Journal of Social Economics Research
2024 Vol. 11, No. 3, pp. 309-320
ISSN(e): 2312-6264
ISSN(p): 2312-6329
DOI: 10.18488/35.v11i3.3826

Environmental pollution and renewal energy consumption in Vietnam

Minh Ngo Ngoc[1+]
Thuc Nguyen Ngoc[2]
Khanh Vo Huu[3]
Giang Pham Xuan[4]
Chan Tran Hoa Phuc[5]

[1,2,3,4,5]*Business Administration Faculty, Industrial University of Hochiminh City, Vietnam.*
[1]*Email: ngongocminh@iuh.edu.vn*
[2]*Email: nguyenngocthuc@iuh.edu.vn*
[3]*Email: vohuukhanh@iuh.edu.vn*
[4]*Email: phamxuangiang@iuh.edu.vn*
[5]*Email: tranhoaphucchan@iuh.edu.vn*


(+ Corresponding author)

Article History
Received: 20 October 2023
Revised: 16 May 2024
Accepted: 11 June 2024
Published: 24 July 2024

Keywords
Environmental pollution
Globalization
Renewable energy consumption.

JEL Classification:
F21; P28; Q43.

ABSTRACT

The purpose of this paper is to find out the perusable empirical evidence on the nexus between environmental pollution and various factors on renewable energy consumption in the case of Vietnam. In Vietnam, being aware of the potential and role of renewable energy in economic development as well as environmental protection, the government affirms that renewable energy development does not only focus on expanding the scale and increasing the proportion of renewable energy sources in the total primary energy supply, contributing to decreasing environmental pollution. This research delves into the application of the autoregressive distributed lag (ARDL) methodology to examine the effects of environmental pollution and various factors on renewable energy consumption in Vietnam from 1995 to 2019. The findings suggest that globalization and population growth have a positive impact on advancing renewable energy consumption, whereas financial development does not have a significant long-term effect. Specifically, the two variables mentioned contribute to the increase in renewable energy consumption. Furthermore, the study reveals that increasing CO2 emissions and financial development are associated with a decrease in renewable energy consumption. Consequently, the paper offers policy recommendations aimed at facilitating the transition to a renewable energy-based economy in Vietnam in the near future.

Contribution/Originality: This is the first quantitative study conducted with the most complete and updated data on the relationship between environmental pollution, other variables, and renewable energy consumption in Vietnam. Therefore, the findings may be more useful for policymaking in the context of Vietnam's economy trying to escape the middle income trap.

1. INTRODUCTION

In the contemporary era of globalization, the majority of nations engaging with the global market feel its impact. The intensifying globalization accelerates economic activity, driving up energy consumption. Consequently, energy assumes a pivotal role across the globe. With the heightened utilization of non-renewable energy sources such as coal, crude oil, and natural gas posing environmental risks due to increased carbon emissions (Shahbaz, Raghutla, Chittedi, Jiao, & Vinh, 2020) renewable energy emerges as a crucial resource for sustainable progress. However, a significant challenge to the adoption of renewable energy lies in its capital costs, which are comparatively higher than those of conventional energy sources. Given that renewable energy projects demand

substantial capital investment and entail extended payback periods, the advancement of financial mechanisms becomes a critical determinant in fostering renewable energy development.

Energy holds paramount significance in the economic and social fabric of humanity. As societies progress, the need for energy continues to surge. Yet, amidst its considerable benefits, the extraction, processing, and utilization of energy also inflict substantial pollution upon the environment, notably through the emission of greenhouse gases such as CO_2, which stands as the primary driver of ongoing global climate change.

Aside from the conventional discourse surrounding the interplay among energy consumption, economic advancement, and environmental degradation, recent scholarly investigations have delved into the correlation between financial progress and the uptake of renewable energy. Financial development primarily denotes an augmentation in a nation's financial endeavors, encompassing heightened foreign direct investment (FDI), increased credit provision to both financial and private sectors by banks, and the maturation of stock markets. Chang (2015) elucidates that the evolution of finance can significantly influence the demand for renewable energy, as financial institutions and well-established capital markets can furnish loans and financing for renewable energy ventures. A mature financial system holds the potential to mobilize greater funding for the renewable energy sector at reduced costs, thereby presenting augmented investment and financing avenues for eco-friendly projects (Anton & Nucu, 2020). Nonetheless, only a handful of studies have ventured into examining the nexus between financial development and renewable energy utilization.

In the contemporary landscape, where conventional primary energy sources increasingly reveal their environmental unfriendliness, the adoption of renewable energy sources remains relatively modest. Vietnam has initiated endeavors to cultivate and implement green and sustainable development models, supplanting antiquated, energy-intensive paradigms. The nexus between economics and energy consumption emerges as a critical focal point that requires thorough investigation. Hence, alongside enhancing production capabilities and seeking novel supply sources, there's a pressing need to address solutions aimed at curbing demand or employing energy in a thrifty and efficient manner.

For affluent nations, the dilemma between prioritizing economic expansion and environmental preservation continues to be a significant concern, motivating governmental actions. In 2019, Vietnam secured the second position within the Association of Southeast Asian Nations (ASEAN) and stood at the forefront globally in terms of gross domestic product (GDP) growth rate, demonstrating remarkable economic advancement compared to other nations. Nonetheless, this growth trajectory poses challenges in terms of escalating energy consumption and the consequent rise in CO_2 emissions.

Unlike previous studies, this study proposes a research model that introduces the globalization index for the first time in the context of Vietnam. Furthermore, the dataset used covers the longest period of time to date. The paper is organized as follows: Part 2 provides an overview of the most pertinent literature, Part 3 outlines the methodologies and data employed, Part 4 presents the empirical findings and subsequent discussion, and finally, the conclusion and policy implications are discussed.

2. THE MOST RELATED PAPERS

The literature on renewable energy has witnessed significant expansion in recent decades. Within these papers, exploration of renewable energy consumption often intersects with globalization, financial development, economic growth, and environmental pollution. Therefore, we structure the literature review around these themes:

2.1. The Relationship Between Globalization and Renewable Energy Consumption

In the process of globalization, the flows of capital, international trade, and technology move across national borders, changing the trend of production and consumption on a global scale. Globalization makes it easier to transfer technologies from developed countries to developing countries. Through globalization, greater openness to

international markets brings technological advancements, production methods, management skills, and technologies for energy efficiency and environmental protection. The increasing degree of globalization increases economic activities, accelerating the transition to renewable energy technology due to the requirement for technological innovation in production. Increasing costs, stemming from the adverse effects of rising energy prices based on fossil fuel sources, facilitate the widespread deployment of renewable energy. The high concentration of FDI in high-growth countries requires the transfer of capital, knowledge, and technology that can promote the deployment and use of renewable energy.

Research papers cover three aspects of globalization: political, social, and economic. Using a variety of metrics, recent empirical research shows that globalization has varying effects on the use of renewable energy. According to Gozgor, Mahalik, Demir, and Padhan (2020) the Organization for Economic Cooperation and Development (OECD) reports that the demand for renewable energy in thirty nations has increased due to economic expansion and growing globalization. On the other hand, Padhan, Padhang, Tiwari, Ahmed, and Hammoudeh (2020) draw attention to the negative consequences of economic globalization on the use of renewable energy. Leitão (2014) and Yazdi and Shakouri (2017) provide more support for a two-way causal relationship between renewable energy and globalization.

2.2. The Relationship Between Financial Development and Renewable Energy Consumption

Three different mechanisms explain the relationship between financial progress and energy usage. First, as financial development increases FDI (foreign direct investment), energy consumption also rises. Second, financial development creates more favorable conditions, increases demand for energy accessibility, boosts the advancement of the renewable energy industry, reduces financial risks, lowers borrowing costs, and facilitates transparent economic transactions between borrowers and lenders. It also encourages investment and guarantees liquidity for viable projects. Finally, thanks to the development of capital and financial markets, economies now have more storage capacity, increasing energy demand (Lu et al., 2021).

Most empirical research has focused on examining the relationship between financial development and energy consumption in general; very few studies have examined the association between financial development and the consumption of renewable energy. From 1990 to 2010, Wu and Broadstock (2015) found that financial development had a significant positive influence on the use of renewable energy in 22 developing market economies. Best (2017) argued that from 1998 to 2013, financial capital was crucial in helping 137 countries make the shift to more capital-intensive energy sources. Financial capital functioned as a stimulus for the transition away from fossil fuels and toward modern renewable energy, most notably wind power, especially in high-income countries. Kutan, Paramati, Ummalla, and Zakari (2018) concluded that FDI inflows and stock market developments significantly influenced the consumption of renewable energy in some countries between 1990 and 2012. According to Anton and Nucu (2020) between 1990 and 2015, the 28 member states of the European Union had an increase in the share of renewable energy consumption due to financial development.

2.3. The Relationship Between Growth and Renewable Energy Consumption

The literature concerning the correlation between renewable energy and economic growth has experienced a notable surge in research activity over the past couple of decades. Empirical investigations have centered around four principal hypotheses. Firstly, the growth hypothesis posits that greater consumption of renewable energy fosters economic growth; in other words, an uptick in renewable energy usage correlates with increased output, while any decrease in such consumption due to energy-saving policies could negatively impact growth. Secondly, the conservation hypothesis suggests a unidirectional causal link from economic growth to renewable energy consumption, implying that fluctuations in renewable energy usage have no discernible effect on economic growth. Thirdly, the feedback hypothesis postulates a reciprocal causal relationship between renewable energy consumption

and economic growth, indicating that higher levels of renewable energy consumption stimulate economic growth, and conversely, economic growth encourages greater adoption of renewable energy. Lastly, the neutral hypothesis posits independence between these two variables, suggesting that they are unrelated to each other (Burakov & Freidin, 2017).

Various empirical studies have produced differing conclusions about the relationship between the use of renewable energy and economic growth. While some studies by Ocal and Aslan (2013) indicate a unidirectional causal relationship between growth and renewable energy usage, others by Lee and Jung (2018) and Ozturk and Bilgili (2015) show evidence of a one-way causative relationship. Furthermore, some records attest to a reciprocal causal link between the two variables (Hwang & Yoo, 2014). The body of research on the subject shows mixed results about how economic expansion affects the use of renewable energy. While some studies by Sadorsky (2009) have shown that growth has a beneficial effect on the consumption of renewable energy, other studies by Shahbaz, Topcu, Sarıgül, and Vinh (2021) have found that growth has a considerable negative impact on this consumption.

2.4. The Relationship between CO_2 Emissions and Renewable Energy Consumption

Diverse empirical results exist about the relationship between CO2 emissions and the use of renewable energy. While some studies by Charfeddine and Kahia (2019) and Shafiei and Salim (2014) find a unidirectional causative relationship between CO2 emissions and renewable energy usage, others confirm a one-way causation relationship. Furthermore, although some studies establish a causal association directly between CO2 emissions and renewable energy, others discover a causal relationship between these two variables (Paweenawat & Plyngam, 2017).

Regarding the impact of CO2 emissions on the use of renewable energy, Sadorsky (2009) suggested that GDP and carbon emissions work together to encourage the use of renewable energy. Apergis and Payne (2015) found that real GDP per capita and CO2 emissions per capita positively and significantly impact the long-term consumption of renewable energy in South American countries. According to Omri, Daly, and Nguyen (2015) rising GDP and CO2 emissions cause a rise in the use of renewable energy. But according to Sinha, Shahbaz, and Sengupta (2018) the high upfront costs of renewable energy discourage investment in developing nations because of worries that it will impede growth in the near term.

The presented analysis highlights the conflicting findings in the literature regarding the effects of globalization, financial development, economic growth, and CO_2 emissions on renewable energy consumption. Various factors, such as the use of samples with diverse characteristics and alternative estimation methodologies, can account for these mixed results. Consequently, this study aims to contribute to clarifying the influence of growth, globalization, financial development, and CO_2 emissions on renewable energy consumption, specifically in developing countries such as Vietnam. By focusing on a specific context and employing robust methodologies, this research endeavors to provide insights that can inform policy-making and contribute to a better understanding of the dynamics driving renewable energy adoption in developing nations like Vietnam.

3. RESEARCH METHODOLOGY

The study uses an autoregressive distributional lag (ARDL) approach with the following steps to examine the impact of growth, globalization, financial development, and CO_2 emissions on renewable energy consumption:

First, the data series are tested for stationarity by the extended Dickey-Fuller unit root (ADF) test. To determine whether the series Xt is stationary or not, the model is estimated:

$$\Delta X_t = \beta_1 + \beta_2 t + \delta X_{t-1} + \sum_{i=1}^{q} \alpha_i \Delta X_{t-i} + \varepsilon_t$$

Where $\Delta X_t = X_t - X_{t-1}$ and test the pair of hypotheses:

H_0: $\delta = 0$ (sequence X_t is not stationary); H_1: < 0 (sequence X_t is stationary)

If the sequence Xt remains stationary, it's termed an integral of order 0, denoted as I(0). In the event that the sequence Xt doesn't exhibit stationarity, the ADF test is applied to the difference between the original sequence andΔXt. If the resulting series ΔXt displays stationarity, the original series is classified as an integral of order 1, indicated as I(1).

We conducted the Johansen test to assess cointegration if the sequences used in the integrated analysis share the same order. However, if the sequences exhibit different orders of integration, and none of them are integrated at order 2 or higher, the suitable lags of the variables in the ARDL model are chosen using the AIC criterion before conducting the bound test. If a cointegration relationship is identified, then employing the ARDL approach is suitable. To investigate, the influence of various factors on renewable energy consumption in Vietnam, this study employs an ARDL model as follows:

$$\Delta LRE_t = \beta_0 + \sum_{i=1}^{p} \beta_{0i} \Delta LRE_{t-i} + \sum_{i=0}^{q1} \beta_{1i} \Delta KOF_{t-i} + \sum_{i=0}^{q2} \beta_{2i} \Delta FD_{t-i} + \sum_{i=0}^{q3} \beta_{3i} LGDP_{t-i} + \sum_{i=0}^{q4} \beta_{4i} \Delta LCO2_{t-i} + \sum_{i=0}^{q5} \beta_{5i} \Delta POP_{t-i} + \theta_0 LRE_{t-1} + \theta_1 KOF_{t-1} + \theta_2 FD_{t-1} + \theta_3 LGDP_{t-1} + \theta_4 LCO2_{t-1} + \theta_5 POP_{t-1} + u_t \quad (1)$$

In which: θ_i (i=1,2,3,4,5), β_0 and β_{kj} (k=1,2,3,4,5) are parameters, Δ is difference order 1, u_t is the error term.

Next, the short-run and long-run coefficients of the ARDL model with optimal lags are estimated. An error correction model (ECM) that considers the short-term impact of variables on renewable energy consumption forms as:

$$\Delta LRE_t = \beta_0 + \sum_{i=1}^{p} \beta_{0i} \Delta LRE_{t-i} + \sum_{i=0}^{q1} \beta_{1i} \Delta KOF_{t-i} + \sum_{i=0}^{q2} \beta_{2i} \Delta FD_{t-i} + \sum_{i=0}^{q3} \beta_{3i} LGDP_{t-i} + \sum_{i=0}^{q4} \beta_{4i} \Delta LCO2_{t-i} + \sum_{i=0}^{q5} \beta_{5i} \Delta POP_{t-i} + \mu ECT_{t-1} + \vartheta_t \quad (2)$$

This study uses data from Vietnam for the period 1995-2019 (Table 1).

Table 1. Variables.

Variables	Descriptions	Source
KOF	Globalization index	KOF globalization index (2021)
FD	Domestic credit to the private sector of banks (% GDP)	The world bank development indicators (2021)
LGDP	Logarithm of GDP per capita	
LPOP	Logarithm of population	
LCO_2	Logarithm of CO_2 emissions	Our world in data (2021)
LRE	The natural logarithm of renewable energy consumption	

4. EMPIRICAL RESULTS AND DISCUSSION

4.1. Unit Root Test

The Augmented Dickey-Fuller (ADF) unit root test results in Table 2 indicate that the sequences LRE, KOF, FD, LGDP, and LCO_2 are non-stationary in their original form, but become stationary after taking the first difference, indicating they are integrated of order 1. However, the LPOP sequence is stationary in its original form, indicating it is of order 0. We deemed the ARDL estimation appropriate for the empirical investigation, given that the sequences in model (1) exhibit integration of order 0 or order 1.

Table 2. ADF tests.

Variables	Original sequences		Difference sequences order 1		Results
	t-statistics	p-value	t-statistics	p-value	
LRE	-0.611	0.858	-3.812	0.008	I(1)
KOF	-0.460	0.891	-5.412	0.000	I(1)
FD	-0.152	0.921	-4.420	0.003	I(1)
LGDP	-0.409	0.881	-3.057	0.043	I(1)
LCO_2	-1.717	0.424	-6.281	0.000	I(1)
LPOP	-5.818	0.000	-2.116	0.000	I(0)

The bound test tests the hypotheses:

H_0: $\theta_0 = \theta_1 = \theta_2 = \theta_3 = \theta_4 = \theta_5 = 0$ (There is no co-integration relationship between the variables) H_1: $\theta_0 \neq \theta_1 \neq \theta_2 \neq \theta_3 \neq \theta_4 \neq \theta_5 \neq 0$ (there exists a co-integration relationship between the variables).

The outcomes of the bound test reveal that the F-statistic exceeds the critical value for integration of order 1 at all significance levels. Therefore, the null hypothesis (H0) is rejected, and the alternative hypothesis (H1) is accepted, indicating the presence of a long-run equilibrium relationship among the variables in model (1).

Table 3. Bound tests.

Degree of freedom	F-statistics	Critical values							
		90%		95%		97.5%		99%	
		I(0)	I(1)	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)
5	5.533	2.16	3.25	2.52	3.89	2.86	4.518	3.31	4.58

Table 3 reports the results of the calculated F-statistics for the equations under the ARDL regressions. The calculated F-statistic is 5.533, higher than the upper bound critical value of4.58 at 1% level. Thus, the null hypothesis is rejected, implying that there is a long-term co-integration relationship among variables in the model.

4.2. The Results of Long-Run Estimation

Table 4 illustrates how, throughout time, population growth, economic expansion, globalization, and CO2 emissions all impact the use of renewable energy. Wherein the use of renewable energy is strongly positively impacted by population increases. According to the statistical significance of the computed coefficient of the LPOP variable, population growth is a powerful long-term driver of rising renewable energy consumption. Population growth will increase demand for energy, increase concern about issues of energy security, environment (such as air pollution, global warming, climate change, etc.), push society towards cleaner energy sources, and thus, use more renewable energy.

With an estimated KOF variable coefficient of 5%, which is positive and statistically significant, globalization has a long-term positive effect on the use of renewable energy. The application of new technology in the production process is responsible for KOF's beneficial impact on LRE. This result suggests that production-related technological innovation requirements may have encouraged Vietnam to use more renewable energy through the transfer to import of technology that utilizes renewable energy.

The non-significant coefficient of FD suggests that financial development has not directly influenced renewable energy consumption in Vietnam. The Vietnamese economy primarily relies on traditional energy sources for its production and consumption needs, which could explain this. Despite recent advancements in the financial system, the focus has primarily been on facilitating general energy access rather than specifically promoting renewable energy utilization. A well-established financial infrastructure could potentially offer stronger incentives for clean energy production initiatives and research and development (R&D) endeavors supporting renewable energy adoption. On the other hand, limited financial resources might impede renewable energy consumption, while enhanced financial services can facilitate business access to funding for clean energy adoption. These findings diverge from those of several other studies Eren, Taspinar, and Gokmenoglu (2019) and Hassine and Harrathi

(2017) have reported a positive and statistically significant relationship between financial development and renewable energy consumption. The estimated results show that GDP per capita has a negative impact on renewable energy consumption. Specifically, other things being equal, renewable energy consumption fell by 3.11% when GDP per capita increased by 1%. This can be explained by the fact that Vietnam is a developing economy, growth is a top priority, and the environment is placed at a lower priority in the development process. Consequently, the economy allocates resources without considering the environmental impact. Renewable energy requires expensive technology, high initial investment costs. This leads to continued growth in traditional energy consumption. Alternatively, the negative correlation between per capita income and renewable energy consumption can also be attributed to cost. Current non-renewable energy sources are less expensive than renewable energy sources. Because households are quite price-sensitive and have low average income, they are not willing to spend on renewable energy. Another possibility is that the policy to support renewable energy consumption is lacking or has not been effective. This result is similar to the findings of Shahbaz et al. (2021).

CO2 emissions negatively impact Vietnam's use of renewable energy, according to the data. Keeping all other things equal, the statistically significant coefficient of LCO2 shows that for every 1% increase in CO2 emissions, the consumption of renewable energy falls by 1.78%. Vietnam's use of renewable energy is still quite low as apercentage of total energy consumed. Other than hydroelectric electricity, Vietnam has just lately started to develop renewable energy sources like solar and wind energy, and they have not yet been able to keep up with the country's growing energy demand, which is still mostly satisfied by fossil fuels. Assuming that rising emissions will increase public awareness of environmental issues, low societal wealth levels mean that sustainability and climate change mitigation objectives receive insufficient attention. Consequently, the transition from traditional to renewable energy sources has been sluggish. This suggests that environmental considerations may not have been a top priority in Vietnam's national development plan in recent years. These findings align with the results of Jaforullah and King (2015); Attiaoui, Toumi, Ammouri, and Gargouri (2017) and Bilan et al. (2019) but contradict those of Saidi and Hammami (2015) and Hwang and Yoo (2014) which suggest that carbon emissions stimulate renewable energy consumption.

Table 4. The results of long-run coefficient estimation.

Independent variables	Dependent variable-LRE		
	Coefficient	Standard error	t-statistics
C	-343.833	152.734	-2.262
KOF	0.185**	0.077	2.236
FD	0.011	0.007	1.541
LGDP	-3.120*	1.440	-2.148
LCO_2	-1.778**	0.780	-2.252
LPOP	21.134**	8.754	2.413

Note: * p < 0.1, **p < 0.05.

4.3. The Results of Short-Run Estimation

The results show how population growth and globalization have a favorable impact on the use of renewable energy. On the other hand, changes in CO2 emissions and financial development have a detrimental effect on the use of renewable energy. This implies that financial development may limit the use of renewable energy sources unless there is a systematic change in the direction of energy policy. Furthermore, there doesn't seem to be any immediate correlation between economic growth and the use of renewable energy. These findings highlight policy inadequacies related to the growth of renewable energy in Vietnam and point to the necessity of altering policies to promote the increased use of renewable energy sources in the face of shifting national and international conditions.

The findings presented in Table 5 reveal a negative one-period lagged error correction term (-0.558793), which is statistically significant at the 1% level. This indicates that renewable energy consumption has the capability to

self-adjust towards long-term equilibrium following short-term disturbances arising from fluctuations in globalization, financial development, per capita income, emissions, and population.

Table 5. The results of short-run coefficient estimation.

Independent variables	Dependent variable-LRE		
	Coefficient	Standard error	t-statistics
D(KOF)	0.060**	0.027	2.512
D(FD)	-0.005	0.003	-1.514
D(FD-1)	-0.010**	0.004	-2.422
D(LGDPPC)	-0.952	0.536	-1.673
D(LCO_2)	-1.027***	0.306	-3.207
D(LPOP)	565.506*	270.147	2.039
D(LPOP-1)	-446.951**	188.944	-2.283
ECT(-1)	-0.559***	0.151	-3.443
ECT = LRE – (0.1845*KOF + 0.0113*FD – 3.1193*LGDPPC – 1.7780*LCO_2 + 21.1341*LPOP – 343.8329)			

Note: * p < 0.1, **p < 0.05, ***p < 0.01.

4.4. The Results of the ECM Model Test

The results of the ECM model test (Table 6) show that the model satisfies the basic assumptions of the estimation method.

Table 6. Diagnostic test.

Tests	F- statistics	p-values
RAMSEY	0.399	0.539
BG	2.162	0.158
BPG	0.262	0.969
JB	0.888	0.641

The results show that both cumulative sum of recursive residual tests (CUSUM) and cumulative sum of squares of recursive residual test (CUSUMSQ) are well within critical boundsat 5% significance level (Figure 1a, b), so the model's robustness is ensured.

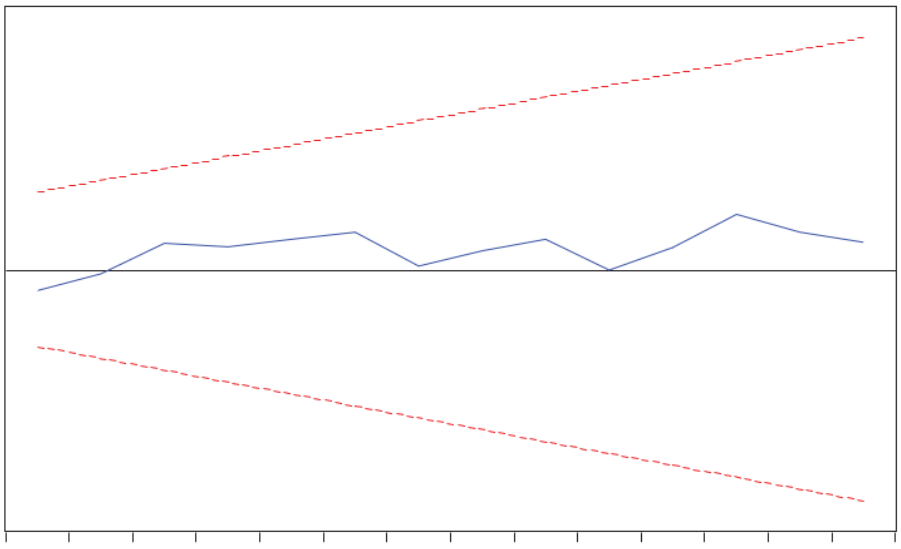

Figure 1a. Cumulative sum of recursive residual test.

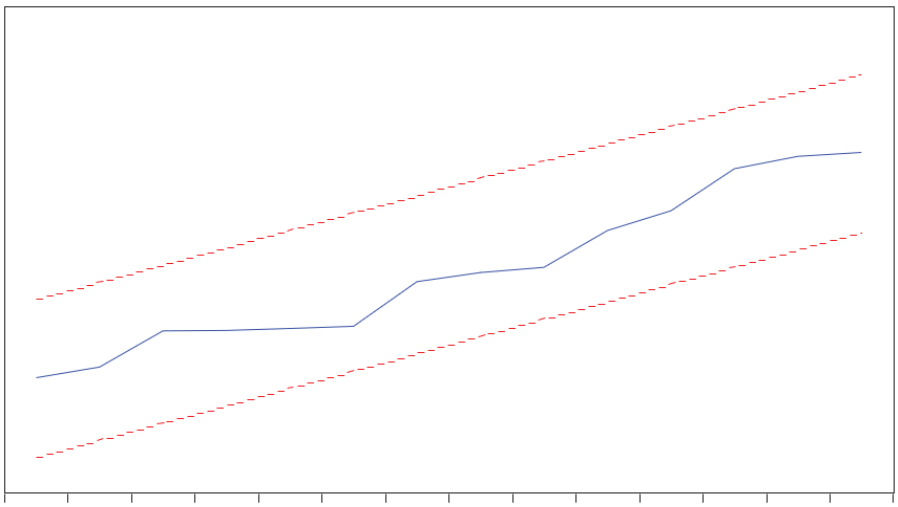

Figure 1b. Cumulative sum of squares of recursive residual test.

5. CONCLUSIONS AND POLICY IMPLICATIONS

The Autoregressive Distributed Lag (ARDL) method is used in this study to examine how CO2 emissions, financial development, globalization, and economic expansion have affected Vietnam's use of renewable energy from 1995 to 2019. The empirical results provide a number of important insights. First, globalization, financial development, GDP per capita, CO2 emissions, and renewable energy use all have long-term equilibrium relationships.

Second, while economic expansion and CO2 emissions have a negative impact on renewable energy consumption, globalization and population growth ultimately drive it in a favorable way. Notably, financial development does not directly impact Vietnam's use of renewable energy. Third, in the near run, population expansion and globalization will support the use of renewable energy. Alterations in carbon dioxide emissions and financial progress, on the other hand, result in a decrease in the use of renewable energy.

The empirical findings validate the positive influence of globalization on renewable energy consumption in Vietnam. Consequently, it is imperative for the government to sustain its support for globalization to further stimulate renewable energy consumption in the future. Specifically, Vietnam should implement favorable policies aimed at attracting Foreign Direct Investment (FDI) capital linked to green and clean technologies. Additionally, maintaining an outward-focused trade strategy and fostering the dissemination and transfer of new technologies will be crucial in leveraging the advantages of globalization to expedite the transition towards a renewable energy-based economy.

By embracing these measures, Vietnam can enhance its position in the global renewable energy landscape and contribute significantly to sustainable development efforts.

The paper's findings underscore that financial development does not exert an influence on renewable energy consumption in Vietnam over the long term. As a result, along with advancing the domestic renewable energy agenda, Vietnam should prioritize the enhancement of its financial system. This involves offering improved incentives for clean energy production projects and supporting research and development (R&D) initiatives geared towards renewable energy utilization. To achieve this, Vietnam should consider implementing appropriate financial incentives for clean technology and renewable energy adoption while simultaneously reducing its reliance on fossil fuels.

Furthermore, efforts should be made to encourage financial institutions to facilitate easier access to finance from both the stock market and banking sectors. This would enable businesses to invest in advanced and energy-efficient equipment and technologies, thereby fostering sustainable development and improving environmental quality in Vietnam.

The study highlights the negative impact of CO_2 emissions on renewable energy consumption that can be overlooked because of the lower cost of non-renewable energy.

Cost-related obstacles need to be overcome with the support of government, large corporations, and international organizations. In order to promote the transition to a renewable energy economy, along with the need for the participation of market forces, policymakers need to pay attention to raising public awareness about the importance and role of renewable energy consumption for sustainable development.

Although the dataset of this study is relatively large, during this period there was the Asian financial crisis, which may have had certain impacts on research results.

Therefore, it would be better if this dataset were processed into two stages or dummy variables could be added to the empirical research model. The researchers should certainly pursue this important work in the future.

Funding: This study received no specific financial support.
Institutional Review Board Statement: Not applicable.
Transparency: The authors state that the manuscript is honest, truthful, and transparent, that no key aspects of the investigation have been omitted, and that any differences from the study as planned have been clarified. This study followed all writing ethics.
Data Availability Statement: The corresponding author can provide the supporting data of this study upon a reasonable request.
Competing Interests: The authors declare that they have no competing interests.
Authors' Contributions: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Wrote the paper, M.N.N.; performed the experiments; contributed reagents, materials, analysis tools or data; wrote the paper, T.N.N.; analyzed and interpreted the data; wrote the paper, K.V.H.; analyzed and interpreted the data, G.P.X. and C.T.H.P. All authors have read and agreed to the published version of the manuscript.

REFERENCES

Anton, S. G., & Nucu, A. E. A. (2020). The effect of financial development on renewable energy consumption a panel data approach. *Renewable Energy, 147*, 330-338. https://doi.org/10.1016/j.renene.2019.09.005

Apergis, N., & Payne, J. E. (2015). Renewable energy, output, carbon dioxide emissions, and oil prices: Evidence from South America. *Energy Sources, Part B: Economics, Planning, and Policy, 10*(3), 281-287. https://doi.org/10.1080/15567249.2013.853713

Attiaoui, I., Toumi, H., Ammouri, B., & Gargouri, I. (2017). Causality links among renewable energy consumption, CO2 emissions, and economic growth in Africa: Evidence from a panel ARDL-PMG approach. *Environmental Science and Pollution Research, 24*(14), 13036-13048. https://doi.org/10.1007/s11356-017-8850-7

Best, R. (2017). Switching towards coal or renewable energy? The effects of financial capital on energy transitions. *Energy Economics, 63*, 75-83. https://doi.org/10.1016/j.eneco.2017.01.019

Bilan, Y., Streimikiene, D., Vasylieva, T., Lyulyov, O., Pimonenko, T., & Pavlyk, A. (2019). Linking between renewable energy, CO2 emissions, and economic growth: Challenges for candidates and potential candidates for the EU membership. *Sustainability, 11*(6), 1528. https://doi.org/10.3390/su11061528

Burakov, D., & Freidin, M. (2017). Financial development, economic growth and renewable energy consumption in Russia: A vector error correction approach. *International Journal of Energy Economics and Policy, 7*(6), 39-47.

Chang, S.-C. (2015). Effects of financial developments and income on energy consumption. *International Review of Economics & Finance, 35*, 28-44. https://doi.org/10.1016/j.iref.2014.08.011

Charfeddine, L., & Kahia, M. (2019). Impact of renewable energy consumption and financial development on CO2 emissions and economic growth in the MENA region: A panel vector autoregressive (PVAR) analysis. *Renewable Energy, 139*, 198-213. https://doi.org/10.1016/j.renene.2019.01.010

Eren, B. M., Taspinar, N., & Gokmenoglu, K. K. (2019). The impact of financial development and economic growth on renewable energy consumption: Empirical analysis of India. *Science of the Total Environment, 663*, 189-197. https://doi.org/10.1016/j.scitotenv.2019.01.323

Gozgor, G., Mahalik, M. K., Demir, E., & Padhan, H. (2020). The impact of economic globalization on renewable energy in the OECD countries. *Energy Policy, 139*, 111365. https://doi.org/10.1016/j.enpol.2020.111365

Hassine, M. B., & Harrathi, N. (2017). The causal links between economic growth, renewable energy, financial development and foreign trade in gulf cooperation council countries. *International Journal of Energy Economics and Policy, 7*(2), 76-85. https://doi.org/10.1016/j.rser.2015.06.005

Hwang, J. H., & Yoo, S. H. (2014). Energy consumption, CO2 emissions, and economic growth: Evidence from Indonesia. *Quality & Quantity, 48*(1), 63-73. https://doi.org/10.1007/s11135-012-9749-5

Jaforullah, M., & King, A. (2015). Does the use of renewable energy sources mitigate CO2 emissions? A reassessment of the US evidence. *Energy Economics, 49*, 711-717. https://doi.org/10.1016/j.eneco.2015.04.006

Kutan, A. M., Paramati, S. R., Ummalla, M., & Zakari, A. (2018). Financing renewable energy projects in major emerging market economies: Evidence in the perspective of sustainable economic development. *Emerging Markets Finance and Trade, 54*(8), 1761-1777. https://doi.org/10.1080/1540496x.2017.1363036

Lee, S.-H., & Jung, Y. (2018). Causal dynamics between renewable energy consumption and economic growth in South Korea: Empirical analysis and policy implications. *Energy & Environment, 29*(7), 1298-1315. https://doi.org/10.1177/0958305x18776546

Leitão, N. C. (2014). Economic growth, carbon dioxide emissions, renewable energy and globalization. *International Journal of Energy Economics and Policy, 4*(3), 391-399. https://doi.org/10.26650/ekoist.2018.14.29.0013

Lu, J., Imran, M., Haseeb, A., Saud, S., Wu, M., Siddiqui, F., & Khan, M. J. (2021). Nexus between financial development, FDI, globalization, energy consumption and environment: Evidence from BRI countries. *Frontiers in Energy Research, 9*, 707590. https://doi.org/10.3389/fenrg.2021.707590

Ocal, O., & Aslan, A. (2013). Renewable energy consumption-economic growth nexus in Turkey. *Renewable and Sustainable Energy Reviews, 28*(C), 494-499. https://doi.org/10.1016/j.rser.2013.08.036

Omri, A., Daly, S., & Nguyen, D. K. (2015). A robust analysis of the relationship between renewable energy consumption and its main drivers. *Applied Economics, 47*(28), 2913-2923. https://doi.org/10.1080/00036846.2015.1011312

Ozturk, I., & Bilgili, F. (2015). Economic growth and biomass consumption nexus: Dynamic panel analysis for Sub-Sahara African countries. *Applied Energy, 137*, 110-116. https://doi.org/10.1016/j.apenergy.2014.10.017

Padhan, H., Padhang, P. C., Tiwari, A. K., Ahmed, R., & Hammoudeh, S. (2020). Renewable energy consumption and robust globalization (s) in OECD countries: Do oil, carbon emissions and economic activity matter? *Energy Strategy Reviews, 32*, 100535. https://doi.org/10.1016/j.esr.2020.100535

Paweenawat, S. W., & Plyngam, S. (2017). Does the causal relationship between renewable energy consumption, CO2 emissions, and economic growth exist in Thailand? An ARDL approach. *Economics Bulletin, 37*(2), 697-711.

Sadorsky, P. (2009). Renewable energy consumption and income in emerging economies. *Energy Policy, 37*(10), 4021-4028. https://doi.org/10.1016/j.enpol.2009.05.003

Saidi, K., & Hammami, S. (2015). The impact of CO2 emissions and economic growth on energy consumption in 58 countries. *Energy Reports, 1*, 62-70. https://doi.org/10.1016/j.egyr.2015.01.003

Shafiei, S., & Salim, R. A. (2014). Non-renewable and renewable energy consumption and CO2 emissions in OECD countries: A comparative analysis. *Energy Policy, 66*, 547-556. https://doi.org/10.1016/j.enpol.2009.05.003

Shahbaz, M., Raghutla, C., Chittedi, K. R., Jiao, Z., & Vinh, V. X. (2020). The effect of renewable energy consumption on economic growth: Evidence from the renewable energy country attractive index. *Energy, Elsevier, 207*(C), 118162. https://doi.org/10.1016/j.energy.2020.118162

Shahbaz, M., Topcu, B. A., Sarıgül, S. S., & Vinh, V. X. (2021). The effect of financial development on renewable energy demand: The case of developing countries. *Renewable Energy, Elsevier 178*(C), 1370-1380. https://doi.org/10.1016/j.renene.2021.06.121

Sinha, A., Shahbaz, M., & Sengupta, T. (2018). Renewable energy policies and contradictions in causality: A case of Next 11 countries. *Journal of Cleaner Production, 197*, 73-84. https://doi.org/10.1016/j.jclepro.2018.06.219

Wu, L., & Broadstock, D. C. (2015). Does economic, financial and institutional development matter for renewable energy consumption? Evidence from emerging economies. *International Journal of Economic Policy in Emerging Economies, 8*(1), 20-39. https://doi.org/10.1504/ijepee.2015.068246

Yazdi, K. S., & Shakouri, B. (2017). The globalization, financial development, renewable energy, and economic growth. *Energy Sources, Part B: Economics, Planning, and Policy, 12*(8), 707-714.