN.

Economic growth and renewable energy

Several previous research employed qualitative methodologies to examine the various avenues via economic expansion to expand renewable energy usage in a group of economies or specific nations. In research by Murshed (2021), the authors employed the AMG to scrutinize the impact of economic growth on REN in South Asian nations within the timeline spanning between 1992 and 2015. The empirical outcome reported that REN is positively affected by economic growth. Employing the quantile regression, Fatima et al. (2022) researched the impact of economic growth on REN in GCC economies for the period between 1990 and 2019. The authors highlighted that economic expansions play a crucial role in the usage of REN. In an investigation by Przychodzen and Przychodzen (2020), the authors studied the influence of economic growth on REN in twenty-seven economies for the period between 1990 and 2014. The authors documented that the usage of REN increases due to economic growth. Eren et al. (2019) conducted research on the effect of economic growth on renewable energy in India. This research spans the period between 1971 and 2015 and detected that economic growth enhances REN in India. Alam and Murad (2020) studied the connection between REN and economic growth in OECD economies for 43 observations. The authors reported that economic growth intensifies renewable energy. Bano et al. (2022) inspected the effect of economic growth on REN usage in BRICS economies for the timeline from 2000 to 2017. The findings of the research concluded that economic growth increases REN.

Environmental degradation and renewable energy

Several studies looked into the environmental degradation (ED) and renewable energy (REN) nexus. However, these studies employed several proxies for environmental degradation such as carbon emissions, and ecological footprint, which is among many. For instance, Adebayo (2022a) inspected the ED-REN nexus in Sweden for the period between 1965 and 2019. The authors highlighted an adverse connection between ED and REN. Similarly, the research of Zheng et al. (2021) documented a negative connection between REN and ED in China. Also, in MENA economies, the connection between REN and ED was inspected by Sun et al. (2022) for the period between 1991 and 2019, which confirmed an adverse connection between REN and ED. Meanwhile, the study of Xu et al. (2022) opposes this findings. Furthermore, Wang et al. (2021a, b) found ED lowers REN use in twenty-five selected economies. Using the dataset of BRICS economies for the period between 1990 and 2015, Mahalik et al. (2021) documented an adverse relation between ED and REN. Wang et al. (2021a, b) utilized the dataset which span between 1980 and 2014 and established that ED and REN are negatively related in ten economies. Haldar and Sethi (2022) inspected the ED-REN nexus in sixteen nations for the period between 2000 and 2018. The authors highlighted a negative connection between ED and REN. Bekun (2022) utilized the dataset which span between 1990 and 2016 and established that ED and REN are negatively related in India.

Literature gap

From the preceding sub-sections, we can highlight various shortcomings in the existing literature. First, the studies on economic globalization-renewable energy are quite scarce for the time series approach, and the political risk-renewable energy nexus also faces the same circumstances. Furthermore, no prior research has attempted to ascertain the contributing factors of renewable energy use in the case of Vietnam. However, in terms of attaining the SDG 7, ascertaining the driver of renewable energy usage for Vietnam is critical to enable the country to meet the SDG target by 2030. For this purpose, this present work intends to bridge the gap in knowledge by employing a unique indicator of political risk, which contains components of investment profile, rule of law, democratic accountability, corruption index, government stability of the nation, and economic globalization (which combines the financial and trade globalization). This research is carried out in the presence of environmental degradation, by utilizing carbon emissions as the proxy.

Model framework and data

The current research inspects the role of political risk and economic globalization on renewable energy usage. Economic globalization encompasses the inflow of goods and services, as well as income payments to foreign nationals, portfolio investments, FDI, and trade. Economic globalization offers cutting-edge technology to the host nation through technological transfer, so they can raise their energy efficiency. Economic globalization promotes the inflow of financial resources, which also supports the investment in renewable energy by shifting conventional energy generation to renewable generation. Thus, economic globalization has an impact on renewable energy sources through the scale, technique, and substitution effects. The generation of renewable energy can also be considered to be affected by political risk. Any developmental process may be hampered by high political risk. Energy is a major engine of this developmental pathway, although political risk may result in escalating discrepancies in renewable energy output. As a result, the political risk-renewable energy connection may be described from the perspective of the theory of political economy. For example, external and internal conflicts, unstable political environment, military in politics, weak institutions, religious tension, quality of bureaucracy and corruption, and so on can impede or affect renewable energy investment, which is anticipated to lower renewable energy usage. Furthermore, in the presence of high levels of political risk, expenditures in research and development for renewable energy-related technological advancement may be considered to be low; hence, political risk can be expected to have a negative influence on renewable energy. The cross-border flows of FDI might be impeded as a result of political risk. According to this assumption, political risk has been identified as a key macroeconomic issue limiting the growth of renewable energy. The renewable energy function is modeled as follows:

$$REN_t = f\left(EGLO_t, PR_t, GDP_t, ED_t\right) \tag{1}$$

wherein REN, EGLO, PR, GDP, and ED denote renewable energy, economic globalization, political risk, economic growth, and environmental degradation; t denotes the period of study (1984–2019). Furthermore, the econometric function is presented as follows:

$$REN_t = \vartheta_0 + \vartheta_1 EGLO_t + \vartheta_2 PR_t + \vartheta_3 GDP_t + \vartheta_4 ED_t + \varepsilon_t \quad (2)$$

where ϑ_0 denotes the constant of the model; ϑ_{1-4} denotes the coefficient of the EGLO, PR, GDP, and ED; ε_t represents the error term.

This empirical research is focused on Vietnam using the time series dataset for the period spanning between 1984 and 2019 (36 observations). The dataset of environmental degradation (carbon emissions) and renewable energy is gotten from the British petroleum database (BPD). The political risk index and economic globalization are sourced from the database of Risk Service Group (RSG) and the Swiss Economic Institute, respectively. These datasets were transformed into their logarithm forms with the sole purpose of reducing heteroscedasticity. The description of the parameters of this research is summarized in Table 1.

Methodology

The flow chart of the methodology process is presented in Fig. 2. It details the step-by-step process of the methodology used in our current research.

Cointegration approach

Deploying Pesaran et al.'s (2001) ARDL bounds testing approach, we assessed the cointegrating connection between renewable energy and political risk, economic growth, economic globalization, and environmental degradation. The cointegration among the parameters of concern is detected using the F- and T-statistics values. We confirm proof of cointegration provided that the F- and T-statistics value is more than the lower critical values (LCV) and upper critical values (UCV); nevertheless, proof of no cointegration can be detected if the value of the F- and T-statistics is lesser than the LCV and UCV. When determining whether endogenous and exogenous variables are cointegrated, the following hypotheses are used.

$$H_0 = \varphi_1 = \varphi_2 = \varphi_3 = \varphi_4 = \varphi_5 = 0,$$

$$H_1 \neq \varphi_1 \neq \varphi_2 \neq \varphi_3 \neq \varphi_4 \neq \varphi_5 \neq 0$$

To assess the connection between the parameters of the research and whether they are cointegrating depending on the preceding two hypotheses.

$$\begin{aligned} REN_t = {} & \phi_0 + \sum_{i=1}^{o} \phi_1 \Delta REN_{t-i} + \sum_{i=1}^{o} \phi_2 \Delta EGLO_{t-1} \\ & + \sum_{i=1}^{o} \phi_3 PR_{t-1} + \sum_{i=1}^{o} \phi_4 \Delta GDP_{t-1} + \sum_{i=1}^{o} \phi_5 \Delta ED_{t-1} \\ & + \varphi_1 REN_{t-1} + \varphi_2 EGLO_{t-1} + \varphi_3 PR_{t-1} \\ & + \varphi_4 GDP_{t-1} + \varphi_5 ED_{t-1} + \varepsilon_t \end{aligned} \quad (3)$$

Variation in operator in Eq. 3 is indicated by Δ. The suitable lag choice is represented by $t - i$ and is predicated on SIC in both equations. Furthermore, the elements evaluated in the preceding equations are ϕ_{1-5} and δ_{1-5}, respectively. Upon the parameters under investigation are cointegrated, the short and long-term dynamic ARDL simulations framework is studied utilizing the generated F statistics.

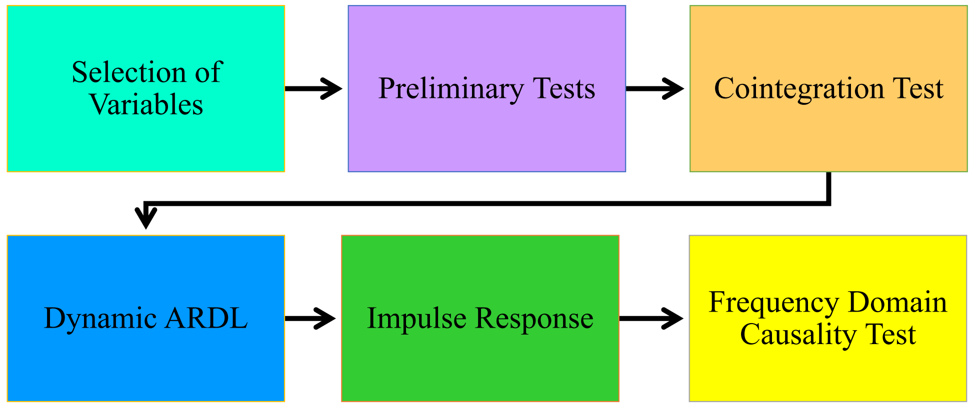
Dynamic ARDL simulations

This research, like other studies (such as Adebayo et al. 2022b; Das et al. 2022; Pata and Isik 2021), employs the Dynamic ARDL approach, which was built by Jordan and Philips (2018). The approach was developed to overcome a shortcoming in the basic ARDL methodology, specifically the capacity to assess the long- and short-term interrelationships between the parameters used in the research. By incorporating favorable and unfavorable variation to the regressors while maintaining the other independent variable fixed, the DARDL approach can adequately evaluate, simulate, and predict graphs. The DARDL approach can be applied if the variables in this study have a cointegration connection. The latest

Table 1 Description of variable

Variables	Definitions	Measurement	Sources
Renewable energy	An aggregate of all shares of renewable energy sources	TWh	BPD (2021)
Economic globalization	Globalization index measured in economic (financial and trade)	Index	KOF (2022)
Economic growth	The aggregate amount of goods and services manufactured within an economy	Constant 2010	WDI (2022)
Environment degradation	Carbon emission per capita emission	Metric ton	BPD (2022)
Political risk	The stability of an economy's political	Index	RSG (2020)

Fig. 2 Flow of analysis



investigation matches every one of the dynamic ARDL model's requirements. For the DARDL approach, we performed 500 iterations for the vector of variables using multivariate normal distributions..

$$\begin{aligned} REN_t = {} & \alpha_0 + \delta_0 REN_{t-1} + \delta_1 \Delta EGLO_t \\ & + \vartheta_1 EGLO_{t-1} + \delta_2 \Delta PR_t + \vartheta_2 PR_{t-1} \\ & + \delta_3 \Delta GDP_t + \vartheta_3 GDP_{t-1} + \delta_4 \Delta ED_t \\ & + \vartheta_4 ED_{t-1} + \rho ECT_{t-1} + \varepsilon_t \end{aligned} \tag{5}$$

Frequency domain causality test

The study outcomes are tested for soundness in this section, with the purpose of evaluating the DARDL's susceptibility to vector lag size and assessment. All of the variables were recomputed in three distinct pathways. In addition, a rigorous frequency domain approach is done to investigate the long, medium, and short-term causal interaction among CO_2 emissions and its exogenous parameters. In contrast to the standard Granger causality test, this approach utilized in this study forecasts the response element at various time frequencies (Breitung and Candelon 2006). However, since the technique is limited to a given period, infinite horizon frameworks are not possible to predict.

Result and discussions

Descriptive statistics

The most pertinent aspect of a collection of data detailing the science of quantitative is referred to as descriptive statistics. Descriptive statistics are important for the evaluation and interpretation of data. For this study, details findings of the descriptive statistics are presented in Table 2. It reveals the mean, range, standard deviation, skewness, and kurtosis of the concerned variables. The highest mean value is detected in economic growth while the lowest mean value is CO_2 emissions. The range of REN, economic growth, economic globalization, CO_2 emissions, and political risk are 0.5848 to 2.3478, 2.5769 to 3.2932, 1.4692 to 1.7872, − 0.5844 to 0.3456, and 1.2844 to 1.8548, respectively. However, three of these variables, like renewable energy, economic globalization, and political risk, are negatively skewed, whereas economic growth and CO_2 emissions are positively skewed. All the variables have lower tails indicating that they are platykurtic with the exception of the political risk, whose kurtosis has a long and skinny tail, which is Leptokurtic.

Stationary test

Here, the stationary nature, as well as the integration order of the dataset, is the next step. Failure to identify this, the result of our analysis will be erroneous and misleading. The results of the ADF and PP unit root test are presented in Table 3. These tests reported that economic growth and political risk are integrated at level ($I(0)$) while the remaining variables (REN, ED, and economic globalization) are integrated at first difference. Although these outcomes corroborate certain assumptions of using the dynamic ARDL, they cannot be used to draw any conclusions because these tests did not expressly account for the possibility of structural breakdowns throughout the sampling time.

As a result, we will employ the ZA unit root, which factored into consideration the occurrence of a structural break. The results of the ZA unit root test (see Table 3) report that economic growth is integrated at level, whereas economic globalization, REN, political risk, and ED are integrated at first difference. Since the analysis of the ADF, PP, and ZA unit root tests are close given the order of integration is mixed, which is sufficient for the use of bound testing approach to establish the cointegration test.

Table 2 Descriptive statistics

	REN	GDP	EGLO	CO_2	PR
Mean	1.5704	2.9090	1.6698	− 0.1310	1.7724
Median	1.6494	2.9053	1.7065	− 0.1323	1.8084
Maximum	2.3478	3.2932	1.7872	0.3456	1.8548
Minimum	0.5848	2.5769	1.4692	− 0.5844	1.2844
Standard Dev	0.5098	0.2320	0.1105	0.3090	0.1026
Kurtosis	2.5074	1.6739	2.0751	1.4733	15.6621
Skewness	− 0.5146	0.0318	− 0.7131	0.0083	− 3.2550

Cointegration test

The cointegration test is the next analysis carried out in our current research. Using the ARDL approach, wherein the estimations are presented in Table 4. It reports that the value of the F-statistics (18.2738) outweighs the critical value in the lower and upper bound at a 5% significance level. Furthermore, the value of *T*-statistics (− 10.2677) also outweighs the upper and lower critical values at 5% level of significance. The rejection of the null hypothesis of no cointegration is evident, suggesting that there is a strong significant indication of a cointegrating association between REN and economic globalization, political risk, economic growth and ED. Furthermore, as observed in Table 4, the result of the diagnostic tests confirms there are no concerns with serial correlation, misspecification, or heteroscedasticity with regards to the residual of this model but they are normally distributed, given that the null hypothesis is not rejected. As presented in Fig. 3, the plots of CUMSUM and CUMSUMSQ show that the residuals are stable. The proof of cointegration serves as the bedrock to assess the impact of economic growth, economic globalization, political risk, and ED on renewable energy.

Dynamic ARDL test

Based on the empirical outcomes of the DARDL approach, the short and long-term findings are summarized in Table 5. The coefficient of the error correction term is negative and statistically significant, suggesting that the model will achieve equilibrium and this shows the robustness of our findings. Hence, the rate of adjustment in the long term due to an imbalance in the short term is 61.23%. The effect of economic growth on renewable energy in the long and short term is positive. With the increase in per capita income by 1%, the usage of renewable energy will also increase by 2.173% (long run) and 8.4142% (short run); therefore, the level of income boosts the renewable energy usage in Vietnam. This demonstrates that improved economic activities in Vietnam are capable of meeting the demand for the usage of more renewable/clean energy. As a result, the consumption of fossil fuels will decline, while the proportion of renewable energy demand in the overall energy composition in Vietnam will rise. Based on this process, Vietnam is projected to generate less pollution. This outcome is congruous with the research of Murshed (2021) for South Asian economies, Fatima et al. (2022) for GCC economies, Przychodzen and Przychodzen (2020) for twenty-seven countries, Eren et al. (2019) for India, Alam and Murad (2020) for OECD economies, and Bano et al. (2022) for the BRICS economies. They highlighted that per capita income is a determinant of renewable energy and concluded that per capita income contributes to the usage of renewable energy. Vietnam's present economic expansion is the result of massive economic operations and the ambitions of policymakers. The persistence of larger-scale development activities in the public and private sectors is heavily dependent on affordable energy sources through a feed-in-tariff system. The Vietnamese policymakers began several renewable energy initiatives in

Table 4 Bound cointegration test outcome

F-stat	18.2738*
T-stat	− 10.2677*
Diagnostic check	
χ^2 normality	1.2527 (0.5333)
χ^2 LM	0.1002 (0.9050)
χ^2 heteroscedasticity	0.6928 (0.6774)
χ^2 Ramsey	2.1887 (0.1339)

*Significance level of 0.05

Table 3 Stationary test

	ADF		PP		ZA			
	Level	Δ	Level	Δ	Level	BP	Δ	BP
REN	− 1.4749	− 4.0128**	− 1.6517	− 4.0128**	− 4.4878	1993	− 5.3819**	2011
CO_2	− 2.4036	− 4.3112*	− 2.1454	− 5.6012*	− 3.4553	1996	− 6.5561*	1994
GDP	− 4.2893*	− 4.3481	− 3.8711**	− 2.5123	− 4.8754***	2012	− 4.6091	1997
EGLO	− 1.4519	− 5.8365*	− 1.4860	− 5.8405*	− 4.5461	1995	− 5.9978*	1998
PR	− 3.226***	− 2.5770	− 6.5750*	− 17.3999*	− 3.2521	2000	− 5.5074**	1995

Note: ***, **, and * represent 0.05 and 0.01 significance levels, respectively

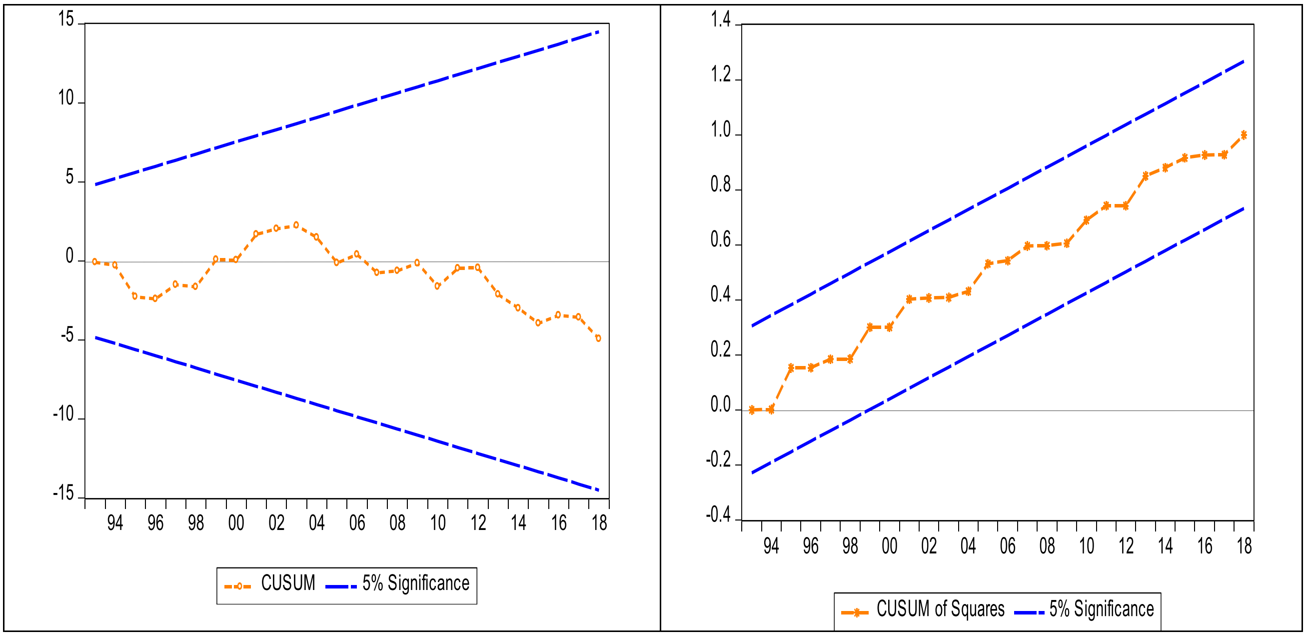


Fig. 3 Test for stability

2007, aiming to meet 11% of the economy's energy needs through renewable energy projects by 2050.

The connection between renewable energy and economic globalization is positive in the long term but a neutral interaction exists in the short term. A 1% increase in economic globalization in the long run will cause the consumption of renewable energy to increase by 1.7418%. Our finding demonstrates that economic globalization is critical in stimulating renewable energy in Vietnam. Thus, economic globalization can help to improve environmental quality through its role in boosting the usage of renewable energy. Economic globalization, which increased financial and trade openness, could well have lured the inflow of FDI into the Vietnam economy, which is supported by larger profit margins and accelerated economic progress in the host economy. When foreign investors come to developing economies to establish their businesses and invest, they often bring with them their sophisticated energy-efficient technologies or provide more funding for the research and development of alternative energy sources. This result is congruous with the findings of Gozgor et al. (2020) for the OECD nations, who concluded that economic globalization increases the consumption of renewable energy. Likewise, extant evidence from Murshed et al. (2022a, b) for the Bangladeshi economy revealed that FDI inflows improve the generation of renewable electricity but degrade the environment, making the country a pollution haven for developed economies. Furthermore, the study of Urom et al. (2022) for the G7 nations discovered that globalization enhances renewable energy. The prior study by Murshed (2021) for South Asian economies established that trade openness boosts renewable energy. Conversely, evidence from prior studies such as Padhan et al. (2020) for the OECD economies concurs with the current study's outcome since they uncovered that economic globalization decreases the usage of REN.

Table 5 Dynamic ARDL estimator outcome

Variable	Coefficients	Standard error	*T*-stat	*P*-value
ECT	−0.6132	0.1282	−4.78	0.000
GDP	2.1731*	0.5544	3.92	0.001
ΔGDP	8.4142*	2.3086	3.64	0.001
EGLO	1.7418*	0.3583	4.86	0.000
ΔEGLO	0.1863	0.4316	0.43	0.670
ED	−1.2258*	0.2678	−4.58	0.000
ΔED	−1.2531*	0.2109	−5.94	0.000
PR	−1.2461*	0.3299	−3.78	0.001
ΔPR	−1.3016*	0.3360	−3.87	0.001
Constant	−6.2982	1.6176	−3.89	0.001
R-squared	0.8160			
Adjusted *R*-squared	0.7470			
F-statistics (*P*-value)	11.82 (0.000)			

Note: *Significance level of 0.01

Furthermore, the ED is adversely associated with renewable energy at a 1% level of significance in the long and short term. Thus, all things being equal, if the level of ED increases by 1%, the consumption of renewable energy will decrease by 1.2258% (long term) and 1.2531% (short term). Thus, ED mitigates renewable energy usage in Vietnam. However our outcome is congruent with the research of Yuping et al. (2021) for Argentina; Bekun et al. (2022) for E7 nations, Alola and Adebayo (2023) for Nordic economies, Mata et al. (2022) for Colombia, and He et al. (2021) for ten selected economies, who also provided crucial policy perspectives for developing and emerging economies. Prior studies of Ibrahim et al. (2022) for Germany, Beton Kalmaz and Awosusi (2022) for Malaysia and Awosusi et al. (2022) for Uruguay established the an adverse connection between ED and renewable energy. Conversely, the study of Bekun et al. (2021) concluded that an insignificant association between ED and renewable energy in South Africa. As the environment degrades due to a persistent surge in carbon emissions, it is predicted that this will exacerbate climate change and have detrimental consequences for the life expectancy of humans, animals, and other species. This finding should encourage policymakers to heighten awareness and motivation among households and the industrial sector in Vietnam to convert their energy usage patterns from fossil fuel to renewable energy. As a result, the usage of renewable energy will serve as a "win–win" situation for Vietnam and other developing economies. Hence, renewable energy could serve as an alternative energy solution to fossil fuel, thus helping to ensure the long-term sustainability of environmental quality and energy security in Vietnam and other developing economies in the twenty-first century.

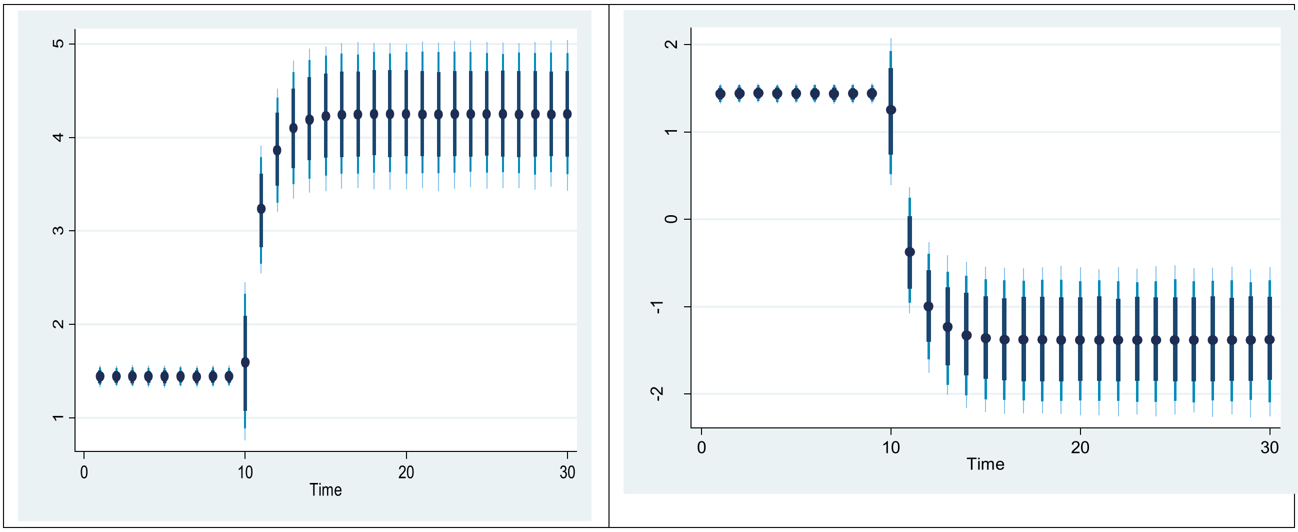
Finally, but certainly not least, the increases in the index of political risk increases the renewable energy use in prior literature such as (Su et al. 2021). Meanwhile, in our case study, it was found that the usage of renewable energy decreases as a result of the political risk index. As the level of political risk increases by 1%, the usage of renewable energy will reduce by 1.2461% (long term) and 1.3016% (short term). This finding indicates that the expansion of renewable energy may be hampered by political risk and that the increase in political risk may have an adverse environmental externality by exerting a burden on the country's natural resources. When the level of political risk rises, trade in capital goods may place a further burden on the pool of natural resources, resulting in a downward trend in the development of renewable energy solutions in Vietnam. This could reduce the accessibility of renewable energy, causing the country to move away from achieving SDG 7. This outcome can be expressed from the perspective of the theory of political economy, which states that political risk impedes the inflow of capital from abroad, resulting in a reduction in renewable energy investment. The research of Su et al. (2021) contradicts this study's outcome, as they reported that political risk improves renewable energy in the OECD economies, and a similar finding was reported by Uzar (2020), who discovered that institutional quality contributes to the usage of renewable energy in thirty-eight economies. However, this study's finding is congruent with the study of Zhao et al. (2022) on OECD economies and Appiah et al. (2022) on Sub-Saharan African economies.

Impulse response

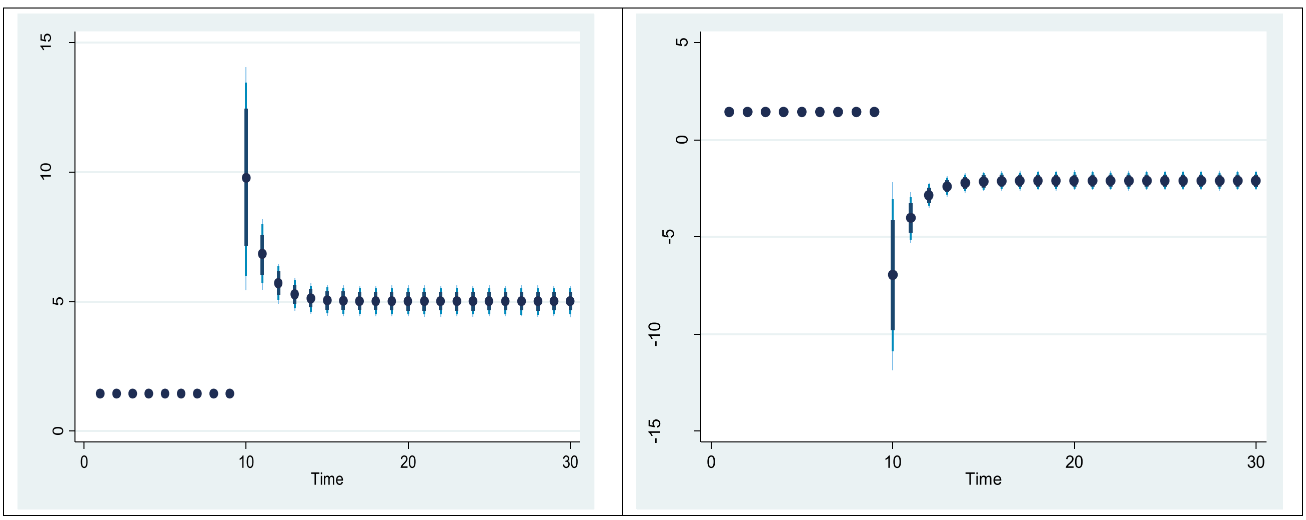
Next, we examine the counterfactual changes of ED, political risk, economic growth, and economic globalization on renewable energy, which is the novelty of the dynamic ARDL approach. We executed approximately 500 iterations for the parameter vector in the DARDL approach, the results of which are presented in Fig. 4a–d; these graphs reflect the behavior of renewable energy induced by a 1% variation in ED, political risk, economic globalization, and economic growth. Figure 4a illustrates that a 1% rise in EGLO boosts REN, whereas a 1% decrease in EGLO decreases REN. Furthermore, a 1% positive change in GDP enhances REN, whereas a 1% negative shock in GDP decreases REN (see Fig. 4b). In addition, Fig. 4c shows that a 1% increase in ED decreases REN, but a 1% decrease in ED increases ED. Figure 4d reveals that a 1% positive shock to PR curbs REN, while a 1% negative shift in PR surges REN.

Causality pathway

The current research further explores the causal interaction between renewable energy and the exogenous variables (ED, political risk, economic globalization, and economic growth) by utilizing the frequency domain approach. The peculiarity of this approach is that it predicts the response element for several time horizons. Table 6 depicts the causal interactions between renewable energy and the exogenous variables at different time frequencies. The non-causality interaction from economic growth to renewable energy is rejected in the long term, as well as the non-causality association from REN to economic growth in the long run. Thus, REN and economic growth can predict each other in the long term in Vietnam. Furthermore, in the long term, the null hypothesis of a non-causal interaction from ED to REN is rejected in the long term, while a causality association from REN to ED is evident in the long term. Hence, a bi-directional causality is evident between ED and renewable energy in Vietnam. However, no causal interaction is evident from economic globalization to renewable energy, but the non-causality association from renewable energy to economic globalization is rejected in the long, medium, and short run. Thus, REN can predict economic globalization in the long, medium, and short run in Vietnam. Lastly, no casual association is found from renewable energy to political risk, while a causality relationship from political risk to



a



b

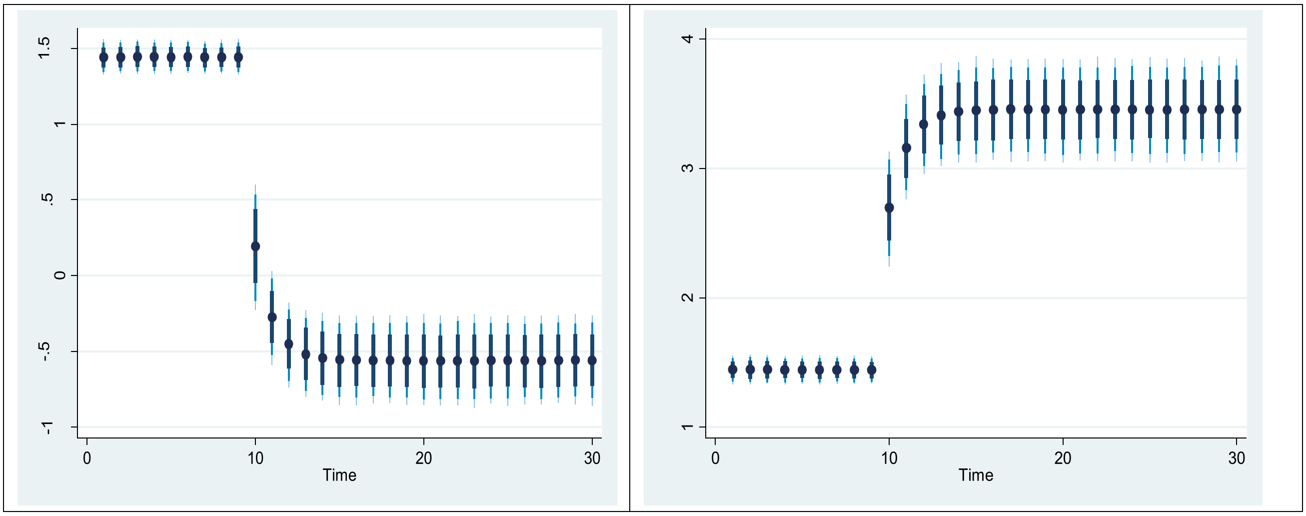
Fig. 4 **a** A 1% increase (decrease) in EGLO and its influence on REN. The small box signifies average value prediction. The light to dark blue line symbolized 95%, 90%, and 75% CI, correspondingly. **b** A 1% increase (decrease) in GDP and its influence on REN. The small box signifies average value prediction. The light to dark blue line symbolized 95%, 90%, and 75% CI, correspondingly. **c** A 1% increase (decrease) in ED and its influence on REN. The small box signifies average value prediction. The light to dark blue line symbolized 95%, 90%, and 75% CI, correspondingly. **d** A 1% increase (decrease) in PR and its influence on REN. The small box signifies average value prediction. The light to dark blue line symbolized 95%, 90%, and 75% CI, correspondingly.

renewable energy is uncovered in the long, medium, and short term. Hence, political risk can predict renewable energy in the short, medium, and long run in Vietnam.

Conclusion and policy suggestions

Conclusion

Given the contradictory evidence on the association between economic globalization and renewable energy, as well as the potential effect of political risk on renewable energy, the current study evaluated the impact of economic globalization and political risk on renewable energy in Vietnam, a country that is becoming highly integrated into the global market and moderately stable politically. To construct the model of this study, we incorporated environmental degradation (ED) and economic growth. For the empirical analysis, we employed the stationary test with and without a structural break and the findings revealed a mixed integration order among the studied variables. Following that, we utilized the bounds testing procedure using



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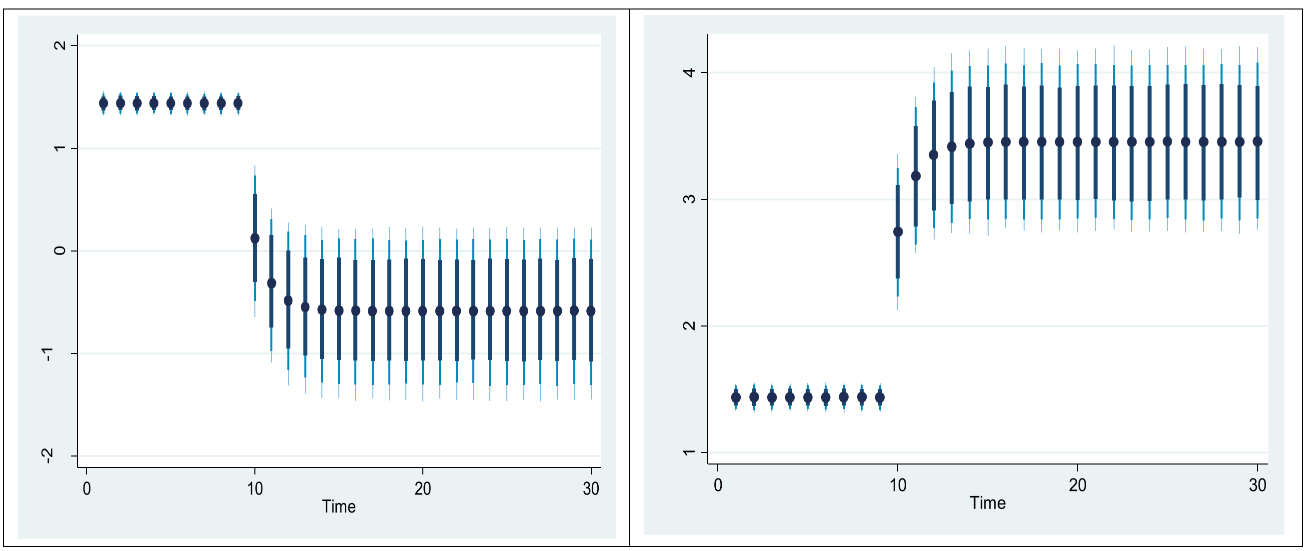

d

Fig. 4 (continued)

Table 6 Causality outcome

	Long run		Medium run		Short run	
	T-statis	Pro-value	*T*-statis	Pro-value	*T*-statis	Pro-value
REN→GDP	6.9643**	0.0307	0.7168	0.6988	0.6126	0.7362
GDP→REN	6.6215**	0.0365	0.3779	0.8278	0.4704	0.7904
REN→ED	9.7833*	0.0075	0.7620	0.6832	0.6590	0.7193
ED→REN	8.3685**	0.0152	0.7302	0.6941	0.8189	0.6640
REN→EGLO	5.4899**	0.0643	8.9022**	0.0117	10.1541*	0.0062
EGLO→REN	0.0537	0.9735	0.4562	0.7960	0.5690	0.7524
REN→PR	0.2164	0.8974	2.2502	0.3246	3.4384	0.1792
PR→REN	5.1426***	0.0764	6.3757**	0.0413	6.5487**	0.0378

*, **, and *** portray significance level of 0.01, 0.05, and 0.1

an annual dataset between 1984 and 2019 in Vietnam. We identified a cointegrating association between renewable energy and ED, political risk, economic globalization, and economic growth. Furthermore, we uncovered the long and short-term impact of ED, political risk, economic globalization, and economic growth on renewable energy utilizing the dynamic ARDL technique. Economic growth enhances the usage of renewable energy in the long and short term. Economic globalization promotes renewable energy in the long term, but a neutral impact was uncovered in the short term. Political risk and environmental degradation are adversely related with renewable energy in the short and long term. The results from the frequency domain approach revealed causal interaction from political risk to renewable energy, and from renewable energy to economic globalization, whereas a feedback causal interaction was discovered between renewable energy and ED, as well as between economic growth and REN.

Policy implications

The research results provide crucial perspectives that may be relevant from a policymaking standpoint; specifically, the policy framework can assist Vietnam with achieving the SDGs. Vietnam's economic expansion pathway is beneficial for expanding the initiative of renewable energy generation. Therefore, the prominence of the usage of fossil fuel-driven energy must be progressively displaced in order for renewable energy options to increase in the country's energy mix. Since the renewable energy demand is projected to expand, the need for technological advancement will grow accordingly. Meanwhile, it will be impossible for Vietnam to discover such solutions within its borders, and thus, these kinds of solutions may need to be imported from other countries via the route of economic globalization. As a result, until the technological expertise of the country reaches its maximum potential, the economic globalization route could be employed in the generation and development of renewable energy via FDI and technological transfer.

The industrial sector must use capital-intensive technology-driven solutions instead of labor-augmentation alternatives to implement these solutions. Thus, the increasing demand for renewable energy sources will be achieved via this process. Unfortunately, this effort may influence the employment situation of the country, considering that much of the workforce would be eventually displaced by innovation advancement. To alleviate such concerns, the policymakers must intervene to preserve societal order, which could be accomplished by offering appropriate training to the workforce so that they can utilize the new machinery and be employable. This would not only assist these countries in addressing unemployment, but also in maintaining their economic development patterns. This initiative will assist Vietnam in moving closer to achieving SDG 8 (decent work and economic growth).

Rent-seeking mechanisms in bureaucratic processes should be reduced to allow for seamless technology dissemination. Policymakers should pay greater attention to differentiated taxation mechanisms, so that companies with a lower level of carbon emissions can be given tax holidays and subsidies, while those with a higher level of carbon emissions can be levied with a higher tax rate. This would eventually deter businesses from using fossil fuel-based options in their manufacturing activities, forcing them to switch to sustainable energy. The progressive surge in the utilization of renewable energy in Vietnam would aid the country in tackling climate change challenges and, as a result, in reaching the SDG 13 targets.

Limitations and future projections

New insights could be provided through the inclusion of sectorial-level assessment and innovative components in the policy framework. Therein lies the constraint, as it should be emphasized that the policy framework is only a starting point for building additional policies that are a better fit for other emerging and developing economies aiming to increase renewable energy output. The generalizability feature is the peculiarity of the framework from this standpoint. Future studies could consider the asymmetric analysis of these drivers of renewable energy generation for panel dataset.

Author contribution Abraham Ayobamiji Awosusi and Husam Rjoub designed the experiment and collected the dataset. The introduction and literature review sections were written by Abraham Ayobamiji Awosusi, Hazar Dördüncü, and Dervis Kirikkaleli. Abraham Ayobamiji Awosusi constructed the methodology section and empirical outcomes in the study. Abraham Ayobamiji Awosusi, Husam Rjoub, Hazar Dördüncü, and Dervis Kirikkaleli contributed to the validation and review of the study. All the authors read and approved the final manuscript.

Data availability Data is readily available at the request from the corresponding author.

Declarations

Ethical approval This study follows all ethical practices during writing.

Consent to participate Not applicable.

Consent for publication Not applicable.

Competing interests The authors declare no competing interests.

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