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RESEARCH ARTICLE

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Will financial development and clean energy utilization rejuvenate the environment in BRICS economies?

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Abstract

Global warming and environmental degradation caused essentially by changes in climate have attracted enormous surveillance considering the menace of its reverberation on the health of humans during the past two decades. Utilization of energy and financial development (FD) are among the key drivers of climatic change. Thus, using second-generation panel cointegration (the Westerlund, 2007 error-correction model), pooled mean group autoregressive distributive lag model (PMG-ARDL), and the panel dynamic ordinary least square (PDOLS) estimation techniques, the paper scrutinized the nexus between financial development, clean energy usage, economic growth, and environmental quality (proxied by CO_2 emissions) of BRICS countries starting from 1980 to 2018. The findings from the study reveal that economic growth and labor force participation, in the long run, deteriorate the environmental quality by increasing the effusion of carbon. Contrarily, financial development, industrialization, trade openness, and renewable energy usage enhance the environmental quality of BRICS countries in the long run. In the short run, financial development was found to have a significant positive impact on the environmental quality of Brazil, China, and Russia, while it is negative for South Africa and India. The outcome of the PVECM Granger causality test reveals a two-way Granger causality that runs from renewable energy to carbon emissions in the short run. The policy implication of this study is that the government of BRICS countries needs to concentrate on improving their clean energy sources and also work on their industries. The BRICS nations' governments should formulate financial and trade policies that promote a sustainable environment and economic development.

KEYWORDS
BRICS countries, environmental sustainability, financial development, renewable energy, trade

1 | INTRODUCTION

Global warming and environmental degradation caused essentially by changes in climate have captured enormous surveillance considering

Abbreviations: BRICS, Brazil, Russia, India, China, and South Africa.

the menace of its reverberation on the health of humans during the preceding two decagons (Ekwueme et al., 2021). The utilization of energy and fossil fuel are among the key drivers of climatic change. For instance, the world's report on energy and its financial implication by the International Energy Agency (IEA) reported that about 6 million deaths annually were caused by haze pollution and other hazardous substance; these, in turn, affect the development of finance which also affects the level of investment in the environmental sector (IEA, 2016; Zhang et al., 2017). Alternative energy sources development has been mentioned as an important strategy to moderate the changes in the world climate by mitigating the effusion of CO_2 (Cong & Shen, 2014; Shue, 2020). Furthermore, research has shown that acceleration in the utilization of clean energy has enhanced the effectiveness of economies, particularly at the macroeconomic level.

Renewable energy is seen as a limitless source of energy because they increase with maximum utilization. Furthermore, the alternate resource of renewable energy (solar, hydrogen energy, hydro, biomass, and wind resources) is economical and sustainable (Zhao et al., 2020). Also, renewable energy consumption is less harmful to environmental quality (Acar & Dincer, 2020; Tuna & Tuna, 2019). Numerous current research revealed that a viable substitution for unclean energy such as coal and hydroelectric can be done using renewable energy sources. Clean energy origin in contrast to unclean energy origin performs an essential function in the mitigation of CO_2. Inquisitively, it has been debated that the long-term feedback loop might have been underrated by the climate system, therefore emphasizing the need to drastically mitigate the emissions of carbon globally (Kang et al., 2019).

Kang et al. (2019), for instance, debated that by 2050, half of the energy demands will be met by clean energy origin. Thus, it is a prerequisite to practically reexamine the broad orifice between the supply and demand of energy through the implementation and execution of policy decisions to accelerate the clean energy origin source. Growth in the economy will be actualized by this attempt. Further, the acceleration of the usage of clean energy conceivably can enhance a sustainable energy outlook globally. Consequently, a substantial amount of effort and resources have been devoted by numerous advanced and advancing nations to enhance their dependence on clean energy origin. For instance, in the past few decades, India has accelerated the unclean energy origin usage, and they map out the goal of achieving the production of 40% of its total demand for energy via clean origin by 2030 based on the Paris agreement.

To address the economic issues on the emission of carbon which produces economic and environmental imprint of undesirable results (such as pollution of water, land, and air), existing literature has been deliberating the correlation between renewable energy, financial development (FD), trade, economic growth, energy usage, and emissions (Ahmad et al., 2019). The financial sector contributes immensely towards checking and control of energy emissions through the application of advanced techniques in the energy sector to decrease the level of emission. FD has been viewed as a central support force for economic growth because it encourages investment, provides an avenue for trade openness, and promotes capital accumulation (Ahmad et al., 2019; Gorus & Aydin, 2019; Sarkodie & Strezov, 2018).

Consequently, the broad objective of this study is to evaluate the linkages between financial development, trade openness, renewable energy usage, economic growth, and the effusion of CO_2 in BRICS nations by applying second-generation panel cointegration (the Westerlund, 2007 error-correction [EC] model), pooled mean group autoregressive distributive lag model (PMG-ARDL), and the panel dynamic ordinary least square (PDOLS) estimation techniques on the annual panel data starting from 1980 to 2018. That is, we intend to assess the environmental quality by evaluating the connections among these variables and CO_2 emissions which have been a lingering factor and major contributor to the worldwide economic crisis and global warming. Westerlund's (2007) cointegration test was used because it is developed to cope with cross-sectionally dependent data and it permits for large heterogeneity in the short-run dynamics and the long-run cointegration relation. The PMG-ARDL is deemed effective being an alternative model to the generalized methods of moments (GMM) because it utilizes the cointegration form of the standard (ordinary) ARDL model developed by Pesaran et al., (1999). The outcomes reveal the existence of a long-run relationship between financial development, renewable energy, labor force, gross domestic production, trade openness, industrialization, and environmental sustainability of countries in BRICS.

The revitalized curiosity in the identification of how environmental quality responds to its shock and the shock from the other variables employed in this study for a sustainable environment and economic growth of BRICS nations is the underlying motivation for this research. The novelty of the study will heighten the prevailing literature as it considers CO_2 emission in establishing the changing relationship between financial development (FD), trade openness, renewable energy utilization, and economic growth which aligns with the environmental quality of the BRICS countries during this period. Some theoretical opinions have been established connecting CO_2 emission, FD, trade, and clean energy utilization. Generally, the connecting channels are anticipated to be the means of attaining environmental quality and economic growth. Charfeddine and Kahia (2019) employing the PVAR method discovered that FD and renewable energy are still exhibiting a weak reaction even with their great contribution to economic growth and environmental quality.

From a sustainability viewpoint, having an adequate comprehension of the between clean energy origin, real economic activity, and the emanating contamination proxied by CO_2 effusions is very essential. Centering on the latent time alteration seems highly vital for appraising the impacts of previous policies. Major enlightenment obtained from the current study is whether the goal of having a sustainable environment through mitigation of carbon effusions has been promoted by renewable energy usage and the financial development of BRICS countries. Therefore, the research is a pioneering and inventive assay to provide conjectural solutions to a group of scorching questions.

BRICS nations were chosen considering their constant emphasis on the quality of the environment as an important key policy to control the predominant high proportions of CO_2 emission in the countries within the region. Considering the importance of BRICS nations in the present economic scenery, focusing on how the quality of their environments can be enhanced through the utilization of clean energy is very essential and timely. There is a systematic rise of GDP of BRICS nations from ($US 2187 billion) to ($US 16,266 billion) within 1985 and that of 2016, with an average annual growth rate of about 6.5% (World Bank, 2017). Thus there is need to establish strict environmental regulations that will reduce environmental pollution and enhance the quality of the environment.. This is further explained by Figure 1 below which showed that CO_2 emission demonstrates a similar trend with the renewable energy consumption (RENC) and labor force (LF), industrialization (IND), gross domestic product (GDP), financial development (FD), and trade (TRAD).

Theoretical and empirical review as seen in the next section of this study reveal that carbon emissions, financial level of development, renewable energy along with economic growth are expected to function from diverse frequencies, and the net effect is likely to be uncertain (Baloch et al., 2021; Kahia et al., 2017; Kirikkaleli et al., 2021; Kirikkaleli & Adebayo, 2021; Murshed et al., 2021; Özbuğday & Erbas, 2015, Tuna and Tuna (2019)). Therefore, investigation of the linkages between financial development, trade, renewable energy utilization, economic growth and carbon emission as examined by this study is insightful for policymakers in the BRICS countries.

Additionally, the available few literatures in the BRICS region concerning the linkages between renewable energy use, economic growth, and environmental quality using the first-generation econometrics technique produce mixed reactions and outcomes, most especially the outcomes from the work of Alola et al. (2019) and Balsalobre-Lorente and Leitão (2020). Thus, this current research fills the underline gap. Therefore, additional empirical examination of the correlation between clean energy use, economic growth, and carbon dioxide emissions within the BRICS countries is required based on the divergent views and indistinct outcomes of previous studies. However, this particular study is novel by including trade openness, financial development, and labor force participation in addition to renewable energy and economic growth in scrutinizing the environmental footprint of the BRICS countries using the second-generation cointegration approach. Thus, the result will be more vigorous and policy oriented.

The remaining components in this study are organized as follows: Section 2 represents the literature that was reviewed; Section 3 contains the data description and methodology; Section 4 is the presentation; Section 5 contains the discussion of the empirical results; and Section 6 provides the conclusion and policy inference.

2 | LITERATURE

In this part of the study, prior literature concerning environmental quality, FD, and energy usage was reviewed. From the standpoint of alteration in climate, it is conventional evidence that the utilization of clean energy enhances the quality of the environment by mitigating

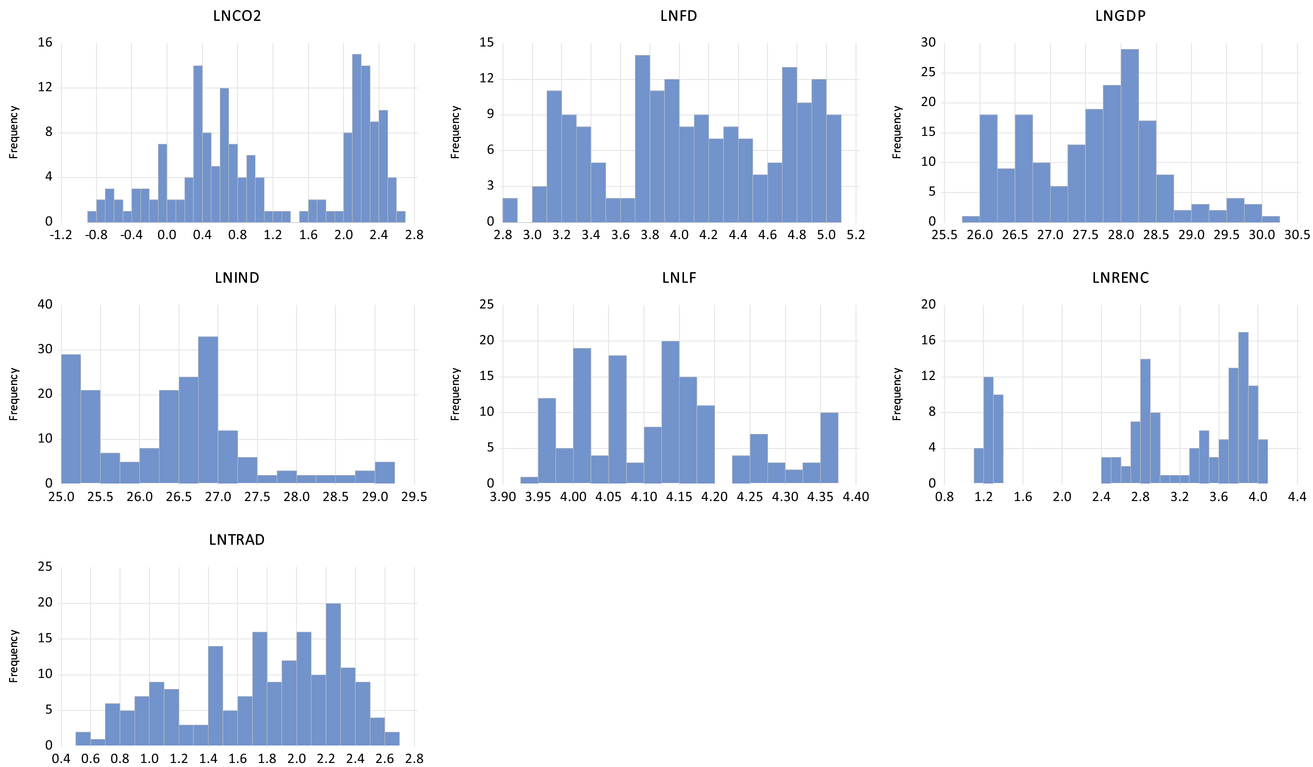

FIGURE 1 CO_2 emission, financial development, gross domestic product, renewable energy consumption, industrialization, labor force, and trade in BRICS countries for 1980–2018. *Source*: Author's computation using data from World Bank Indicator and International Labor Organization, 2020 [Colour figure can be viewed at wileyonlinelibrary.com]

the level of emissions from greenhouse gas in the air (Bekun et al., 2019; Bhattacharya et al., 2016; Muhammad et al., 2021).

More than a few essential policy decisions from a real-world perspective have been improved to the more advanced environmental approach which can presume the growing level of financial development, CO_2 emission, trade openness, renewable energy utilization, and economic growth. Specifically, in consideration of economic, environmental, and energy perceptions, the following three-point of interest are considered:

1. Carbon emission impact of renewable energy advancement and industrialization
2. Carbon emission effect of financial sector development and GDP
3. Carbon emission effect of trade openness and labor force participation

2.1 | Carbon emission impact of renewable energy advancement and industrialization

The first point comprises of the advancement of clean and alternative energy and industrialization intensifying the sources of renewable energy, considered as green energy, clean, and environmentally friendly. According to Doğan et al. (2021), renewable energy is presented as the function of some economic indices and industrialization which align with the emission of CO_2 in G7 and E7 nations using the FGLS and FMOLS. With these, the sources of renewable energy can assist meaningfully in moderating the emissions of CO_2 and some other noxious waste (Kahia et al., 2017; Tiwari, 2011). Additionally, renewable energy, industrialization, and trade openness contribute to decreasing environmental degradation within the EU region (Destek et al., 2018; Udemba et al., 2020). On the contrary, controlling for energy consumption, economic growth, and trade openness, Kirikkaleli and Adebayo (2021) discovered that renewable energy has a negative impact on CO_2 emission in both the long run and short run; trade openness mitigates ecological footprint only in the short run. However, they found that economic growth increases CO_2 emissions. It was also argued that advancement in renewable energy encourages the use of heavy-duty and excessive energy consumption machines which contribute to expanding the business activities which will promote the acquisition of new plants and machines thereby increasing CO_2 emission settlements in the environment and providing a negative impact to the environment (Udemba, 2020).

Ekwueme et al. (2021) examined the impact of renewable energy on CO_2 emission of South Africa using VAR and ARDL and discovered the existence of a long-run link between emission and renewable energy. Balsalobre-Lorente et al. (2018) in their study on renewable energy and emission of CO_2 in EU5 countries that include the United Kingdom, Spain, France, Germany, and Italy between 1985 and 2016 stress that utilization of renewable energy and renewable resources influences the environment positively. Thus, renewable energy and extraction of natural resources aid the decrease in environmental corrosion as a result of energy conditions and waste chemicals removal obsessed by water and to air then finally to land.

2.2 | Carbon emission effect of financial sector development and GDP

From point two, several studies empirically have indicated that an improvement in the financial sector development can contribute importantly to a reduction in emission of CO_2 through encouraging technical advances within the sector. Concerning the previous proposition in the interface among the consumption of the clean and alternative energy, the literature shows that FD and clean energy can play a very imperative part in reducing CO_2 emissions (Abbasi & Riaz, 2016; Kim & Park, 2016; Nasreen et al., 2017). According to Udemba et al. (2020), CO_2 emissions increase directly or indirectly in a country with an increase in financial development and trade because countries improve in their export with higher financial development and research and development (R&D). They further stated that it is essential for nations to have a formal and congenital plan for energy, financial development, urbanization, and FDI, to assimilate the emission effects. According to them, there is an introduction of new debates and technologies such as climate and energy finance that have emerged from the notion of fiscal development and its impact on the climate. They provide explanations on the reasons why a nation's finance should be connected to its energy policies and strategies. The credit markets and commercial banking can also be of great and dynamic importance in stimulating and motivating the alternative energy sector. Furthermore, it is established that the reliance in the sector of renewable energy on equity financing and debt management has resulted in an unreasonably more rapid intensification in the countries having a developed and advanced financial sector and market (Brunnschweiler, 2010; Kim & Park, 2016).

Additionally, some research such as Bhattacharya et al. (2016) reveals that the outcomes from FD and energy usage influence the environmental quality positively and enhance economic growth by adopting FMOLS and GMM techniques on the data extract of 85 advancing and advanced countries. This finding was also supported by Muhammad et al. (2021) who scrutinized this for 16 nations in the European Union applying the panel fixed-effect (PFE) model. Also, a similar outcome was revealed by Haque (2021) employing the techniques of pooled mean group and the GMM on the data extract of 45 advancing nations. Dogan (2014) discovered that there is a unidirectional causality running from energy use to economic growth in Kenya and no causality linkage between Energy consumption and economic growth in Benin, Congo, and Zimbabwe. Also, for both short- and long-run effects, Udemba (2019) and Udemba et al. (2019) found that economic growth (GDP) has a positive relationship with energy use, FDI, and CO_2 emissions for Indonesia and China. Nevertheless, a negative influence of renewable energy utilization on economic growth was discovered by only a handful of studies (for instance, similar output was discovered for Spain, Denmark, and Portugal by the study of Silva et al., 2012).

Discovered that the development of the financial sector contributes immensely towards checking and controlling emissions from energy utilization through the application of advanced techniques in the energy sector to decrease the level of emission. Furthermore, according to Ahmad et al. (2019), financial development has been viewed as a central support force for economic growth because it encourages investment, provides an avenue for trade openness, and enhances capital accumulation. Shahbaz et al. (2017) in their study of the links between utilization of energy, growth of the economy, and financial development of India from 1960 to 2015 discovered a long-run correlation in the presence of asymmetries among the variables. Furthermore, outputs of asymmetric causal effect reveal that energy usage and financial development has a negative impacts on economic growth.

According to Wu et al. (2020) for the production sector, financial investment assists the Asian region towards moving into renewable resources. Gorus and Aydin (2019) opine that financial investment encourages home industries in implementing renewable and domestic technologies, the opening of trade, and mitigates the causes of pollution in industries, with less strict environmental guidelines. According to Dogan and Seker (2016), carbon emissions of their sampled countries (23 countries) were substantially reduced by the financial development of these countries who utilize clean energy origin, thus they concluded that financial development can enhance renewable energy usage and consequently enhance environmental standards through mitigation of carbon emissions. This was further supported by Ekwueme and Zoaka (2020), who discovered that a negative correlation exists between carbon emissions of MENA nations and financial development using the techniques of FMOLS on data extract of MENA nations. According to them, this suggests that the environmental standard of nations in MENA nations was improved by the development of the financial sector that substantially aids in the mitigation of emissions in the region. Also, openness in trade was discovered to influence the emissions of CO_2 in the MENA region positively.

2.3 | Carbon emission effect of trade openness and labor force participation

According to Empora et al. (2020), the environmental pollution reduction strategy is found to be more effective with the utilization of emission (CO_2) instrument that regulates the behavior of firms within the industrial and environmental framework as the case may be. These assist in the control of pollutant emissions and mitigation of the pollutant supply, which is not only the major outline of local authorities but also the ultimate objective of developing and developed economies (2014).

Tang (2020) found that market-based tools such as trade and labor contribution have a positive effect on emission in the long run; this implies that a rise in trade participation will encourage the reduction of CO_2 emission thereby improving the quality of the environment. On the contrary, labor participation accelerates the general emission as expressed in their findings. Confirmation of the correlation between growths in the economy, trade openness, and effusions of carbon was supported by the output of Zhang et al. (2017). They revealed a two-way causality among economic growth and emissions of carbon and between trade utilization and carbon effusions. Further, they discovered that CO_2 emissions are caused by economic swing and energy utilization in the long run; also, energy usage is caused by economic swing and carbon emissions. Esteve and Tamarit (2012) discovered a nonlinear relationship between per capita CO_2 emissions and the income of Spain using threshold cointegration techniques. A causal relationship also runs between economic growth and CO_2 emissions for Nigeria according to the findings of Udemba (2020) and Udemba and Agha (2020).

Consequently, in a review of the empirical research, quite a several studies that previously examined the procedures and effect of financial development, and renewable energy on economic growth and CO_2 effusion put more weight on univariate methods of analysis through the use of either panel or time-series data techniques. On the other hand, it is noticed that only a few studies have concurrently involved the aspect of financial development, trade openness, consumption of renewable energy, CO_2 effusion, and economic growth to evaluate their influence on environmental quality. Thus, the gap will be covered by this research.

3 | DATA AND METHODOLOGY

3.1 | Description of data

The study covers the period of 1980 to 2018, and the annual data used in this study were sourced from the world development indicator. Due to missing data for some of the variables of interest for several countries, the study was limited from 1980 to 2018. The BRICS nations that consist of Brazil, China, India, Russia, and South Africa were the case study. BRICS nations were selected because of their good experience in financial development, trade, and clean energy utilization which is geared towards mitigating carbon emissions. The study however decided to use the panel method to check for heterogeneity differences. Klevmark (1989) explains that the misspecification of results will occur if there is no account for heterogeneity differences. The variables used in this study are explained in Table 1.

3.2 | Model specification

The model for our study was construed based on the adjustment and extension of the model adopted by Charfeddine and Kahia (2019) and Alola et al. (2019) and is written below:

$$\ln X_{it} = \beta_{0i} + \beta_{1i} \ln Y_{it} + \mu_{it}. \quad (1)$$

X_{it} is the environmental footprint proxied by CO_2 emission in BRICS country i at time t. Y_{it} is the independent variables (financial

TABLE 1 Description of variables

Variables	Proxy	Symbols
CO_2 emissions	Metric per tons per capita	CO_2
Financial development	Domestic credit to private (% of GDP)	FD
Renewable energy usage	% of total final energy consumption	RENC
Trade openness	Summation of imports and exports (% of GDP)	TRAD
Labor force participation	% of aggregate (total) population ages 15+	LF
Economic growth	(Constant 2010 US dollars) Gross domestic product	GDP
Industrialization	Industrial value added (as a share of gross domestic product)	IND

development [FD], gross domestic product [GDP], renewable energy consumption [RENC], the labor force [LF], and trade openness [TRAD] of BRICS country i at time t). All the variables are expressed in logarithm form.

3.3 | Econometric techniques

Before we can estimate Equation 1, we need to ascertain whether there is the existence of a long-run association between financial development (FD), the labor force (LF), gross domestic product (GDP), industrialization (IND), renewable energy (RENC), trade openness (TRAD), and carbon emission.

The first step to this is to check for the presence of cross-sectional dependence (CD) in panel data, that is, whether cross-sectional units are independent of each other or not. The presence of omitted unobserved common factors present across countries may be one of the reasons for the existence of CD.

The statistical properties of the panel unit root tests may be greatly affected by CD. Neglecting dependence and utilizing test first-generation panel unit root test to a data series that has CD lead to size distortions and low power (O'Connell, 1998), that is, the probability of rejecting the correct hypothesis becomes very high. Therefore, it is important to take into account this feature in our panel analysis considering that the presence of CD can affect the outcome of the test.

3.3.1 | Panel CD

This procedure adopts the Pesaran (2021), Pesaran et al. (2004) scaled LM, and Breusch and Pagan (1980) to detect the existence of CD. The test estimates the coefficients of correlation among the variables between country i and country j. The higher the coefficient of correlation, the stronger the CD among the residuals. Rejection of the null hypothesis implies that the panel is cross-sectionally dependent or correlated.

A simple panel model is considered by this study:

$$x_{it} = \beta_i + \alpha' y_{it} + \mu_{it}, \tag{2}$$

where α_i is the parameters to be estimated and β_i represents individual parameters.

In testing for the existence of CD, a CD statistics was proposed by Pesaran et al. (2004):

$$CD = \sqrt{\frac{2L}{M(M-1)}\left(\sum_{t=1}^{M-1}\sum_{i=t+1}^{M}\widehat{p}ti\right)}, \tag{3}$$

where $\widehat{p}ti$ represents sample estimate.

3.3.2 | Unit root tests

Because of the existence of CD, we cannot go on with the first-generation panel unit root test. Thus, we applied the more recent unit root tests since it permits CD. This analysis is advantageous as it does need the estimation of the common factors. The test applied the following cross-sectionally augmented DF (CADF) regression:

$$\Delta x_{it} = \beta_i + \alpha_i x_{i,t-1} + g_i \overline{x_{t-1}} + b_i \Delta \overline{x_t} + \varepsilon_{it}, \tag{4}$$

where $\Delta \overline{x_t}$ means the first differences of x_{it} and $\overline{x_{t-1}}$ means the lagged variables of x_{it}.

3.3.3 | Testing for cointegration

We proceed to ascertain the existence of cointegrating association among the variables, after establishing that the variables are all 1 (1) series. We considered the second-generation LM-based panel cointegration test developed by Kao (1999) and the EC-based panel cointegration test developed by Westerlund (2007) for unobserved factors for our study. Each test allows for heterogeneity and cross dependence.

Cointegration test by Westerlund (2007)

The Westerlund (2007) EC model ascertain correction on either individual or panel members and also check the existence of cointegration through the following cointegration statistics (Ga, Gt, Pa, and Pt). All the statistics mentioned are distributed accordingly. By using the null hypothesis of no cointegration, the estimations (Gt, Pt) are analyzed using the following standard errors ($\lambda_i^{\log K}$) while (Ga, Pa) is estimated with Newey and West (1994) standard errors; these standard errors are adjusted for autocorrelations and heteroscedasticity. We estimate the panel tests on $\lambda^{\log K}$, on the other hand, the weighted sums of the $\lambda_i^{\log K}$ was evaluated for individual countries considering the group-mean tests. We utilized this Westerlund (2007) cointegration test based on the following reasons: It manages cross-sectionally dependent data; it permits for large heterogeneity in the short-run dynamics and cointegration relation in the long run.

Therefore, we test for the existence of cointegration using the equations below:

$$\Delta \ln CO_{2_{it}} = \beta_i^{CO_2} + \lambda_i^{CO_2}\left(\ln CO_{2_{i,t-1}} - \alpha_i^{CO_2}\ln FD_{i,t-1}\right) + \sum_{j=1}^{n} \vartheta_{ij}^{CO_2}\Delta \ln CO_{2_{it-j}} + \sum_{j-1}^{n} \delta_{ij}^{CO_2}\Delta \ln FD_{it-j} + \varepsilon_{i,j}, \quad (5)$$

$$\Delta D_{it} = \beta_i^{D} + \lambda_i^{D}\left(D_{i,t-1} - \alpha_i^{D}\ln FD_{i,t-1}\right) + \sum_{j=1}^{n} \vartheta_{ij}^{D}\Delta D_{it-j} + \sum_{j-1}^{n} \delta_{ij}^{D}\Delta \ln FD_{it-j} + \varepsilon_{i,j}, \quad (6)$$

$$\Delta ND_{it} = \beta_i^{ND} + \lambda_i^{ND}\left(ND_{i,t-1} - \alpha_i^{ND}\ln FD_{i,t-1}\right) + \sum_{j=1}^{n} \vartheta_{ij}^{ND}\Delta ND_{it-j} + \sum_{j-1}^{n} \delta_{ij}^{ND}\Delta \ln FD_{it-j} + \varepsilon_{i,j}, \quad (7)$$

Here, the parameters ${}_i^kK \in (CO_2, D, ND)$ are for EC term and its speed of adjustment in the long run for country i, whereas $\varepsilon_{i,t}$ is the disturbances term.

3.3.4 | PDOLS estimation

The PDOLS technique developed by Pedroni (2001) extends the time-series (DOLS) technique by Stock and Watson (1993). PDOLS estimator is normally distributed and asymptotically unbiased even in the presence of endogenous regressors, having discovered the existence of long-run association among our sampled variables. The group-mean PDOLS estimator has high robustness to the omission of the variable. Additionally, this method was used because environmental quality proxied by CO_2 emission can be endogenous. Furthermore, the assumptions of the exogeneity are not required by the PDOLS. Finally, it calculates the mean group estimator and takes into account heterogeneity across groups. Therefore, Equation 8 represents DOLS regression.

$$\ln X_{it} = \beta_i + \vartheta_i t + \alpha_{it}\ln(Y_{it}) + \sum_{j=-Fi}^{Fi} \delta_{ij}\Delta L_{it-j} + \varepsilon_{it}, \quad (8)$$

where X_{it} is environmental quality, Y_{it} is the independent variable, and the differences between lags and leads are δ_{ij}.

$$\widehat{\alpha} = M^{-1}\sum_{i=1}^{M} \widehat{\alpha}_i.$$

$\widehat{\alpha}_i$ stands for the normal DOLS estimator for the ith country in the panel.

3.3.5 | PMG-ARDL

The pooled mean group (PMG-ARDL) was also conducted to examine the association between financial development (lnFD), renewable energy consumption (lnRENC), labor force (lnLF), gross domestic product (lnGDP), trade openness (lnTRAD), industrialization value (IND), and carbon emissions ($\ln CO_2$) of the BRICS countries for comparative purpose. The PMG-ARDL is deemed effective being an alternative model to the GMM because it utilizes the cointegration form of the standard (ordinary) ARDL model developed by Pesaran (2007). PMG-ARDL provides short-run and long-run estimates alongside the degree of adjustment during a situation of disequilibrium. According to Blackburne and Frank (2007), this is useful especially when there are rationales to anticipate that equilibrium association among the variables look alike across countries in the long run. A major characteristic of the variables that are cointegrated is their receptiveness to any digression from the long run. The implication of these characteristics is an (ECM) technique, as shown in Equation 9:

$$\Delta X_{it} = \emptyset_i\left(x_{i,t-1} - \theta_i' Y_{it}\right) + \sum_{j=1}^{F-1} \psi_{ij}^{*}\Delta X_{i,t-1} + \sum_{j=0}^{q-1} \vartheta_{ij}^{*}\Delta Y_{i,t-j} + \mu_i + \ell_{it}, \quad (9)$$

where

$$\emptyset_i = -\left(1 - \sum_{j=1}^{F}\psi_{ij}\right), \theta_i = \sum_{j=0}^{q}\vartheta_{ij} \Big/ \left(1 - \sum_{k}\psi_{ij}\right), \psi_{ij}^{*} = -\sum_{n=j+1}^{p}\psi_{in},$$

$$j = 1, 2, \ldots, f-1, \text{and } \vartheta_{ij}^{*} = -\sum_{n=j+1}^{q}\vartheta_{in}, j = 1, 2, \ldots, q-1.$$

X_{it} is the environmental quality proxied by carbon emission, and Y_{it} is the independent variable. The parameter $\emptyset_i$ is the degree of balancing from disequilibrium. Under the preceding assumption that a return to equilibrium is shown by the variables, it is expected that this parameter should be negative and statistically significant. The long-run association between the variables is shown by the vector θ_i. The outcome of the PMG-ARDL is presented in Table 9.

3.3.6 | Granger causality

Finally, the VECM technique was used to estimate panel Granger causality. The panel-based VECM variables in the short run as specified below were utilized to test for panel causality.

$$\Delta(L_{yt}) = \delta + q\Delta(L_{yt-1}) + \phi_{yt}, \quad (10)$$

where Δ means the first difference of the variables; L_{yt} is the vector of the six variables used in this study; δ is the vector constant term; ϕ is the vector error term; L_{yt-1} is the vector of the six variables lagged by 1 year; and $q = (6 \times 6)$ matrix of parameters.

After obtaining the short-run estimates, the long-run relationship will be estimated using a PVECM model whereby apart from the main variable of interest ($lnCO_2$); the other control variables (lnFD, lnGDP, lnIND, lnLF, and lnRENC) are also examined to investigate their influence.

The outcome of the Granger causality and the PVECM test are presented in Table 10. In the short run, alternative energy has a negative and statistical impact on the emission of carbon. A two-way causality runs from renewable energy (RENC) to carbon emissions in the short run. A unidirectional causality runs from industrialization to carbon emissions. There is no Granger causality between financial development (FD), GDP (economic growth), labor force (LF), trade openness (TRAD), and carbon emissions. The ECT in the CO_2 equations, FD equations, GDP equations, industrialization equation, and energy equations is statistically significant; this implies that a bidirectional relationship exists between financial development, GDP, industrialization, renewable energy, and CO_2 emissions in the long run, and the feedback hypothesis is valid in BRICS nations. There are no proofs of Granger causality among trade openness, labor force, and carbon emissions in the long run.

4 | EMPIRICAL RESULTS

4.1 | Descriptive statistics

The summary of descriptive statistics is demonstrated in Table 2 of CO_2 (carbon dioxide emissions), financial development (lnFD), labor force (lnLF), gross domestic product (lnGDP), industrialization (lnIND), renewable energy (lnRENC), and trade openness (lnTRAD). However, from the descriptive statistic, the maximum value of environmental quality represented by CO_2 and renewable energy is 2.63 and 4.07, and the minimum value is (−0.80, 0.00), respectively. On the other hand, lnFD, lnGDP, lnLF, and trade representing economic growth have a maximum value of (5.08, 30.01, 4.37, and 2.61) and minimum value of (0.00, 0.00, 0.00, and 0.00), respectively. Therefore, the environmental quality in the BRICS nation is determined by the high level of economic growth. The matrix of correlation in Table 3 reveals the correlation between the series under study in scrutinizing the interconnection between financial development and renewable energy consumption on CO_2 emission (which is a proxy for environmental quality). The output of the CM agrees with the established economic theories, for example, emission of carbon is anticipated to exhibit a negative correlation with clean energy usage, and this implies that renewable energy is anticipated to mitigate the effusion of carbon. Also, FD is anticipated to exhibit a positive correlation with labor force participation and GDP.

4.2 | Results of panel CD

The null hypothesis of no CD is rejected by all the tests in Table 4. Thus, we conclude that there exists CD within the sample.

4.3 | Results of Pesaran CADF panel unit root test

Following the outcome of Pesaran (2007), the outcome of the second-generation panel unit root test is presented in Table 5. The presence of nonstationarity (unit root) was tested the seven variables (emission of carbon [$lnCO_2$], financial development [lnFD], renewable energy consumption [lnRENC], the value of labor force [lnLF], gross domestic product [lnGDP], trade openness [lnTRAD], and the industrialization value [IND]). The level and first difference tests were carried out for all the above-mentioned variables. At the level, the variables are not stationary for both the versions with the trend and without the trend. However, the variables became stationary at the first difference for both versions with the trend and without trend. Thus, we conclude that the variables are 1(1) series. Also, the results include specific deterministic terms and thus are robust.

4.4 | Results of the cointegration test by Westerlund (2007) and Kao cointegration test

The Westerlund (2007) cointegration test for the variables under study is presented in Table 6. The test was done with a constant but no trend and with a trend or no constant. The outcome of both models suggests no cointegrating association between the variables both within and across countries. The statistics of the value of the Gt, Ga, Pt, and Pa shows that at 0.05%, the null hypothesis of no cointegrating relationship cannot be rejected. By including a constant or a trend the countries exhibit an absence of cointegration within and across the panel. Thus, based on the outcome of the

TABLE 2 Descriptive statistics

Statistics	$lnCO_2$	lnFD	lnLF	lnGDP	lnIND	lnRENC	lnTRAD
Mean	0.9514	3.5964	3.0676	26.332	25.079	1.9824	1.6139
Median	0.6265	3.9490	4.0615	27.663	26.474	2.6327	1.7824
Maximum	2.6376	5.0822	4.3711	30.010	29.236	4.0716	2.6106
Minimum	−0.8001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SD	1.0100	1.4692	1.8087	5.8791	5.9265	1.6100	0.6988
Skewness	0.2837	−1.6302	−1.1053	−4.1528	−3.8831	−0.1416	−0.8674
Kurtosis	1.6020	4.6288	2.2378	18.777	16.630	1.3311	2.9713

TABLE 3 Correlation coefficient matrix

Correlation	$lnCO_2$	lnFD	lnGDP	lnIND	lnLF	lnRENC	lnTRAD
$lnCO_2$	1						
T-stat	—						
PV	—						
lnFD	0.1253	1					
T-stat	1.7559	—					
PV	0.0807**	—					
lnGDP	0.1773	0.5387	1				
T-stat	2.5030	8.8846	—				
PV	0.0131**	0.0000*	—				
lnIND	0.2012	0.5718	0.9454	1			
T-stat	2.8546	9.6847	40.307	—			
PV	0.0048*	0.0000*	0.0000*	—			
lnLF	0.2560	0.2613	0.4341	0.4548	1		
T-stat	3.6805	3.7622	6.6961	7.0945	—		
PV	0.0003*	0.0002*	0.0000*	0.0000*	—		
lnRENC	0.0588	0.2699	0.2984	0.3095	0.7261	1	
T-stat	0.8196	3.8946	4.3439	4.5219	14.673	—	
PV	0.4134	0.0001*	0.0000*	0.0000*	0.0000*	—	
lnTRAD	0.4038	0.4826	0.5097	0.5412	0.5704	0.3275	1
T-stat	6.1336	7.6553	8.2306	8.9415	9.6487	4.8157	—
PV	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	—

*The rejection of null hypothesis at 0.01% level of significance discretely.

**The rejection of null hypothesis at 0.05% level of significance discretely.

TABLE 4 Cross-sectional dependence tests

Test	Statistic	Probability value
Breusch–Pagan LM	220.05	.0000*
Pesaran scaled LM	46.969	.0000*
Pesaran CD	14.739	.0000*

*Statistically significant at 0.05%.

Westerlund (2007) cointegration test, there is no cointegration between the sampled variable.

However, the outcome of the Kao cointegration test is illustrated in Table 7. The null hypothesis of no cointegration is rejected at a 0.05% significance level based on the findings in Table 7. Thus, we conclude that there is an existence of a stable relationship between financial development, renewable energy, labor force, gross domestic production, trade openness, industrialization, and environmental sustainability (carbon emission) of countries in BRICS based on the outcome of the Kao panel cointegration test.

4.5 | The outcome of the PDOLS

The estimates of the PDOLS of Equation 1 are displayed in Table 8. The outcomes reveal that GDP and labor force have a significant effect on environmental quality within the region. This implies that a 1% increase in the GDP and labor force will lead to a 1.52% and 1.07% increase in the emission of carbon in the region, which in turn will deteriorate the quality of the environment. On the other hand, industrialization, trade openness, and renewable energy usage have a significant negative impact on the environmental quality of BRICS countries. This suggests that a 1% increase in industrialization, trade openness, and renewable energy usage will lead to 0.85%, 0.27%, and 0.12% on the emission of carbon, thus increasing the quality of the environment in the region. FD has an insignificant positive impact on the emission of carbon in the region.

4.6 | Estimation output of the PMG-ARDL

The outputs of the PMG-ARDL estimation are presented in Table 9. The long-run coefficients of the PMG-ARDL reveal that FD, clean energy, industrialization, and trade openness appear to be negative and have a significant on the emission of carbon of BRICS countries. This indicates that a 1% increase in financial development, industrialization, renewable energy, and trade will lead to 14%, 29%, 85%, and 5% mitigation on the emission of carbon. It is worthy to note that renewable energy has an enormous impact on the long-run reduction of carbon in BRICS. Thus, financial development, renewable energy, industrialization, and trade improve the quality of the environment of BRICS in the long run. Contrarily, GDP (economic growth) appears to

TABLE 5 Pesaran CADF panel unit root test

	Levels		First differences	
Variables	Intercept	Intercept and trend	Intercept	Intercept and trend
lnCO$_2$	0.724 (.766)	0.986 (.838)	−3.377 (.000)*	−2.094* (.000)*
lnGDP	2.550 (.988)	0.751 (.774)	−3.320 (.000)*	−3.050 (.001)*
lnFD	−0.764 (.222)	−0.141 (.444)	−2.855 (.002)*	−1.513 (.065)***
lnTRAD	−0.400 (.344)	1.813 (.965)	−2.050 (.020)**	−1.443 (.075)**
lnRENC	0.108 (.543)	0.067 (.527)	−3.316 (.000)*	−4.596 (.000)*
lnLF	−0.071 (.472)	0.105 (.542)	−2.543 (.006)*	−1.860** (.031)
lnIND	−2.687 (.004)	−1.063 (.144)	−3.146 (.001)*	−2.442 (.007)*

Note: Probability values are in parenthesis. Stata rountine pescadf was used.
*Statistically significant at 0.01%.
**Statistically significant at 0.05%.
***Statistically significant at 0.10%.

TABLE 6 Cointegration outcome of Westerlund (2007)

	Constant		Trend	
Statistics	Value	*Z* value	Value	*Z* value
Gt	−2.089	1.738	−2.023	2.769
Ga	−2.171	3.745	−1.379	4.582
Pt	−3.296	2.290	−3.063	3.560
Pa	−1.374	2.967	−1.172	3.858

TABLE 7 Outcome of Kao cointegration test

	T statistic	Probability value
ADF	−2.5171	.0059

TABLE 8 The outcome of the PDOLS

Variable	Coefficient	*T* statistics	Probability
lnFD	0.0078	0.3418	.7413
lnGDP	1.5277	11.238	.0000*
lnIND	−0.8580	−6.4184	.0002*
lnLF	1.0705	3.5210	.0078*
lnRENC	−0.2760	−2.9667	.0180*
lnTRAD	−0.1265	−4.0780	.0002*

*Significant at 0.05%.

be positive and is having a significant effect on the emission of carbon. This implies that an increase in GDP by 1% leads to a 0.74% increase in the emission of carbon in the BRICS countries. The coefficient of GDP suggests that economic growth deteriorates the environmental quality of the BRICS countries. The convergence parameter or the EC coefficient is negative and statistically significant for the panel, showing adjustment to the long-run equilibrium. Also, for the individual countries, the convergence parameter was significant for all the countries.

Further, the estimations of the short-run coefficients of the individual countries are sown in Table 9. Table 9 reveals that in the short run, the coefficients of financial development are negative and significant in Brazil, China, and Russia. Financial development has a positive significant impact on the emission of carbon in South Africa and India. GDP has a negative significant impact on the emission of carbon in India, while for Russia, its impact on the emission of carbon is positive in the short run. In Brazil, China, and South Africa, the impact of economic growth on the emission of carbon is insignificant. Industrialization has a negative significant impact on the emission of carbon in India and Russia in the short run, and the impact is insignificant in Brazil, China, and South Africa. Labor force is negative and significant in India, Russia, and South Africa, and the impact is insignificant in Brazil and China. Renewable energy has a negative significant impact on the emission of carbon in Brazil, China, India, and South Africa in the short run, while the impact is positive in Russia. Trade openness has a negative significant impact on carbon emissions in Brazil, China, and India in the short run, while the impact is positive in Russia and South Africa.

5 | DISCUSSIONS

Both the outcome of the PDOLS and the PMG-ARDL reveal that economic growth in the longer period hampers the sustainable environment of BRICS by increasing the effusion of carbon. This is insightful for policymakers. The acceleration in the degradation of the environment in the BRICS countries is a result of the nature of the growth of GDP in these nations. This can be attributed to the utilization of fossil fuel-based energy for propelling growth. Similar findings were discovered by Naqvi et al. (2020) who found that economics mitigates the environmental quality of lower middle income countries. In the long run, the PDOLS reveals that an increase in labor force participation deteriorates the environmental quality of the BRICS countries. An increase in labor force participation will accelerate productivity and the use of energy; this, in turn, mitigates the environmental quality by increasing the emissions of carbon (Empora et al., 2020).

TABLE 9 The pooled mean group with dynamic ARDL (1, 1, 1, 1, 1, 1, 1)

	lnFD	lnGDP	lnIND	lnLF	lnRENC	lnTRAD	Adjustment parameter
Long run	−0.1448* (0.0325)	0.7404 (0.1302)	−0.2952* (0.1456)	−0.0015 (0.2942)	−0.8535* (0.1979)	−0.0563* (0.0263)	−0.3824** (0.2048)
Short run of cross-sections							
Brazil	−0.0015* (0.0004)	0.5508 (0.6871)	0.0104 (0.1473)	−0.5618 (0.2902)	−0.9771* (0.0282)	−0.0219* (0.0014)	0.0023* (0.0056)
China	−0.0656* (0.0052)	−1.4331 (0.6456)	1.5142 (0.2942)	−4.8875 (6.1970)	−0.4007* (0.0225)	−0.0244* (0.0006)	−0.1104* (0.0019)
India	0.0285* (0.0077)	−0.2906* (0.0825)	−0.1603* (0.0461)	−1.8274* (0.4550)	−0.7187* (0.1009)	−0.0534* (0.0019)	−1.0856* (0.0295)
Russia	−0.1601* (0.0011)	1.1589* (0.0765)	−0.4353* (0.0352)	−1.6721* (0.0726)	0.2863* (0.0045)	0.0531* (0.0019)	−0.6056* (0.0066)
South Africa	0.1966* (0.0150)	1.2221 (1.8165)	−0.8027 (0.7490)	−1.3793** (0.4717)	−0.2840* (0.0878)	0.3134** (0.0666)	−0.1125* (0.0096)

Note: Parenthesis numbers represent the standard error.
*5%.
**10%.

On the other hand, industrialization, trade openness, and renewable energy usage have a significant impact on the environmental quality of BRICS countries. This suggests that a 1% increase in industrialization, trade openness, and renewable energy usage will lead to 0.85, 0.27%, and 0.12% on the emission of carbon, thus increasing the quality of the environment in the region. However, the advancement process must begin from within through substantial industrialization, advanced trade, and energy improvement so that a solid basis for a clean and better environment can be established. Contrarily, Udemba (2020) in their findings reveals that the quality of the environment was not improved by renewable energy or trade but rather improved by technological advancement.

The long-run coefficients of the PMG-ARDL reveal that financial development, renewable energy, industrialization, and trade openness have a substantial impact on the emission of carbon of BRICS countries in the long run. This implies that a 1% increase in financial development, renewable energy, industrialization, and trade will lead to 0.14%, 0.29%, 0.85%, and 0.5% mitigation on the emission of carbon. It is worthy to note that renewable energy has an enormous impact on the long-run reduction of carbon in BRICS. Thus, financial development, renewable energy, industrialization, and trade enhance the quality of the environment of BRICS in the long run. Therefore, by providing financial incentives for firms through FD, this approach promotes the use of advanced environmentally friendly technologies in the production processes. Contrarily, the growth rate has a significant effect on emissions. This implies that an increase in GDP by 1% leads to a 0.74% reduction in the emission of carbon in the BRICS countries. Therefore, the economic implication here is that the coefficient of GDP suggests that economic growth deteriorates emission, thereby improving the environmental quality of the BRICS countries. Labor force is insignificant with a negative effect on the emissions of carbon in the longer period. Additionally, for the individual countries, the convergence parameter was significant for all the countries.

Furthermore, the estimations of the short-run coefficients of the individual countries are shown in Table 9. The findings reveal that in the short run, the coefficients of financial development are negative and significant in Brazil, China, and Russia. Financial development has a positive significant impact on the emission of carbon in South Africa and India. The growth rate (GDP) is negative with a significant impact on the CO_2 of India, while for Russia, its impact on the emission of carbon is positive in the short run. The impact of economic growth on the emission of carbon is insignificant in South Africa, China, and Brazil. Industrialization is also having a significant effect on the emission of carbon in India and Russia in the short run, and the impact is insignificant in Brazil, China, and South Africa. Labor force is negative and significant in India, Russia, and South Africa, and the impact is insignificant in Brazil and China. In the short run, renewable energy is having a negative and significant impact on the emission of carbon in Brazil, China, India, and South Africa, while the impact is positive in Russia. Trade openness in the same vein is also negative with a significant impact on the emission of carbon in Brazil, China, and India in the short run, while the impact is positive in Russia and South Africa.

The outcome of the Granger causality and the PVECM test are presented in Table 10. In the short run, renewable energy has a negative and statistical impact on the emission of carbon. A two-way Granger causality runs from renewable energy (RENC) to carbon emissions in the short run. A one-way causality runs from industrialization to carbon emissions. The ECT in the carbon emission equations, FD equations, GDP equations, industrialization equation, and energy equations is statistically significant, this implies that a two-way relationship exists between FD, GDP, industrialization, renewable energy, and CO_2 emissions in the long run, and feedback hypothesis is valid in BRICS nations. Thus, some studies that have similar outcomes include Adedoyin et al. (2020) and Su et al. (2021).

TABLE 10 VECM test results and panel Granger causality

Dependent variable	Source of causation (independent variables)								
	Short-run causality								Long-run causality
	D(lnCO₂)	*D*(lnFD)	*D*(lnGDP)	*D*(lnIND)	*D*(lnLF)	*D*(lnRENC)	*D*(lnTRAD)	C	ECT
D($lnCO_2$)	−0.0279 (−0.1899)	−0.2649 (−0.7930)	−0.1194 (−1.5094)	−0.2237* (−1.9568)	−0.0157 (−0.4727)	−0.2883* (−2.1060)	−0.0442 (−0.1052)	0.0290* (2.226)	−0.0403* (−2.3331)
D(lnFD)	−0.0186 (−0.4903)	0.3367* (3.9049)	0.0362 (3.9049)	0.0711* (2.4119)	0.0113 (1.3172)	0.0470 (1.3318)	0.0461 (1.4245)	−0.0392 (−1.3247)	0.1372* (3.4993)
D(lnGDP)	0.0314 (0.0725)	2.4081* (2.4495)	0.3261 (1.4006)	0.2587 (0.7691)	−0.0441 (−0.4499)	−0.4241 (−1.0528)	0.1326 (0.9145)	0.0290* (−4.1356)	−0.0240* (−2.5861)
D(lnIND)	−0.0175 (−0.0618)	−1.5487* (−2.4047)	0.1337 (0.8767)	0.2177 (0.9880)	0.0633 (0.9852)	0.3334 (1.2635)	−0.3784 (−0.4664)	0.0324* (3.2017)	−0.0523* (3.9001)
D(lnLF)	0.1483 (0.3008)	−0.9442 (−0.8442)	−0.4691 (−1.7709)	−0.8348* (−2.1810)	0.2415* (2.1642)	−0.0996 (−0.2174)	0.4231 (0.3002)	−0.0003 (−0.1087)	0.0052 (1.3346)
D(lnRENC)	−0.2700* (2.4074)	−0.0587* (−0.1734)	0.0330 (0.4119)	−0.0629 (0.5438)	0.0161 (0.4774)	−0.1821 (−1.3133)	0.5361 (1.2575)	−0.0029 (−0.2467)	0.0495* (3.0847)
D(lnTRAD)	−0.0452 (−1.2128)	0.1330 (1.5715)	−0.0142 (−0.7086)	−0.0139 (−0.4817)	−0.0008 (−0.0967)	0.0385 (1.1106)	−0.0327 (−0.3072)	0.0278 (0.7466)	−0.0527 (−1.0671)

Note: Parenthesis numbers represent the standard error.
*5%.
**10%.

6 | CONCLUSION AND POLICY IMPLICATION

Global warming and environmental degradation caused essentially by changes in climate have captured enormous surveillance considering the menace of its reverberation on the health of humans during the preceding two decagons. Utilization of energy and FD are among the key drivers of climatic change. Thus, using second-generation panel cointegration (the Westerlund (2007) EC model), PMG-ARDL, and the PDOLS estimation techniques, the paper scrutinized the nexus between financial development, clean energy usage, economic growth, and environmental quality (proxied by CO_2 emissions) of BRICS countries starting from 1980 to 2018.

The major findings from the study reveal that GDP (economic growth) and labor force have a significant positive influence on the environmental quality within the BRICS nations in the long run. In contrast, financial development, industrialization, trade openness, and renewable energy usage have a significant negative impact on the environmental quality of BRICS countries. The outcome of the Granger causality shows that a two-way causality runs from renewable energy to carbon emissions in the short run, and a unidirectional causality runs from industrialization to carbon emissions.

The findings annotate that increase in economic growth and labor force participation degrades the quality of the environment because BRICS nation's higher income and greater labor force participation entail clean water, health, loading facilities, nitration, and transport. Outrageous energy use and productivity are majorly related to labor force participation and economic growth. Therefore, this research recommends that countries in BRICS should provide numerous environmental sensitization conglomerations to employers of labor in both the public and private sectors. Commercial and residential buildings should be furnished with subsidized energy panels and energy-efficient appliances. Additionally, the empirical results suggest that financial development, industrialization, trade openness, and clean energy enhance the environmental quality of BRICS in the long run. Thus, to avoid any environmental damage in the longer period, the BRICS countries' government needs to concentrate on improving its clean energy sources and also work on its industries. The BRICS nations' government should formulate financial and trade policies that promote a sustainable environment. The industrial sector should encourage and develop green technology to minimize pollution of the environment during the process of production. Contribution to energy technological innovations should be embraced equally by both private and public organizations. The policymakers of BRICS economies should formulate policies that are geared to subsidizing the clean energy sector and making it free from taxation. Finally, policymakers need to encourage suitable measures aimed to enhance the development of the financial sector, promote openness in trade, and industrialization to improve the quality of the environment.

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