Determinants of CO_2 emissions in the BRICS. A dynamic Panel ARDL approach

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Abstract. This paper examines the effects of Foreign Direct Investment, Economic Growth, Trade Openness, Energy Consumption, and Renewable Energy on CO_2 Emissions in BRICS nations. This study employs the panel ARDL model to investigate the short- and long-term effects of an association between variables. The PMG estimator has shown itself to be more trustworthy and performs at a higher level of efficiency, leading us to the conclusion that it is the preferable technique. Because the error correction parameter, also known as the adjustment coefficient, is negatively significant, the findings demonstrate that there is a long-term relationship. According to the paper's findings, there are both short-term and long-term effects of free trade and energy consumption on CO_2 emissions. In the short run, FDI has positive impact on CO_2 emissions, whilst renewable energy has detrimental effect. Surprisingly, the BRICS countries have not shown a correlation between economic development and carbon dioxide emissions. These findings may encourage policymakers in these countries in better recognizing the complexities of this occurrence, which in turn can assist direct future choices about this growing international security danger.
Keywords: BRICS, Energy, Trade, $\mathbf{CO_2}$, Panel ARDL.

1 Introduction

The magnitude of environmental change caused by humans is remarkable. Human activity is almost definitely responsible for the rapid increase in atmospheric concentrations of both greenhouse gases and ozone-depleting gases [1]. Even if environmental disasters caused by humans are not uncommon, the subject of how economic activities influence the environment became prominent among academics in the 1960s. Carbon dioxide (CO_2) in the atmosphere has been an increasingly important topic of concern throughout the world over the last three decades as a result of the impact of numerous industries. Large-scale production, on the other hand, has severe environmental consequences. The political and economic decisions of countries now include dealing with this phenomenon. The global embodiment of this topic was the holding of seminars in Stockholm in 1979, Rio de Janeiro in 1992, Johannesburg in 2002, Copenhagen in 2009, and Durban in December 2011. Currently, many nations,

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particularly those that are still in the process of developing, face a formidable obstacle: the complex interaction of economic, social, and environmental factors in national progress. They are the ones attempting to alleviate poverty, broaden economic opportunities, and safeguard the natural world.

There has been a tremendous deal of political and scholarly focus on the BRICS nations in recent years [2]. Culturally, historically, linguistically, and economically, these nations could not be more unlike one another. They all have one thing in common, though: the BRICS' economic growth has far outpaced that of the world's top industrialized countries. Following the global economic downturn that began in 2007, they still managed to outperform most of the world. While major economies like Japan's and Germany's shrank by as much as 6% in 2009, Brazil and India held stable, while China expanded by 8.1%, with Russia being the group's worst performance by contracting by 7%.

Over the past two decades, numerous studies have been performed to explain the multivariate pattern between energy usage and GDP, FDI and GDP, and some CO_2 emissions, energy consumption, and GDP. When it comes to environmental policy, the information provided by these studies is typically unreliable because of the limitations imposed by the measuring technique. These restrictions include collecting data from just one nation, using data from a sample that covers too little time, and failing to account for key factors. This study aims to alleviate these econometric estimation issues by extending the multivariate paradigm to account for the impact of FDI, renewable energy, and energy consumption on the nexus by employing a panel data set. Pollutant emissions, energy consumption, gross domestic product, and foreign direct investment are all interconnected, but there has been no structured time series analysis of this relationship among the BRIC nations. This study was undertaken with the intention of bridging the resulting knowledge gap in the existing literature. Using a panel ARDL approach, we investigate the short- and long-term dynamics of the interdependence among economic growth, energy consumption, foreign direct investment, and environmental degradation.

This paper will be organized as follows: Section 2 gives a summary of the relevant previous studies, while Section 3 discusses the study's data, methods, and results. The results are summarized in the last section of the study.

2 Literature review

Factors that have been empirically explored in regard to their influence on carbon dioxide emissions include FDI, energy usage, economic growth, renewable energy, and trade openness. The connections between them will be discussed in the next section.
By using the Augmented Mean Group (AMG) estimator, Rafique [3] investigate the impacts of FDI inflows on carbon emissions in BRICS member nations using data ranging from 1990 to 2017. The results show that CO_2 emissions and FDI inflows in the BRICS countries have a negative relationship that is statistically significant over time. Kilicarslan and Dumrul [4] investigate the connection between inward FDI and pollution in Turkey from 1974 to 2013 was studied using the Johansen Co-integration test and the vector error correction model. The results of the study indicate that long-term carbon dioxide emissions are favorably impacted by the presence of FDI.

By using the FMLOS estimator and data from 1990 to 2019, Abid [5] investigated the impacts of technological innovation, economic development, foreign direct investment, energy consumption, and urbanization on carbon emissions in G8 member countries. The results show that FDI, GDP growth, and technical innovation all have a statistically significant negative long-term relationship with CO_2 in the G8 countries. Utilizing regression analysis, Do and Dinh [6] evaluate the long- and short-term impacts of GDP, energy consumption, FDI, and trade openness on CO_2 emissions in Vietnam from 1980 to 2014.

Results showed that a negative correlation between GDP growth per capita and CO_2 emissions existed. The use of energy and the free flow of trade are both negatively impacted by CO_2 emissions. In the long run, CO_2 emissions are positively correlated with foreign direct investment (FDI) inflows. Applying VAR Granger causality estimations, Naz, Sultan et al. [7] analyzed the impacts of renewable energy consumption, FDI inflows, and economic development on CO_2 emissions in Pakistan. The study covered the period from 1975 to 2016. Economic growth and FDI inflows, according to the data, both have a significant positive effect on CO_2emissions. Still, the usage of renewable energy sources results in a substantial decrease in CO_2emissions.

Gule [8] examines how FDI, economic development, and capital stock affect CO_2 emissions in 16 SADC nations. The study combines panel data spanning the years 1990 to 2014. The study employed both static and dynamic estimating techniques to test the impact. Both static panels estimate using pooled ordinary least square and dynamic panel estimation using system general techniques of the moments reveal that FDI and economic development in SADC have a positive and substantial influence on CO_2 emissions. Using dynamic estimating methodologies of co-integration, Panigrahi [9] investigates the dynamic influence that energy consumption, FDI, and economic development have on carbon emissions for the countries of Oman and the United Arab Emirates. For this study, quarterly panel data was collected from Oman and the UAE from 1991 till 2018. The influence is examined using the generalized method of moments (GMM) and the Granger causality test. According to the findings, there is a significant positive effect on CO_2 emissions in Oman and the United Arab Emirates that corresponds with energy consumption and FDI. However, there is a significant negative effect associated with economic development on CO_2 emissions. Yuldoshboy et al. [10] also found a unidirectional link between GDP and CO_2 emissions, GDP and energy consumption, and energy consumption and CO_2 in Central Asian countries by using Pooled OLS, Random Effect and Fixed Effect Models including time span from 2000 to 2020.

3 Data and Methodology

3.1 Data

Using panel data, this study looks at how the BRICS countries' FDI, energy consumption, economic development, renewable energy utilization, and trade openness all affect their CO_2 emissions. Employing annual time series data gathered from the World Development Indicators database, the empirical study spanned the years 1996-2020. The output of the following factors-foreign direct investment, energy consumption, economic growth, renewable energy, and trade openness-is the independent variables that influence carbon dioxide emissions.

3.2 Model and methodology

To examine how foreign direct investment (FDI), energy consumption, economic development, renewable energy use, and trade openness affect CO_2 emissions in BRICS countries, we employ the Panel Autoregressive Distributed Lag Model (ARDL) model.
The empirically relevant variables that are included in our model are outlined in Table 1, which provides a summary of those variables. In total, there are maximum 125 observations because of data limitation, and there are 6 variables, with only one of them being dependent on the others.

Table 1. Descriptive Statistics

Variable	Obs	Mean	Std. dev.	Min	Max
lnCO_2	120	1.362173	0.8701871	-0.2383008	2.475277
lnfdi	125	0.5951843	0.7201048	-1.58414	1.680522
lngdp	125	27.68561	1.11247	25.58376	30.31803
lntrade	125	3.700961	0.3416715	2.74955	4.23979
lnenergy	95	7.350335	0.7897456	5.964675	8.55005
lnrnew	120	2.821747	0.9594607	1.156881	3.984668

Source: Computed by Stata 17.0

Following the descriptive statistics, we consider an empirical technique that is based on the panel ARDL to examine the short-term and long-term effects that independent factors have on variables that are dependent on them. With the help of this model, it is feasible to differentiate between effects that will occur in the short run and those that will occur in the long run. Consequently, it is possible to study the process of changing variables to obtain both short-term and long-term equilibrium states. In the first step of our investigation, we developed the equation that is shown below to serve as the basic model:

$$CO_{2_{it}} = \alpha_0 + \alpha_1 FDI_{it} + \alpha_2 GDP_{it} + \alpha_4 Trade_{it} + \alpha_5 Energy_{it} + \alpha_6 rnew_{it} + \varepsilon_{it} \quad (1)$$

$CO_{2_{it}}$- CO_2 emissions (metric tons per capita)
FDI_{it}- Foreign direct investment, net inflows (% of GDP)
GDP_{it}- GDP (current US$)
$Trade_{it}$- Trade (% of GDP)
$Energy_{it}$- Energy use (kg of oil equivalent per capita)
$rnew_{it}$- Renewable energy consumption (% of total final energy consumption)
ε_{it}-is the error term.

Displaying correlations between model's independent variables, Table 2 shows the model's multicollinearity. A correlation value of 0.000 indicates that there is no association between the two variables, whilst a correlation value of 1.000 indicates that the two variables are completely associated with one another. A correlation value of 0.000 indicates that there is absolutely no association between the two variables. In general, correlation values between 0.3 and 0.5 indicate a poor correlation, and correlation scores between 0.5 and 0.7 suggest a moderate connection between two variables. Those with values more than 0.7 to 1 have a strong link; the same is true for those with negative values, which have the opposite effect and have a negative correlation [11].

Table 2. Correlation Matrix

	lnCO_2	lnfdi	lngdp	lntrade	lnenergy	lnrnew
lnCO_2	1.0000					
lnfdi	0.0218	1.0000				
lngdp	-0.1035	0.5664	1.0000			
lntrade	0.6771	-0.0346	-0.0292	1.0000		
lnenergy	0.9648	0.0413	-0.1244	0.5213	1.0000	
lnrnew	-0.9212	0.0412	0.0907	-0.6982	-0.8957	1.0000

Source: Computed by Stata 17.0

3.3 Panel unit root tests

It is important to check the sample's stationarity before proceeding on to the estimate of the ARDL model using a panel dataset. This must be completed before proceeding to step two of the estimating procedure. The autoregressive vector (VAR) technique determines whether the series is I(0), indicating that the dynamics are present in the short run. In the meanwhile, if the variables are either (I(0) or I(1)) or they are (I(1)), then we use the panel ARDL model as if we are supposing the series to be in level. The IPS and Fisher type tests are employed to decide about the existence of a unit root in a collection of panel series. There are two sets of tests that were developed by Im, Pesaran and Shin [12]. Each of these tests follows the same basic format, which may be described as an ADF regression for panel dataset in the following format:

$$\Delta y_{it} = \alpha_i \gamma_i y_{it-1} + \sum_{j=1}^{p} \varphi_j \Delta y_{i,t-1} + \varepsilon_{it} \quad (2)$$

$$\text{where } \gamma_i = \rho_i - 1$$

Both methods are used to examine whether the unit root hypothesis is valid: $\gamma_i = 0$ ($\rho_i = 1$) as contrast to the option of remaining static, H1: $\gamma_i < 0$ ($\rho_i < 1$).

3.4 Panel Autoregressive Distributed Lag Model

To estimate the ARDL model, the unit root test must be performed first, followed by the cointegration test. The ARDL model can be used appropriately for constrained sample sizes, and the distinction between short-run and long-run coefficients may be made. It's also beneficial for looking at information over longer periods of time. According to Pesaran and Shin [13], the long-term parameters are super-consistent whereas the short-term parameters are $\sqrt{T}$ consistent. Consequently, equation (1) is transformed into a panel ARDL (p,q_1,q_2,q_3,q_4,q_5) equation, in which p stands for the lags associated with the dependent variable and q stands for the lags associated with the independent variables. The equation for the panel's ARDL may be expressed as follows:

$$ln\mathrm{CO}_{2_{it}} = \alpha_i + \sum_{j=1}^{p} a_{1,ij}\, ln\mathrm{CO}_{2_{i,t-j}} + \sum_{j=0}^{q_1} a_{2,ij}\, lnFDI_{i,t-j} + \sum_{j=0}^{q_2} a_{3,ij}\, lnGDP_{i,t-j} + \sum_{j=0}^{q_3} a_{4,ij}\, lnTrade_{i,t-j} + \sum_{j=0}^{q_4} a_{5,ij}\, lnEnergy_{i,t-j} + \sum_{j=0}^{q_5} a_{6,ij}\, lnrnew_{i,t-j} + \varepsilon_{it}. \quad (3)$$

where I = 1,2,3,...N and t = 1,2,3,...T. Fixed effects are represented by α_i, a_1−a_5 are the independent variable coefficients and regressors that have been correlated with each other over the time period in question, and ε_{it} is the error term, which is said to be caused by white noise and which varies depending on the country and the time.

This is the panel error correction (ECM) representation of equation (3):

$$lnCO2_{it} = \alpha_i + \sum_{j=1}^{p} a_{1,ij}\, ln\Delta CO2_{i,t-j} + \sum_{j=0}^{q_1} a_{2,ij}\, ln\Delta FDI_{i,t-j} + \sum_{j=0}^{q_2} a_{3,ij}\, ln\Delta GDP_{i,t-j} + \sum_{j=0}^{q_3} a_{4,ij}\, ln\Delta Trade_{i,t-j} + \sum_{j=0}^{q_4} a_{5,ij}\, ln\Delta Energy_{i,t-j} + \sum_{j=0}^{q_5} a_{6,ij}\, ln\Delta rnew_{i,t-j} + \beta_{1,ij}\mathrm{CO}_{2_{i,t-1}} + \beta_{2,ij} lnFDI_{i,t-1} + \beta_{3,ij} lnGDP_{i,t-1} + \beta_{4,ij} lnTrade_{i,t-1} + \beta_{5,ij} lnEnergy_{i,t-1} + \beta_{6,ij} lnrnew_{i,t-1} + \varepsilon_{it} \quad (4)$$

Where, Δ is the first difference of variables. The short-run coefficients are denoted by a_1−a_5.While, the long-term indices of Market Size, FDI, Infrastructure, Trademark applications and Trade Openness are β_1−β_5, respectively. After establishing long-term associations between the dependent variables and the regressors, the panel ECM model equation (4) may be written as follows:

$$ln\Delta CO_{2_{it}} = \alpha_i + \sum_{j=1}^{p} a_{1,ij}\, ln\Delta CO_{2_{i,t-j}} + \sum_{j=0}^{q_1} a_{2,ij}\, ln\Delta FDI_{i,t-j} + \sum_{j=0}^{q_2} a_{3,ij}\, ln\Delta GDP_{i,t-j} + \sum_{j=0}^{q_3} a_{4,ij}\, ln\Delta Trade_{i,t-j} + \sum_{j=0}^{q_4} a_{5,ij}\, ln\Delta Energy_{i,t-j} + \sum_{j=0}^{q_5} a_{6,ij}\, ln\Delta rnew_{i,t-j} + \theta_i ECM_{i,t-1} + \varepsilon_{it} \quad (5)$$

Where, θ_i is the coefficient of the ECM that quantifies the pace of adjustment that is formed each year toward the long-run equilibrium. Given the low number of yearly data, a maximum lag length of three is selected as the ideal choice for the ECM model's optimal lag length, which is obtained by using Akaike's lag selection criterion. The pooled mean group methodology, often known as the PMG technique, is utilized in the estimation of the panel ARDL regression. This is an estimating method which was developed by Pesaran and Smith [14] involves coefficient averaging and pooling of the coefficients in the estimation process. Flexibility group differences in intercepts, short-run coefficients, and error variances are provided using the previously mentioned panel approach. In addition, the likelihood-based PMG estimator requires that the long-run coefficients be identical across groups. Consequently, when homogeneity limitation is fulfilled, reliable estimates are obtained. Moreover, when the number of cross-sectional (N) samples is small, as in this research, the PMG estimate is less susceptible to anomalies and may simultaneously resolve serial autocorrelation. This likelihood-based estimate additionally deals with the endogenous variables issue by calculating the appropriate lag structures in relation to the dependent and independent elements.

3 Results

First, thorough unit root and cointegration tests were performed before applying panel ARDL to investigate the connection between the variables of interest. Table 3 summarizes the findings of stationarity tests performed by utilizing variety of techniques, namely, the augmented dickey fuller (ADF), Phillips Perron (PP), and IPS tests. The findings provide evidence that the variables in our paper are stationary either at their level or first level. Therefore, it can be concluded that the panel ARDL model can be utilized in our analysis.

Specifically, according to the results of stationarity tests, all variables are stationary at their first level. However, there are some variables which are stationary at their level, namely, lnfdi and lnenergy. This may provide us with the order to use the panel ARDL model since it is required to validate the sample's stationarity.

Table 3. Stationarity tests

	Fisher-type tests				IPS test	
	Fisher-ADF statistics		Fisher-PP statistics			
	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)
$lnCO_2$	5.4339	33.4511***	5.4339	69.1643***	0.5278	-4.573***
lngdp	2.8227	121.8***	43.8947***	256.1***	2.0149	-3.2121***
lnfdi	43.8947***	171.2923***	402.8***	171.2923***	-3.3765***	-4.01***
lnTrade	11.0555	76.1703***	11.0555	76.1703***	-0.5713	-5.4308***
lnrnew	11.3709	97.8439***	11.3709	97.8439***	0.5926	-4.6169***
lnenergy	1.3899	66.7139***	1.3899	66.7139***	-1.4325*	-3.6602***

*Note: Standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1*

The outcomes of the cointegration analysis are shown in Table 4. We see that most of the values of p are less than 0.05, and as a result, we can draw the conclusion that there is a cointegrating connection between the variables.

Table 4. Cointegration tests

Between		
Modified variance ratio	-1.3644	0.0862
Modified Phillips–Perron t	1.0502	0.1468
Phillips–Perron t	-2.0769	0.0189
Augmented Dickey–Fuller t	-1.2300	0.1094
Within		
Modified Phillips–Perron t	2.0832	0.0186
Phillips–Perron t	-3.6530	0.0001
Augmented Dickey–Fuller t	-1.8438	0.0326

Source: Computed by Stata 17
*Note: Standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1*

Test for the variance inflation factor (VIF) was also performed to further check that the assumption of negligible multicollinearity was satisfied, as shown in Table 5. The results reveal that none of the independent variables has a VIF greater than 10. The assumption is satisfied since the criterion for spotting multicollinearity is met. As per previous literature, a VIF > 10 or a 1/VIF < 0.10 indicates trouble.

Table 5. VIF

Variable	VIF	1/VIF
lnrnew	8.51	0.117572
lnenergy	6.21	0.161141
lntrade	2.19	0.456325
lnfdi	1.60	0.623427
lngdp	1.58	0.634645
Mean VIF	4.02	

Source: Computed by Stata 17

Table 6 presents the findings of the short- and long-term impacts of FDI, GDP, trade openness, energy consumption, and renewable energy on CO_2 emissions in BRICS by employing panel ARDL method, specifically PMG approach.

Table 6. Panel ARDL, PMG approach results

VARIABLES	PMG	PMG	DFE	DFE	MG	MG
__ec		-0.284		-0.186**		-0.873***
		(0.212)		(0.0885)		(0.174)
D.lngdp		0.0227		0.00245		-0.0352
		(0.0400)		(0.0211)		(0.0571)
D.lnfdi		-0.00139		-0.00946*		-0.0108
		(0.00590)		(0.00496)		(0.00867)
D.lntrade		0.0342**		0.0592*		0.00545
		(0.0135)		(0.0336)		(0.0560)
D.lnrnew		-0.244		-0.142***		-0.0566
		(0.162)		(0.0535)		(0.0481)
D.lnenergy		0.565***		0.680***		0.233
		(0.171)		(0.125)		(0.209)
lngdp	0.0112		-0.0552		0.102	

	(0.0217)		(0.0472)		(0.0912)	
lnfdi	0.0252**		0.0818		0.0231	
	(0.0106)		(0.0531)		(0.0231)	
lntrade	0.126**		0.0719		-0.0608	
	(0.0620)		(0.0915)		(0.0760)	
lnrnew	-0.249***		-0.0182		-0.249*	
	(0.0547)		(0.174)		(0.131)	
lnenergy	0.299*		1.283***		0.654***	
	(0.156)		(0.289)		(0.228)	
Constant		-0.126		-1.276***		-4.060*
		(0.130)		(0.484)		(2.147)
Hausman		35.73***		9.57***		
		PMG is accepted		DFE is accepted		
Observations	90	90				

Source: Computed by Stata 17
*Note: Standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1*

4 Discussion

Firstly, we employ PMG, MG and DFE one by one, and, according to the results of Hausman test, we proceed to utilize PMG model to analyze the impacts of independent variables on dependent variable in our paper.

The overall results of the sample suggest that the impact of foreign direct investment on carbon dioxide emissions is positive in the long run but insignificant in the short run, according to the findings. This finding indicates that a rise of 1 percent in FDI corresponds to a rise of 0.252 percent in carbon dioxide emissions, which indicates that FDI inflows in BRICS nations have a statistically favorable influence on economic development. This finding is in line with other studies on the association between FDI and CO_2 emissions conducted by Jafri, Abbas et al. [15], Teng, Khan et al. [16], Rahaman, Hossain et al. [17]. Table 5 shows that trade openness has a positive influence on CO_2 emissions. According to the findings of the study, CO_2 emissions in BRICS nations increase by 0.126% and 0.0342%, respectively, for every 1% improvement in trade openness over the long and short term. The findings are consistent with the research conducted by Khan, Weili et al. [18], Wang and Wang [19].

According to the findings of our study, there is a negative relationship between renewable energy andCO_2emissions of BRICS nations over the long term, but this relationship does not exist over the short term. According to the findings, a 1 percent increase in renewable energy is directly responsible for a 0.249% percent decrease in CO_2. The results are the same as the works conducted by Namahoro, Wu et al. [20], Zafar, Saleem et al. [21], Sharif, Bhattacharya et al. [22].

The favorable effects of energy on CO_2 emissions have also been seen in Table 5. According to the study's findings, CO_2 emissions in BRICS countries increase by 0.299% and 0.565% for every 1% improvement in energy usage in the long run and the short term, respectively. The results can be back up the works done by Alharthi, Saidmamatov et al. [23], Altarhouni, Danju et al. [24] and Hu, Raghutla et al. [25].

Interestingly, there is not either positive nor negative significant relationship between the rate of economic growth and CO_2 emissions in BRICS counties [26-46].

5 Conclusion

This paper examines the effects of GDP, FDI, trade openness, renewable energy, and energy consumption on CO_2 emissions in BRICS nations. We used panel ARDL, PMG approach as an econometric tool utilizing annual panel data for BRICS countries from 1996 to 2020 to accomplish the objective. The primary goal of this research is to examine the effects of renewable energy and energy consumption on CO_2 emissions in the BRICS countries. Firstly, we employ panel stationarity tests, namely Fisher type and IPS, to ensure if selected series are stationary either level or first difference. According to the results of stationarity tests, the series in this study are stationary either level or first difference which means that Panel ARDL is appropriate to employ in our empirical analysis. After that, panel cointegration tests are done to check the cointegrated relationship between variables of in our interest. Panel cointegration tests indicate that there is a cointegrated relationship between variables in the study. After checking stationarity and cointegration, Hausman test is utilized to check which approach from panel ARDL, namely PMG, MG and DFE, is suitable for our analysis. According to the results of Hausman test, PMG is more appropriate than the others. In this study, the PMG technique is used to assess the effects of independent factors on dependent variables. This paper's empirical findings indicate that trade openness, FDI, and energy consumption have both a short- and long-term relationship with CO_2 emissions in the BRICS nations. In detail, 1% increase in trade openness can contribute to 0.125% and 0.034% increase in CO_2 emissions in short- and long-term, respectively. Next, there is a positive and statistically significant link between BRICS countries' energy use and their CO_2 output over the course of both the short and long terms. To be more precise, a 1 percent rise in energy consumption results in a short-term increase of 0.056 percent and a long-term increase of 0.56 percent. Foreign direct investment (FDI) also has a significant and favorable effect on carbon dioxide (CO_2) emissions. There is no substantial association between FDI and CO_2 emissions in the short run in BRICS, but a 1% increase in FDI may lead to a 0.017% rise in the long run.

Renewable energy, as projected, has a negative and significant influence on CO_2 emissions in the BRICS, but only in the long term. According to the findings of this paper, every percent increase in renewable energy can contribute to decrease the level of CO_2 emissions by -0.243%.

In our example, the economy is named energy, and policies that use energy can lead to a detrimental impact on carbon dioxide emissions. As a result, if energy consumption has an impact on CO_2 emissions, energy conservation regulations should aim at safeguarding the environment. Furthermore, measures promoting energy production and conservation, foreign direct investment, trade openness, and economic growth would be ideal for the entire region. Even if there is a political intent to develop similar goals and objectives, separate policy and strategy designs for participant subgroups should most likely be considered to enhance the environmental protection of the region. The current analysis concludes with the recommendation of a crucial strategy, which is to prioritize the promotion of renewable energy consumption, FDI, and trade openness.

Finally, it should be mentioned that this study has significant drawbacks. Firstly, future researchers should include a firm level date to analyze the determinants of CO_2 emissions in the region. Second, by including a set of missing variables in our analysis, panel cointegration models such as the GMM, PDOLS, and FMOLS may be used to investigate the determinants of CO_2 emissions.

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