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Research Article

Nexus Between Financial Development and Renewable Energy Usage in Bangladesh

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Abstract

Utilizing renewable energy is a method to reduce climate change and address the energy sector crisis in Bangladesh. Nonetheless, the progress of the renewable energy sector depends on monetary expansion, the accessibility of financial assets, and energy costs. This study examined the short- and long-term effects of financial development on green energy usage, accounting for energy pricing and GDP expansion. In accordance with the paper's objective, the Autoregressive Distributed Lag (ARDL) approach was utilized, employing data from 1990 to 2021. The results demonstrated that financial development promotes clean power utilization in Bangladesh, but energy expenses and economic growth exert a detrimental impact. This study significantly contributes to renewable energy literature and facilitates policymakers in exploring alternate energy supplies to meet the country's increasing electricity demands.

Keywords: Renewable energy, financial development, energy price, economic growth, sustainable development.

Introduction

Academic involvement in the relationship involving renewable energy (RE) usage and its determinants has surged in recent decades, likely due to increasing awareness of greenhouse gas (GHG) pollution and its adverse ecological effects [1]. Energy is essential for both emerging and mature regions to achieve equitable prosperity. The last decade observed a significant rise in electricity consumption due to population growth, enhanced living standards, manufacturing improvements, and economic competitiveness [2]. Despite a yearly growth of roughly 5% in renewable energy demand from 2009 to 2019, the volume of fossil fuels in total energy consumption persisted at around 80% during that timeframe [3]. Excessive combustion of fossil fuels generates significant carbon dioxide (CO_2) emissions into the atmosphere, resulting in detrimental environmental effects, including climate change [4]. The greenhouse effect poses a significant threat to the natural balance of life, making it one of the most urgent challenges of our time [5]. One strategy to mitigate

global warming and its severe environmental repercussions includes reducing fossil fuel consumption in electricity production and shifting to sustainable power supplies that do not emit GHGs [6]. Besides mitigating adverse ecological impacts, renewable energy can protect economies that depend significantly on energy imports from external shocks [7]. The relationship between energy requirement and GDP expansion has garnered significant focus in writing; however, the influence of these variables on each other remains ambiguous due to variations in statistical methodologies; the specific measures of fiscal advancement are examined, as well as the countries and timeframes analyzed.

The initial costs and operational expenses of alternative energy initiatives exceed those of non-renewables [8]. A sophisticated finance sector can expedite the development of the renewable energy sector by effectively directing capital towards it [9]. Moreover, clean power projects are reliant on equity and debt investment progress more rapidly in regions with advanced monetary industries compared to those with underdeveloped sectors, as organizational and capital funding are more suitable for projects with high costs [10]. Bangladesh is an emerging nation with a population of over 170 million. As the populace rises, energy consumption also escalates [11]. Nevertheless, Bangladesh imports a larger proportion of its energy requirements, exerting strain on the nation's economy. Bangladesh's financial sector is now undergoing alterations and liberalization. Consequently, its impact on the electricity sector remains at a constant level of change. Consequently, it is essential to investigate the correlation between RE usage and monetary progress.

The paper empirically assessed the implication of financial development (FD) on renewable energy (RE) usage in Bangladesh using several econometric methods. This work diverges from prior research in several respects. This study is likely the first to investigate the relationship between monetary industry expansion and RE utilization in Bangladesh at the national scale. The inquiry examined the influence of FD on RE usage over an extended timeframe. We enhance the existing literature by investigating the conceptual relationship between FD and clean power in Bangladesh. The empirical results from the analysis of the relationship among financial expansion, GDP growth, energy costs, and RE utilization can assist academicians in Bangladesh in devising strategies to enhance sustainable energy consumption; this represents the practical contribution of the investigation. The findings of this article indicate that the modernization of the financial sector in Bangladesh primarily facilitates the utilization of renewable energy. Nevertheless, investments in green electricity are affected by various circumstances. Consequently, policymakers encounter a significant challenge in devising specific responses to this situation. In this perspective, a contribution of the study is to delineate the priorities necessary to achieve this purpose.

Literature review

The study on energy consumption and GDP expansion has garnered considerable attention in recent decades; however, the findings are sometimes contradictory. The results concentrate on four principal hypotheses. The seminal research of Kraft and Kraft [12] asserts that a unidirectional causality exists between GDP expansion and electricity adoption. As economies grow, the requirement for power to enhance the standard of living will rise correspondingly [13-21]. Conversely, certain studies have asserted that energy is a necessary component of industrialization, facilitating monetary development [22-28]. These evaluations support the growth concept. Certain investigations have identified a bidirectional correlation between the rise in GDP and the adoption of RE [29-39]. The outcomes of these analyses align with the feedback hypothesis, which encompasses both the conservative and development theories. It posits that a reliable power supply fosters GDP, which then increases the need for electricity usage. Subsequently, more research has corroborated the neutrality theory, which posits an absence of causality between GDP growth and the utilization of RE [40-45].

Recently, the finance-energy nexus has emerged as a critical issue in economics and finance. The consumption of fossil fuels is recognized to elevate atmospheric CO_2 levels [46], whilst the utilization of renewable energy is acknowledged to reduce CO_2 emissions [47-49]. Certain research indicates that financial progress pushes energy demand [50-60]. Conversely, several research indicated a negative effect of FD on

RE [18,61-63]. Nonetheless, Denisova [54] showed that FD did not influence RE. Additionally, as the FD-energy nexus is complex, they investigated unbalanced impacts and nonlinearities within the relationship [19,64-68].

The fundamental goal of this paper is to explore the implication of FD on the use of green energy, a compelling area of research. Renewable energy initiatives require substantial initial investments and prolonged return on investment periods [46,69,70]. This situation constitutes a significant impediment to enhancing these investigations [14]. Few studies on the FD-RE connections indicate that enhancements in monetary service processes reduce the costs associated with RE finances and promote the adoption of RE [71,72]. Market-oriented financial growth enhances the possibility of directing resources to clean power initiatives, hence increasing the demand for green energy [50,51,73-75]. Brunnschweiler [76] contended that robust financial systems may effectively direct investments into the RE industry, whereas deficient financial systems may obstruct capital flow to this sector. Consequently, stakeholders in the RE sector would prefer countries with an advanced financial mechanism due to the increased probability of rapid availability of funds [77,78].

Furthermore, McFarlane et al. [64] underscored that advancements in the financial industry enhance the transfer of wealth, facilitating access to loans for enterprises and families while augmenting investment prospects. This enables individuals to allocate greater financial resources towards luxury items, hence augmenting energy demand, particularly with autos and machinery [78]. Nonetheless, research regarding the precise influence of FD on RE remains scarce. Babbar and Schuster [79] identified substantial knowledge deficiencies in financing renewable energy initiatives and underscored the necessity for private involvement in underdeveloped countries.

Shahbaz et al. [46] explored the consequence of FD on alternative energies in 34 emerging nations from 1994 to 2015. Empirical research demonstrates that FD propels RE, while economic growth adversely affects RE. The study concluded that energy prices exerted no influence on RE. They claimed that renewable energy will reduce CO_2 emissions in comparison to fossil fuels. To achieve equitable growth, authorities should implement rewards and tax regulations that promote enterprises' adoption of clean power. Mukhtarov et al. [14] employed VECM and ARDL methodologies to examine the impact of FD on RE in Turkey from 1980 to 2019. They found that FD positively affects the consumption of RE. The study reveals that economic expansion positively impacts RE. Nonetheless, their analysis indicated that price escalations adversely affect the adoption of sustainable electricity.

Khan et al. [80] analyzed the effect of FD and RE on CO_2 emission by employing a panel quantile regression methodology on a global panel of 192 countries from 1980 to 2018. They found that RE mitigates CO2, while FD positively influences RE. Utilizing annual data from the leading 15 renewable energy-consuming nations and a panel smooth transition model (PSTR), Raza et al. [67] determined that a high (low) FD regime exerts an adverse influence on RE. Eren et al. [81] examined the correlations among FD, economic growth, and RE in India. Their DOLS estimation findings suggest that FD positively influences RE. Regarding causation, they endorsed the feedback theory and established a unidirectional causality from FD to GDP expansion and RE consumption. Anton and Nucu [82] utilized the fixed effect model on a panel including 28 European Union (EU) countries from 1990 to 2015 and indicated that FD typically exerts a beneficial influence on RE. Nevertheless, the data suggested that the growth of monetary sectors has a minimal influence on real estate in the chosen area.

Kim and Park [73] discovered that in nations with strong financial markets, RE sectors increasingly depend on liabilities and ownership capital financing for rapid expansion. Paramati et al. [75] analyzed a panel of 20 rising nations from 1991 to 2012 and indicated that stock market expansion, FDI, and GDP development favorably influence RE. Their results support Wu and Broadstock [83], who discovered that FD significantly impacted RE in 22 developing nations from 1990 to 2010. Wang et al. [84] demonstrated through the ARDL-PMG model that GDP expansion promotes RE usage, whereas FD adversely affects it in both China and

western China. Ali et al. [85] validated the feedback loop between FD and RE. Rasoulinezhad and Saboori [86] identified unilateral causation from FD to RE. Hassine and Harrathi [23] examined the FD-RE relationship for the Gulf Cooperation Council (GCC) countries from 1980 to 2012. They discovered a unidirectional causal relationship originating from the RE to the FD. The research additionally demonstrated that the long-term coefficients from RE to FD are both encouraging and significant.

The FD-RE correlations for most of the economies are inherently unknown, as indicated by the literature analysis. Consequently, the connection must be determined by empirical methods. Notwithstanding the substantial proof, financial sector changes, and advancements in the green power sector in Bangladesh, there exists minimal consensus regarding the relationship between FD and RE. Regrettably, to the authors' knowledge, empirical study has yet to investigate the link between the advancement of Bangladesh's financial industry and the utilization of renewable energy. Furthermore, the majority of studies focused on a specific indicator and a proxy for renewable energy. However, other factors may significantly impact these endeavors. Therefore, a study that concurrently assesses the implication of several variables on renewable energy is essential to understanding key hurdles in improving investments in this sector. Consequently, this analysis aims to explore the influence of monetary expansion, rise in GDP, and energy pricing on the utilization of clean power.

Methodology

Numerous authors have modeled energy use in relation to the financing gap, electricity costs, and GDP expansion [18,46,56,68,87]. Employing the identical theoretical framework, McFarlane et al. [64], Mukhtarov et al. [14,56], and Shahbaz et al. [46] formulated a model wherein renewable energy (RE) is a function of financial growth, GDP, and the consumer price index (CPI). Anton and Nucu [82] further expanded this model by incorporating foreign direct investment (FDI). Nonetheless, certain research employed FDI as a metric for assessing financial development [19,51,88]. In light of these findings, we did not include FDI as a distinct variable in our model definition. Consequently, in accordance with prior research, we delineate the model as follows:

$$RE_t = \tau_0 + \tau_1 FD_t + \tau_2 GDP_t + \tau_3 EP_t + + \varepsilon_t \quad (1)$$

RE_t signifies renewable energy consumption; FD_t indicates financial development; GDP_t represents economic growth; and EP_t suggests energy costs. εt means the stochastic error term. FD and GDP are anticipated to elevate RE, whereas EP is projected to hinder RE.

This study investigated the influence of FD on RE while incorporating EP in Bangladesh. The sample period extends from 1990 to 2021, contingent upon access to data. The statistics utilized in this study, including sustainable power usage (% of total energy consumption), GDP expansion as indicated by real GDP per capita (current US$), financial development calculated by domestic credit to the private sector (% of GDP), and energy costs represented by the consumer price index (2010=100), were all sourced from World Development Indicators (WDI) [3]. This study utilized the CPI to estimate energy costs, owing to the insufficient information on energy prices across all nations—a method widely adopted in previous research [14,19,51,57,64,89,90].

We transformed all factors into their natural algorithmic form for the sake of calculation and result description [91,92]. This study assesses the long-term effects of FD on RE while accounting for variations in GDP and EP through the ARDL limit testing method. It was selected over traditional cointegration techniques due to its ability to produce precise and dependable outcomes for small and finite sample datasets. Moreover, this technique is appropriate for addressing a conjunction of I(0) and I(1) variables and employs vibrant criteria that consider the implication of lagged values of both the dependent and independent variables [93-95]. This adaptable specification method allows for a concurrent estimation of both long- and short-term relationships. The study incorporates the Augmented Dickey-Fuller (ADF) [96], Dickey-Fuller

Generalized Least Squares (DF-GLS) [97], and Phillips and Perron (P-P) [98] unit root analyses to investigate the unit root properties of the series. The ARDL approach requires that the series be at most I(1). Following the assessment of data stationarity by unit root tests, we examined the long-term cointegration across the parameters utilizing the ARDL bounds examination [99]. The estimation of the ARDL structure is presented below:

$$\Delta LRE_t = \tau_0 + \tau_1 LRE_{t-1} + \tau_2 LFD_{t-1} + \tau_3 LGDP_{t-1} + \tau_4 LEP_{t-1} + \sum_{i=1}^{q} \gamma_1 \Delta LRE_{t-i} + \sum_{i=1}^{q} \gamma_2 \Delta LFD_{t-i} + \sum_{i=1}^{q} \gamma_3 \Delta LGDP_{t-i} + \sum_{i=1}^{q} \gamma_4 \Delta LEP_{t-i} + \varepsilon_t \quad (2)$$

The null hypothesis (H0) posits the absence of cointegration, while the alternative hypothesis (H1) indicates the degree of cointegration among the integration. The limit testing comprises the F-bounds evaluations, and it is computed by adopting the variable and subsequently comparing it to the relevant I(0) and I(1) values at the chosen threshold range. The H0 for all cases is rejected if the projected numbers above their respective I(1) weights at the designated significance level. Moreover, it concludes that the parameters are cointegrated. The maximum lag (n) was established by incorporating the Akaike information criterion (AIC) to ensure that the residuals of the assumed framework are devoid of serial correlation, heteroscedasticity, or non-normality. Upon addressing the cointegration issue across the factors, the investigation advances to calculate the long-run coefficient using Equation (2) within an ARDL structure. Following the verification of sustained connection, the research advances to evaluate the error correcting term (ECT). This inference aims to analyze the short-term trends of the relevant components at which they approach their prolonged stability. This integration of the ECT into the ARDL methodology is demonstrated in Equation (3) to achieve the goal.

$$\Delta LRE_t = \tau_0 + \tau_1 LRE_{t-1} + \tau_2 LFD_{t-1} + \tau_3 LGDP_{t-1} + \tau_4 LEP_{t-1} + \sum_{i=1}^{q} \gamma_1 \Delta LRE_{t-i} + \sum_{i=1}^{q} \gamma_2 \Delta LFD_{t-i} + \sum_{i=1}^{q} \gamma_3 \Delta LGDP_{t-i} + \sum_{i=1}^{q} \gamma_4 \Delta LEP_{t-i} + \theta ECT_{t-1} + \varepsilon_t \quad (3)$$

The parameter θ, known as the speed of adjustment, defines the pace of adjustments. Variance reduction potential arises in situations where ECT exhibits both statistical significance and adverse effects.

Results and discussion

Table 1 presents the outcomes of a series of tests performed to verify the normality of the datasets, together with detailed data description.

Table 1. Summary statistics of the variables.

Variables	LRE	LFD	LGDP	LEP
Mean	3.83	3.34	6.47	4.35
Median	3.90	3.41	6.21	4.27
Maximum	4.29	3.79	7.81	5.30
Minimum	3.22	2.68	5.65	3.47
Std. dev.	0.34	0.37	0.69	0.58
Skewness	-0.38	-0.37	0.62	0.15
Kurtosis	1.89	1.71	2.09	1.70
Jarque-Bera	2.39	2.96	3.18	2.37
Probability	0.30	0.23	0.21	0.31

The dataset clearly exhibited a normal distribution, as indicated by skewness values approaching zero. Furthermore, kurtosis values less than 3 indicated the dominance of platykurtic characteristics. Furthermore,

the probability values exceeded 0.1, and the low Jarque-Bera test values confirmed the normal distribution of all variables.

The ARDL bound test is unsuitable for the inclusion of I(2) variables due to the need for all parameters to fit to order one or I(1). We examined the unit root characteristics of the variables utilizing three distinct unit root tests: ADF, DF-GLS, and P-P, which are showcased in Table 2. The findings indicate that none of the variables exhibits stationarity at level I(0). Subsequent to applying the initial difference I(1), all variables exhibited stationarity. Therefore, the ARDL cointegration method is applicable.

Table 2. Unit root test results.

Variables	ADF		DF-GLS		P-P	
	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)
LRE	-0.59	-5.54***	-0.58	-3.92***	-0.57	-5.53***
LFD	-0.88	-5.23***	-0.66	-3.94***	-0.83	-5.22***
LGDP	-0.92	-4.89***	-0.75	-4.72***	-0.92	-4.86***
LEP	-0.35	-4.34***	-0.46	-4.20***	-0.27	-4.35***

Note: The table reports the results of the unit root tests (ADF, DF-GLS, and P-P) at levels I(0) and first differences I(1). *** indicates significance at the 1% level.

The cointegration association among the elements was assessed utilizing the ARDL bounds examination. Table 3 encapsulates the conclusions of the cointegration evaluation. Results illustrate that the F-test statistic exceeds the I(1) threshold at the 1% threshold (7.86 compared to 4.66). The F-test demonstrates that the null hypothesis may not be accepted. Consequently, it implies that the variables exhibit a cointegrating connection.

Table 3. ARDL bounds test results.

Test statistic	Estimate	Significance levels	I(0)	I(1)
F-statistic	7.86	10%	2.37	3.20
K	3	5%	2.79	3.67
		2.5%	3.15	4.08
		1%	3.65	4.66

Note: The table presents the F-statistic for the ARDL bounds test, along with the critical values for significance levels at I(0) and I(1). K represents the number of regressors in the model.

Considering the cointegration within the estimated factor and the regressors, we incorporated the ARDL framework to check both the short and long-run relationships among the elements (Table 4). The estimations demonstrate that a 1% increment in FD results in a 0.27% upsurge in RE consumption in the immediate time and a 0.59% rise in the long run. Our findings align with prior research [14, 46, 50, 51, 71-78, 80, 82, 83] although some studies contradict with the findings [18, 61-63, 67, 84]. From a theoretical perspective, the advantageous consequence of monetary growth on green power indicates that sophisticated financial systems facilitate access to affordable funding sources for institutions and individuals, hence promoting corporate expansion or a luxury acquisition, which in turn enhances the demand for sustainable power. Moreover, financial expansion can stimulate technological innovation in the renewable energy sector.

This result indicates that a 1% economic development will result in a 0.32% fall in RE consumption in the near run and a 0.48% reduction in the long run. A credible hypothesis is that as Bangladesh's per capita income rose from 1990 to 2021, the consumption of renewable energy diminished due to insufficient income levels, leading consumer expenditure to shift towards fossil fuels. The empirical study corroborates the conclusions of other investigations [46,75] while a few studies contradict with the findings [14,64,84]. Furthermore, we identified an inverse relationship between RE and EP, suggesting that a 1% spike in EP will result in a 0.11% decrease in RE consumption in the near term and a 0.19% fall over time. This finding aligns

with prior investigations [14,64]. Nevertheless, this empirical finding contrasts with multiple research that affirmed the negligible influence of energy costs on renewable energy [46].

Table 4. ARDL long and short-run results.

Variables	Long-run			Short-run		
	Coefficient	t-statistic	p-value	Coefficient	t-statistic	p-value
LFD	0.59***	4.16	0.00	0.27***	3.47	0.00
LGDP	-0.48***	-3.25	0.00	-0.32***	-3.17	0.00
LEP	-0.19***	-3.47	0.00	-0.11***	-3.59	0.00
C	12.33	1.143	0.11	-	-	-
ECT (-1)	-	-	-	-0.65***	-4.20	0.00
R^2	0.98					
Adjusted R^2	0.98					

Note: The table presents the coefficients, t-statistics, and p-values for the ARDL model's long-run and short-run estimates. *** indicates significance at the 1% level.

The regression model demonstrates an excellent fitting for the data, as evidenced by long-run R^2 and adjusted R^2 values of 0.98. This suggests that the exogenous factors can largely explain 98% of the changes in the endogenous variable. The ECT produced by the ARDL method was negative and significant at the 1% threshold. T The consequence is that a mean-reverting process operates, whereby, after a shock, the system's disequilibrium is adjusted toward the long-run trajectory at an approximate rate of 0.65% (speed of adjustment). Additionally, we conducted a diagnostic assessment of the model utilizing the residuals from the predicted ARDL framework. Table 5 displays the statistical accuracy of the ARDL paradigm. Initially, researchers do not reject the null hypothesis for the Breusch-Godfrey serial correlation LM assessment, the Breusch-Pagan-Godfrey heteroskedasticity, and the Jarque-Bera normality examination, as their corresponding p-values over the 10% significance limit. Furthermore, the Ramsey RESET test outcomes are not significant, showing that the simulation does not exhibit any practical form of incorrect definition. Ultimately, as illustrated by Figures 1 and 2, the cumulative sum (CUSUM) of residuals and the CUSUM of squares reside within the appropriate 5% confidence intervals, signifying no predicted volatility at the 5% confidence level or lower.

Table 5. Results of diagnostic tests.

Diagnostic tests	Coefficient	p-value	Decision
Jarque-Bera test	1.23	0.66	Normally distributed residuals
Lagrange Multiplier test	1.01	0.53	No serial correlation
Breusch-Pagan-Godfrey test	1.47	0.42	No heteroscedasticity
Ramsey RESET test	1.29	0.68	Properly specified model

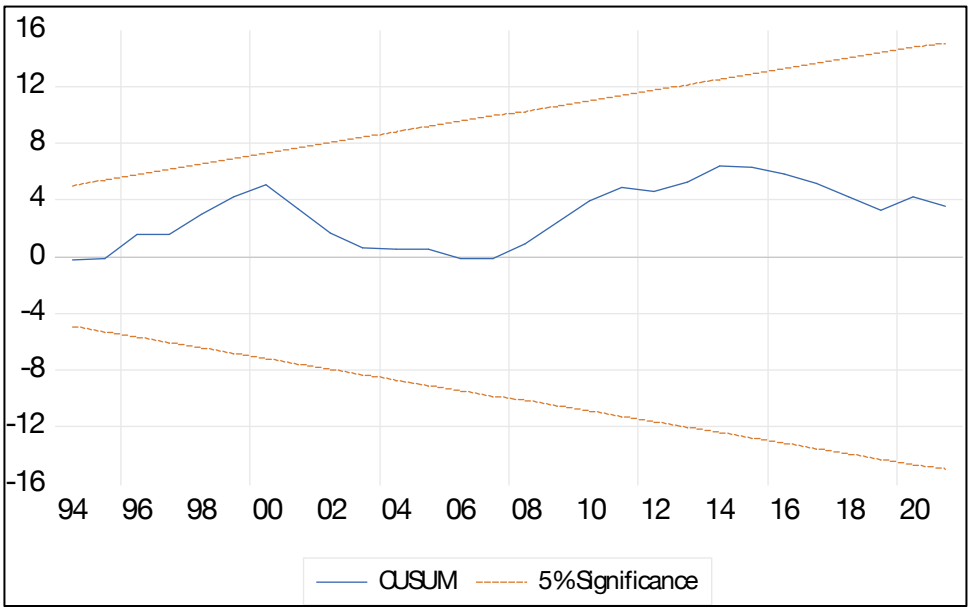

Figure 1. Result of CUSUM test.

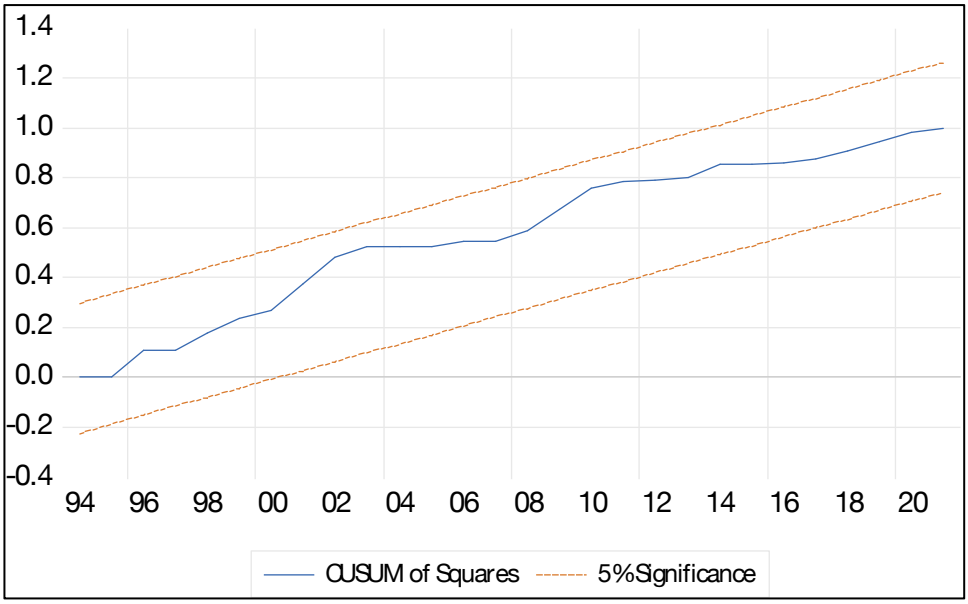

Figure 2. Result of CUSUM of squares test.

Financing renewable energy directly aligns sustainable development theories and green growth models by providing the necessary capital to invest in clean energy sources, which helps mitigate climate change, promote economic growth while minimizing environmental impact, and ultimately contribute to a more sustainable future across social, economic, and ecological dimensions. Renewable energy sources like solar, wind, and hydro power produce significantly lower greenhouse gas emissions compared to fossil fuels, thus contributing to climate change mitigation, a core principle of sustainable development. Investing in renewable energy creates new jobs, stimulates technological innovation, and can lead to energy security by reducing reliance on volatile fossil fuel prices, fostering economic growth. Access to clean energy, especially in developing countries, can improve quality of life, healthcare, and education, promoting social equity and wellbeing.

In addition, issuing green bonds specifically dedicated to funding renewable energy projects allows investors to contribute to environmental goals while achieving financial returns. Carbon pricing incentivizes businesses to switch to cleaner energy sources by placing a cost on carbon emissions, further encouraging investment in renewable energy. Policies like subsidies, tax credits, and feed-in tariffs can reduce the financial burden on renewable energy projects, making them more attractive to investors. Overall, financing renewable energy is considered a crucial component of sustainable development strategies as it enables the transition to a low-carbon economy while promoting economic prosperity, environmental sustainability, and social well-being across communities.

Conclusions and policy implications

Notwithstanding its financial and ecological drawbacks, the adoption of fossil fuels as a power source remains prevalent. Governments and academicians have focused on clean energy options and their application in response to widespread ecosystem degradation and socioeconomic challenges. As alternative power resources gain prominence globally, we examined the intricate interplay involving monetary growth and acceptance of renewable energy. To the best of the writer's knowledge, no new empirical methodologies have thoroughly investigated the impact of economic progress on the use of green electricity in Bangladesh, taking into account income levels and energy prices. This analysis used the ARDL technique to fill the existing gap in research regarding green power. Our principal findings are dual. The ARDL bounds examination outcomes demonstrate an extended connection between clean energy use and its possible determinants, specifically FD, EG, and CPI. The ARDL results indicate that higher levels of FD enhance RE consumption. Nonetheless, rising energy costs and economic expansion adversely affect the use of renewable energy.

This study possesses both operational and sociological implications. The real-world effects pertain to the advancement of the finance industry, which is Bangladesh's primary approach to conservation and energy-related policies. Therefore, the positive impact of financial development (FD) on renewable energy (RE) implies that factors such as rising borrowing costs, increased financial risk, elevated capital expenses, diminished data accountability, and challenging financing accessibility will negatively impact RE, thereby harming the environment. We assert that an enhanced level of economic development in ecological funding will yield beneficial effects on society. Consequently, financial institutions ought to promote environmental sustainability by offering accessible loans to modernize the green power sector. This would assist Bangladesh in attaining its sustainable development goals (SDGs) and diminishing its dependence on fossil fuels.

Additionally, Bangladesh adopted the United Nations SDG-7, which seeks to guarantee equitable possession of cheap and dependable energy services. This target presents a significant challenge for Bangladesh, given its extensive reliance upon conventional energies and the significant neglected prospects for clean energy. Consequently, we recommend that legislators implement necessary incentives and taxes to support the need for sustainable energy among financial services entities. Moreover, the authorities may provide interest-free financing options to incentivize green energy investors. Furthermore, investments in renewable energy are tax-exempt. These characteristics positively influence cost reduction and hence improve project efficiency.

A significant weakness of the article is that the evaluations performed are at an overall level. The author is pleased that these factors have not been correlated at a dispersed scale in Bangladesh. This study represents a prospective avenue for future research. A potential direction for future research may involve examining the unequal effects of financial expansion on alternative power usage in Bangladesh and globally.

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References

1. Aquilas, N. A., & Atemnkeng, J. T. (2022). Climate-related development finance and renewable energy consumption in greenhouse gas emissions reduction in the Congo basin. *Energy Strategy Reviews*, *44*, 100971.
2. Zhang, Y., & Dilanchiev, A. (2022). Economic recovery, industrial structure and natural resource utilization efficiency in China: effect on green economic recovery. *Resources Policy, 79*, 102958.
3. WDI. (2023). World Development Indicators. Available at: https://databank.worldbank.org/source/world-development-indicators# (accessed 11 February 2023).
4. Ogunkunle, O., & Ahmed, N. A. (2021). Overview of biodiesel combustion in mitigating the adverse impacts of engine emissions on the sustainable human–environment scenario. *Sustainability*, *13*(10), 5465.
5. Nunes, L. J. (2023). The rising threat of atmospheric CO_2: a review on the causes, impacts, and mitigation strategies. *Environments*, *10*(4), 66.
6. Kabeyi, M. J. B., & Olanrewaju, O. A. (2022). Sustainable energy transition for renewable and low carbon grid electricity generation and supply. *Frontiers in Energy research, 9*, 743114.
7. Carfora, A., Pansini, R. V., & Scandurra, G. (2022). Energy dependence, renewable energy generation and import demand: Are EU countries resilient?. *Renewable energy*, *195*, 1262-1274.
8. Opeyemi, B. M. (2021). Path to sustainable energy consumption: The possibility of substituting renewable energy for non-renewable energy. *Energy*, *228*, 120519.
9. Ji, Q., & Zhang, D. (2019). How much does financial development contribute to renewable energy growth and upgrading of energy structure in China?. *Energy Policy*, *128*, 114-124.
10. Eberhard, A., Gratwick, K., Morella, E., & Antmann, P. (2017). Independent power projects in sub-Saharan Africa: Investment trends and policy lessons. *Energy Policy*, *108*, 390-424.
11. Islam, M. M., Irfan, M., Shahbaz, M., & Vo, X. V. (2022). Renewable and non-renewable energy consumption in Bangladesh: The relative influencing profiles of economic factors, urbanization, physical infrastructure and institutional quality. *Renewable Energy*, *184*, 1130-1149.
12. Sadorsky, P. (2009). Renewable energy consumption and income in emerging economies. *Energy policy*, *37*(10), 4021-4028.
13. Kraft, J., & Kraft, A. (1978). On the relationship between energy and GNP. *The Journal of Energy and Development, 3*, 401-403.
14. Mukhtarov, S., Yüksel, S., & Dinçer, H. (2022). The impact of financial development on renewable energy consumption: Evidence from Turkey. *Renewable Energy*, *187*, 169-176.
15. Alshehry, A. S., & Belloumi, M. (2015). Energy consumption, carbon dioxide emissions and economic growth: The case of Saudi Arabia. *Renewable and Sustainable Energy Reviews*, *41*, 237-247.
16. Faisal, F., Tursoy, T., & Ercantan, O. (2017). The relationship between energy consumption and economic growth: Evidence from non-Granger causality test. *Procedia Computer Science*, *120*, 671-675.
17. Twerefou, D. K., Iddrisu, K. S., & Twum, E. A. (2018). Energy consumption and economic growth: Evidence from the West African Sub region. *West African Journal of Applied Ecology*, *26*, 217-233.
18. Islam, F., Shahbaz, M., Ahmed, A. U., & Alam, M. M. (2013). Financial development and energy consumption nexus in Malaysia: a multivariate time series analysis. *Economic modelling*, *30*, 435-441.
19. Chang, S. C. (2015). Effects of financial developments and income on energy consumption. *International Review of Economics & Finance*, *35*, 28-44.
20. 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.

21. Destek, M. A., & Sarkodie, S. A. (2019). Investigation of environmental Kuznets curve for ecological footprint: the role of energy and financial development. *Science of the total environment*, *650*, 2483-2489.
22. Can, H., & Korkmaz, Ö. (2019). The relationship between renewable energy consumption and economic growth: The case of Bulgaria. *International Journal of Energy Sector Management*, *13*(3), 573-589.
23. 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.
24. Khobai, H., & Le Roux, P. (2018). Does renewable energy consumption drive economic growth: Evidence from granger-causality technique. *International Journal of Energy Economics and Policy*, *8*(2), 205-212.
25. Hamit-Haggar, M. (2016). Clean energy-growth nexus in sub-Saharan Africa: Evidence from cross-sectionally dependent heterogeneous panel with structural breaks. *Renewable and Sustainable Energy Reviews*, *57*, 1237-1244.
26. Bhattacharya, M., Paramati, S. R., Ozturk, I., & Bhattacharya, S. (2016). The effect of renewable energy consumption on economic growth: Evidence from top 38 countries. *Applied energy*, *162*, 733-741.
27. Kahia, M., Aïssa, M. S. B., & Lanouar, C. (2017). Renewable and non-renewable energy use-economic growth nexus: The case of MENA Net Oil Importing Countries. *Renewable and Sustainable Energy Reviews*, *71*, 127-140.
28. Tang, C. F., Tan, B. W., & Ozturk, I. (2016). Energy consumption and economic growth in Vietnam. *Renewable and Sustainable Energy Reviews*, *54*, 1506-1514.
29. Paramati, S. R., Mo, D., & Gupta, R. (2017). The effects of stock market growth and renewable energy use on CO_2 emissions: evidence from G20 countries. *Energy Economics*, *66*, 360-371.
30. Amri, F. (2016). The relationship amongst energy consumption, foreign direct investment and output in developed and developing countries. *Renewable and Sustainable Energy Reviews*, *64*, 694-702.
31. Saidi, K., & Mbarek, M. B. (2016). Nuclear energy, renewable energy, CO_2 emissions, and economic growth for nine developed countries: Evidence from panel Granger causality tests. *Progress in Nuclear Energy*, *88*, 364-374.
32. Kahia, M., Aïssa, M. S. B., & Charfeddine, L. (2016). Impact of renewable and non-renewable energy consumption on economic growth: New evidence from the MENA Net Oil Exporting Countries (NOECs). *Energy*, *116*, 102-115.
33. Lin, B., & Moubarak, M. (2014). Renewable energy consumption–economic growth nexus for China. *Renewable and Sustainable Energy Reviews*, *40*, 111-117.
34. Sebri, M., & Ben-Salha, O. (2014). On the causal dynamics between economic growth, renewable energy consumption, CO_2 emissions and trade openness: Fresh evidence from BRICS countries. *Renewable and Sustainable Energy Reviews*, *39*, 14-23.
35. Al-Mulali, U., Fereidouni, H. G., & Lee, J. Y. (2014). Electricity consumption from renewable and non-renewable sources and economic growth: Evidence from Latin American countries. *Renewable and Sustainable Energy Reviews*, *30*, 290-298.
36. Apergis, N., & Payne, J. E. (2012). Renewable and non-renewable energy consumption-growth nexus: Evidence from a panel error correction model. *Energy economics*, *34*(3), 733-738.
37. Cherni, A., & Jouini, S. E. (2017). An ARDL approach to the CO_2 emissions, renewable energy and economic growth nexus: Tunisian evidence. *International Journal of Hydrogen Energy*, *42*(48), 29056-29066.
38. Wang, S., Li, Q., Fang, C., & Zhou, C. (2016). The relationship between economic growth, energy consumption, and CO_2 emissions: Empirical evidence from China. *Science of the Total Environment*, *542*, 360-371.
39. Liu, Y., & Hao, Y. (2018). The dynamic links between CO_2 emissions, energy consumption and economic development in the countries along "the Belt and Road". *Science of the total Environment*, *645*, 674-683.
40. Bélaïd, F., & Youssef, M. (2017). Environmental degradation, renewable and non-renewable electricity consumption, and economic growth: Assessing the evidence from Algeria. *Energy policy*, *102*, 277-287.

41. Jebli, M. B., & Youssef, S. B. (2015). Output, renewable and non-renewable energy consumption and international trade: Evidence from a panel of 69 countries. *Renewable energy*, *83*, 799-808.
42. Menegaki, A. N. (2011). Growth and renewable energy in Europe: A random effect model with evidence for neutrality hypothesis. *Energy Economics*, *33*(2), 257-263.
43. Destek, M. A. (2016). Renewable energy consumption and economic growth in newly industrialized countries: Evidence from asymmetric causality test. *Renewable Energy*, *95*, 478-484.
44. Rafiq, S., & Salim, R. A. (2009). Temporal causality between energy consumption and income in six Asian emerging countries. *Applied Economics Quarterly*, (4), 335-350.
45. Ozturk, I., & Acaravci, A. (2010). CO_2 emissions, energy consumption and economic growth in Turkey. *Renewable and Sustainable Energy Reviews*, *14*(9), 3220-3225.
46. Shahbaz, M., Topcu, B. A., Sarıgül, S. S., & Vo, X. V. (2021). The effect of financial development on renewable energy demand: The case of developing countries. *Renewable Energy*, *178*, 1370-1380.
47. Bilgili, F., Koçak, E., & Bulut, Ü. (2016). The dynamic impact of renewable energy consumption on CO_2 emissions: a revisited Environmental Kuznets Curve approach. *Renewable and Sustainable Energy Reviews*, *54*, 838-845.
48. Mert, M., & Bölük, G. (2016). Do foreign direct investment and renewable energy consumption affect the CO_2 emissions? New evidence from a panel ARDL approach to Kyoto Annex countries. *Environmental Science and Pollution Research*, *23*, 21669-21681.
49. Dogan, E., & Seker, F. (2016). The influence of real output, renewable and non-renewable energy, trade and financial development on carbon emissions in the top renewable energy countries. *Renewable and Sustainable Energy Reviews*, *60*, 1074-1085.
50. Sadorsky, P. (2011). Financial development and energy consumption in Central and Eastern European frontier economies. *Energy policy*, *39*(2), 999-1006.
51. Sadorsky, P. (2010). The impact of financial development on energy consumption in emerging economies. *Energy policy*, *38*(5), 2528-2535.
52. Aslan, A., Apergis, N., & Topcu, M. (2014). Banking development and energy consumption: Evidence from a panel of Middle Eastern countries. *Energy*, *72*, 427-433.
53. Ma, X., & Fu, Q. (2020). The influence of financial development on energy consumption: worldwide evidence. *International journal of environmental research and public health*, *17*(4), 1428.
54. Denisova, V. (2020). Financial development and energy consumption: evidence from Germany. *International Journal of Energy Economics and Policy*, *10*(2), 35-39.
55. Yang, L., Hui, P., Yasmeen, R., Ullah, S., & Hafeez, M. (2020). Energy consumption and financial development indicators nexuses in Asian economies: a dynamic seemingly unrelated regression approach. *Environmental Science and Pollution Research*, *27*(14), 16472-16483.
56. Mukhtarov, S., Humbatova, S., Seyfullayev, I., & Kalbiyev, Y. (2020). The effect of financial development on energy consumption in the case of Kazakhstan. *Journal of Applied Economics*, *23*(1), 75-88.
57. Mukhtarov, S., Mikayilov, J. I., Mammadov, J., & Mammadov, E. (2018). The impact of financial development on energy consumption: evidence from an oil-rich economy. *Energies*, *11*(6), 1536.
58. Komal, R., & Abbas, F. (2015). Linking financial development, economic growth and energy consumption in Pakistan. *Renewable and Sustainable Energy Reviews*, *44*, 211-220.
59. Shahbaz, M., Khan, S., & Tahir, M. I. (2013). The dynamic links between energy consumption, economic growth, financial development and trade in China: fresh evidence from multivariate framework analysis. *Energy economics*, *40*, 8-21.
60. Kakar, Z. K. (2016). Financial development and energy consumption: Evidence from Pakistan and Malaysia. *Energy Sources, Part B: Economics, Planning, and Policy*, *11*(9), 868-873.
61. Ansu-Mensah, P., & Kwakwa, P. A. (2022). Modelling electricity consumption in Ghana: the role of financial development indicators. *Green Finance*, *4*(1), 54-70.
62. Shahbaz, M., Mallick, H., Mahalik, M. K., & Sadorsky, P. (2016). The role of globalization on the recent evolution of energy demand in India: Implications for sustainable development. *Energy Economics*, *55*, 52-68.

63. Farhani, S., & Solarin, S. A. (2017). Financial development and energy demand in the United States: new evidence from combined cointegration and asymmetric causality tests. *Energy*, *134*, 1029-1037.
64. McFarlane, A., Brown, L., Campbell, K., & Das, A. (2023). Is the impact of financial development on energy consumption in Jamaica asymmetric?. *International Journal of Energy Sector Management*, *17*(4), 677-692.
65. Sare, Y. A. (2019). Effect of financial sector development on energy consumption in Africa: Is it threshold specific?. *International Journal of Green Energy*, *16*(15), 1637-1645.
66. Shahbaz, M., Van Hoang, T. H., Mahalik, M. K., & Roubaud, D. (2017). Energy consumption, financial development and economic growth in India: New evidence from a nonlinear and asymmetric analysis. *Energy Economics*, *63*, 199-212.
67. Raza, S. A., Shah, N., Qureshi, M. A., Qaiser, S., Ali, R., & Ahmed, F. (2020). Non-linear threshold effect of financial development on renewable energy consumption: evidence from panel smooth transition regression approach. *Environmental Science and Pollution Research*, *27*, 32034-32047.
68. Gaies, B., Kaabia, O., Ayadi, R., Guesmi, K., & Abid, I. (2019). Financial development and energy consumption: Is the MENA region different?. *Energy Policy*, *135*, 111000.
69. Karltorp, K. (2016). Challenges in mobilising financial resources for renewable energy—The cases of biomass gasification and offshore wind power. *Environmental Innovation and Societal Transitions*, *19*, 96-110.
70. D'Orazio, P., & Löwenstein, P. (2022). Mobilising investments in renewable energy in Germany: which role for public investment banks?. *Journal of Sustainable Finance & Investment*, *12*(2), 451-474.
71. Tamazian, A., Chousa, J. P., & Vadlamannati, K. C. (2009). Does higher economic and financial development lead to environmental degradation: evidence from BRIC countries. *Energy policy*, *37*(1), 246-253.
72. Tamazian, A., & Rao, B. B. (2010). Do economic, financial and institutional developments matter for environmental degradation? Evidence from transitional economies. *Energy economics*, *32*(1), 137-145.
73. Kim, J., & Park, K. (2016). Financial development and deployment of renewable energy technologies. *Energy Economics*, *59*, 238-250.
74. Minier, J. (2009). Opening a stock exchange. *Journal of Development Economics*, *90*(1), 135-143.
75. Paramati, S. R., Ummalla, M., & Apergis, N. (2016). The effect of foreign direct investment and stock market growth on clean energy use across a panel of emerging market economies. *Energy economics*, *56*, 29-41.
76. Brunnschweiler, C. N. (2010). Finance for renewable energy: an empirical analysis of developing and transition economies. *Environment and development economics*, *15*(3), 241-274.
77. Usman, M., & Makhdum, M. S. A. (2021). What abates ecological footprint in BRICS-T region? Exploring the influence of renewable energy, non-renewable energy, agriculture, forest area and financial development. *Renewable Energy*, *179*, 12-28.
78. Ehigiamusoe, K. U., Guptan, V., & Narayanan, S. (2021). Rethinking the impact of GDP on financial development: Evidence from heterogeneous panels. *African Development Review*, *33*(1), 1-13.
79. Babbar, S., & Schuster, J. (1998). *Power project finance: experience in developing countries*. The World Bank.
80. Khan, H., Khan, I., & Binh, T. T. (2020). The heterogeneity of renewable energy consumption, carbon emission and financial development in the globe: a panel quantile regression approach. *Energy Reports*, *6*, 859-867.
81. 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.
82. 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.
83. 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.

84. Wang, J., Zhang, S., & Zhang, Q. (2021). The relationship of renewable energy consumption to financial development and economic growth in China. *Renewable Energy*, *170*, 897-904.
85. Ali, Q., Khan, M. T. I., & Khan, M. N. I. (2018). Dynamics between financial development, tourism, sanitation, renewable energy, trade and total reserves in 19 Asia cooperation dialogue members. *Journal of Cleaner Production*, *179*, 114-131.
86. Rasoulinezhad, E., & Saboori, B. (2018). Panel estimation for renewable and non-renewable energy consumption, economic growth, CO_2 emissions, the composite trade intensity, and financial openness of the commonwealth of independent states. *Environmental Science and Pollution Research*, *25*, 17354-17370.
87. Ali, H. S., Yusop, Z. B., & Hook, L. S. (2015). Financial development and energy consumption nexus in Nigeria: An application of autoregressive distributed lag bound testing approach. *International Journal of Energy Economics and Policy*, *5*(3), 816-821.
88. Mielnik, O., & Goldemberg, J. (2002). Foreign direct investment and decoupling between energy and gross domestic product in developing countries. *Energy policy*, *30*(2), 87-89.
89. Komal, R., & Abbas, F. (2015). Linking financial development, economic growth and energy consumption in Pakistan. *Renewable and sustainable energy reviews*, *44*, 211-220.
90. Mahadevan, R., & Asafu-Adjaye, J. (2007). Energy consumption, economic growth and prices: A reassessment using panel VECM for developed and developing countries. *Energy policy*, *35*(4), 2481-2490.
91. Begum, R. A., Raihan, A., & Said, M. N. M. (2020). Dynamic impacts of economic growth and forested area on carbon dioxide emissions in Malaysia. Sustainability, 12(22), 9375.
92. Raihan, A. (2023). The dynamic nexus between economic growth, renewable energy use, urbanization, industrialization, tourism, agricultural productivity, forest area, and carbon dioxide emissions in the Philippines. Energy Nexus, 9, 100180.
93. Raihan, A., & Tuspekova, A. (2022). Toward a sustainable environment: Nexus between economic growth, renewable energy use, forested area, and carbon emissions in Malaysia. Resources, Conservation & Recycling Advances, 15, 200096.
94. Raihan, A., Muhtasim, D. A., Farhana, S., Pavel, M. I., Faruk, O., Rahman, M., & Mahmood, A. (2022). Nexus between carbon emissions, economic growth, renewable energy use, urbanization, industrialization, technological innovation, and forest area towards achieving environmental sustainability in Bangladesh. Energy and Climate Change, 3, 100080.
95. Raihan, A., Pavel, M. I., Muhtasim, D. A., Farhana, S., Faruk, O., & Paul, A. (2023). The role of renewable energy use, technological innovation, and forest cover toward green development: Evidence from Indonesia. Innovation and Green Development, 2(1), 100035.
96. Dickey, D. A., & Fuller, W. A. (1979). Distribution of the estimators for autoregressive time series with a unit root. Journal of the American Statistical Association, 74(366a), 427-431.
97. Elliott, G., Rothenberg, T. J., & Stock, J. H. (1996). Efficient Tests for an Autoregressive Unit Root. Econometrica, 64(4), 813-836.
98. Phillips, P. C., & Perron, P. (1988). Testing for a Unit Root in Time Series Regression. Biometrika, 75(2), 335-346.
99. Pesaran, M. H., Shin, Y., & Smith, R. J. (2001). Bounds testing approaches to the analysis of level relationships. *Journal of Applied Econometrics*, *16*(3), 289-326.