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RESEARCH ARTICLE

Moderating role of institutional quality in validation of pollution haven hypothesis in BRICS: a new evidence by using DCCE approach

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Abstract

The technological innovation and strict environmental protocols in the highly developed regions have become the primary sources for foreign direct investment to move in the pollution haven economies. In this regard, this study attempted to identify the role of foreign direct investment (FDI) in the developing economies of the Brazil, Russia, India, China, and South Africa (BRICS) region. For this reason, a dataset was obtained between 1995 and 2019. Chudik and Pesaran's (2015) latest dynamic common correlated effects (DCCE) technique is used because of its new features when integrating the problems of heterogeneity and structural breaks into panel data that are general and do not encompass much recent research in this context. According to the empirical outcomes, foreign direct investment is a source of pollution haven in this region. However, the moderating effect of institutional quality on foreign direct investment has been found negative for ecological footprint. It also found the threshold point where the foreign direct investment effect becomes negative on ecological footprint. Based on these empirical results, this research suggests that foreign direct investment strategy should be maintained in the presence of good institutional efficiency as it enhances the environment and promotes economic development.

Keywords Ecological footprint · Foreign direct investment · Institutional quality · DCCE approach

Introduction

Environmental degradation comes out as a challenging issue globally, and its outcomes seem to appear severe in the world (Yilanci et al. 2020). Human influence on climate has been the dominant cause of observed warming since the mid of the twentieth century (IPCC 2018). It has been claimed that environmental degradation increases the sea level and average temperature worldwide that cause severe climate occasions (Tsai et al. 2016). The International Energy Agency (IEA) estimated that a global cause of substantial environmental degradation is the energy use of 80% of carbon dioxide emissions. The energy industry has been instrumental in rising CO_2 emissions. It has been argued, in 2030, that in

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comparison to 2000, emissions of greenhouse gasses will rise from 25 to 90% and that the use of energy will minimize CO_2 emissions and rise from 40 to 110% by 2030 (IPCC 2007).

The previous literature shows a bulk of economic variables affect the environment like oil price, tourism, imports and exports, financial development, human capital, and trade openness (Abbas et al. 2020; Ali et al. 2021; Anser et al. 2020; Tanveer et al. 2021). However, our focus is mainly on some essential factors that affect the environment. In the present context, foreign direct investment is the most important indicator for all country economies. Recently, much of the discussion focuses mainly on the pollution haven hypothesis as a new potential determinant for international location choices. According to the pollution haven hypothesis (PHH), multinational companies set up their most polluting activities in countries with the laxest environmental legislations (Yilanci et al. 2020). Some previous investigations reported a positive association of foreign investment with CO_2 emission, favoring the pollution haven hypothesis (Yilanci et al. 2020; Xie et al. 2020) (Adedoyin et al. 2020).

On the other hand, some studies reported a negative impact of foreign investment on CO_2 emission, which supports the pollution halo hypothesis, which means foreign direct investment inflows create environmental quality (Sun et al. 2017; Baloch et al. 2020; Khan and Ozturk 2020). There is ambiguity in the true relation regarding the association of foreign direct investment with the environment. Still, there is a need to address this issue, especially in emerging economies like BRICS.

Brazil, Russia, India, China, and South Africa (BRICS) are large emerging economies that represent almost half of the world's population and have become engines of global growth, with a GDP amounting approximately to 46.22 billion dollars in 2019. These countries became a movement of growth and urbanization over the past few decades. Economic growth and urbanization in BRICS counties to the environment have also become a central question carrying social and economic stakes under significant economic growth. These countries became the biggest energy consumers globally and part of the top 20 polluters of the planet (Menegaki and Ozturk 2016).

Concerning previous studies related to BRICS countries, a lot of attention is given to environmental degradation in the perspective of FDI, energy consumption, economic growth, etc., but the idea of investigation under institutional quality using the DCCE approach is focused to a limited extent (Wang et al. 2021). Several studies are available for environmental degradation in BRICS like Khattak et al. (2020) for innovation, energy consumption, and income and Danish et al. (2020), Muhammad et al. (2021), and Asongu et al. (2018) for FDI, economic growth, ecological footprint, energy consumption, and natural resources. Exploring more about institutional quality in BRICS country motivated to fill the gap using the DCCE technique (Ahmad et al. 2019).

The study's primary purpose is to verify the role of foreign direct investment inflow in polluting or pollution reducing by using a recently developed methodology developed by Chudik and Pesaran (2015) from1995 to 2019 in BRICS. This methodology is novel in incorporating the heterogeneity and structural break issues in panel data that are common and not covered by previous methods. The study further contributed to the literature by adding interaction terms of foreign direct investment and institution quality to check the threshold point or turning point of foreign direct investment at a different level of institutional quality.

The remaining paper is divided as follows: A literature review of various studies on this subject is given in the second chapter. The third section describes the data and methodology. The fourth section explains the findings, and the final section presents a hypothesis and policy consequences.

Literature review

The underlined area of research got the limelight after the robust environmental protocols in the highly developed economies. Foreign direct investment got an attraction in the less developed economies where the environmental regulations are weak compared to highly developed economies. Due to the nature of the foreign direct investment, it has been considered a source of pollution haven in these economies. Yilanci et al. (2020) tested the pollution heaven hypothesis approach by investigating foreign direct investment on CO_2 emission in BRICS over 1982–2014. The result for India shows that foreign investment is having a positive effect on ecological footprint and CO_2 emissions. The result also reported a mixed impact of foreign direct investment on ecological footprint and CO_2 emission in Brazil and Russia. In China and South Africa, the result shows that foreign investment increases environmental quality.

Similarly, Chandio et al. (2020) examined the effect of foreign investment and industrialization on panel information overused using pooled methods in 36 selected African countries. The empirical research has shown an insignificant environmental industrialization impact. Khan and Ozturk (2020) examined the relationship between CO_2 emissions and panel figures from 1980 to 2014 overused by foreign investment in 17 countries. The results of the empirical study show a bidirectional connection between CO_2 emissions and foreign investment. Hanif et al. (2019) used panel data in eight countries to examine the relationship between environmental pollution, foreign investment, extremism, energy use, and economic development. The result demonstrates the two-way link between extremism and CO_2 and foreign investment in the short and long term. He et al. (2020) used 1990–2017 panels to examine income development, renewable energy, foreign investment, and greenhouse gas governance in 47 sub-Saharan African countries, using a complex heterogeneous assessment method. The result shows that foreign investments positively affect climate change, and the consequence has endorsed the heavenly theory for emissions. Xie et al. (2020) used panel data from 2005 to 2014 to test how foreign investment influenced CO_2 emissions in the panel of developing countries by applying a panel smooth transition regression. From the empirical study, the result shows that foreign investment has a positive effect on CO_2 emissions. In Pakistan, Ur Rahman et al. (2019) examined the short-term and long-term relationship between inflows of foreign investment and carbon emissions from 1975 to 2016 using the NARDL model. The results of the empirical study show that foreign investment has a positive effect on CO_2 emissions. Similarly, Huang et al. (2020) examined the environmental impact of the FDI, and the findings promote pollution haven hypotheses in large, low-income, BRICS, and next-11.

On the other hand, a large part of the experimental study reveals that direct foreign investment and the atmosphere are adverse. Likewise, Sun et al. (2017) examined FDI's relationship with the environment in China through the ARDL method, and findings support the hypothesis of pollution haven. Shahbaz et al. (2020) examined FDI effects on the atmosphere, and findings support the BRICS and next-11 emission halo hypothesis. Hanif et al. (2019) investigated FDI's connection to the atmosphere, and the results support the hypothesis of pollution halo. Iqbal et al. (2020a) in Pakistan explored the relationship between foreign investment flows and overused time series from 1971 to 2014 using the ARDL model. The result shows that foreign investment has a negative long-term relationship with the environment.

Other factors influence the climate as well. Many earlier studies include numerous operational quality factors with environmental sustainability through several econometric instruments for empirical research. Ali et al. (2020) examined, for example, the environmental effects of trade openness, international investments, and institutional performance overused panel data by the use of a complex common correlated effect approach in OIC countries and the negative effect of institutional efficiency and environmental degradation. Danish et al. (2019) discovered a negative consequence on CO_2 emissions by using the Westerlund panel co-integration data for BRICS countries. Charfeddine and Mrabet (2017) have recently reported the reduction in environmental footprint by applying FMOL and DOLS approaches to the panel of 15 MENA countries, with political institutions and energy use. On the contrary, Liao et al. (2017) took an institutional quality metric to measure the relationship between wages, energy consumption, and environmental quality (SO_2). The result showed that income growth has a negative relation to environmental protection.

To examine economic growth, energy use, and CO_2 emission, Iqbal et al. (2020b) used cross-sectional data from 1985 to 2007 using heterogeneous OLS panel co-integration. In the long run, the empirical findings indicated a positive relationship between GDP and energy usage. Moreover, actual GDP and energy consumption have both a positive effect on CO_2 emissions. Nathaniel et al. (2020) have investigated the relationship between energy use, urbanization, and environmental footprint for South Africa through panel data from 1965 to 2014. The results show by using the ARDL model that financial progress and economic growth are short-term damaging to the ecological footprint. In the MENA countries' panel, Nathaniel et al. (2019) studied the relationship between renewable and non-renewable energy with panel data from 1990 to 2016 on ecological footprint. The result showed that uniform causality flows from economic development, urbanization, and climate change energy use. The relationship between energy use, foreign investment, economic growth, and CO_2 emissions over time series data of 1976–2009 is examined in Vietnam by Iram et al. (2020), through co-integration and Granger causality. The empirical results suggest that income and energy consumption positively affect CO_2 emissions, but square income has a negative impact on CO_2 emissions. In addition, the result reported that the environmental Kuznets curve was endorsed.

Data and methodology

To assess the pollution haven hypothesis, we use the ecological footprint as a dependent variable, as it is a more accurate proxy for an ecosystem that reveals a country's biological and ecological potential. The other independent variables are foreign direct investment (FDI), gross domestic product (GDP), energy consumption (EC), institutional quality (INSQ), and the interaction term of institutional quality and foreign direct investment (FDI*INSQ). The description of our variables and their data sources are reported in Table 1. The study uses panel dataset, which covers the time 1995–2019 for BRICS.

The previous literature used different methodologies to prove this hypothesis in different countries. Some use ARDL, NARDL, VAR, and simple and quantile regression time series methods for the single country analysis. There is an issue in conventional methodologies like ignoring heterogeneity issues and changing the inter-sectional units' intercepts. Our methodology will incorporate the ignored issue of cross-sectional dependence (CD).

Dynamic common correlated effects (DCCE) estimation

Several studies argue the existence of CD as the response of uncertain shocks and factors in economies in this era of development. A new methodology developed by Chudik and Pesaran (2015), which is "dynamic common correlated effects (DCCE)," copes with this CD issue and gives reliable

Table 1 Data description and its sources

Abbreviations	LEF	LINSQ	LFDI	LGDP	LEC
Variables	Ecological footprint	Institutional quality	Foreign direct investment	Growth rate	Energy usage
Unit of measurement	Global hectares	Panel principal component analysis	Net inflows (% of GDP)	Constant 2010 US$	mt oil equivalent
Data sources	Global footprint network	International country risk guide (ICRG)	World development indicator (WDI)	World development indicator (WDI)	British Petroleum (BP Stat)

estimates. This approach considers the CD due to unobserved factors and assumes the variables as common factors. That is based on the principle of the mean group (MG) estimation, pooled mean group (PMG) estimation, and common correlated effects (CCE) developed by Pesaran and Smith (1995) and Pesaran (2006), respectively. The main problem that copes with this new methodology is that it is suitable for dynamic panels and incorporates the issues covered in the CCE methodology. Furthermore, the DCCE approach of Chudik and Pesaran (2015) was extended by Ditzen (2018) for heterogeneous panel results for the short run and long run. Several critical issues covered in DCCE which are ignored in traditional methodologies are as follows: (i) it incorporates the issue of CD and solves this issue by taking lags and average values of cross-sectional units together in analysis; (ii) it deals with heterogeneity problem; (iii) it incorporates the dynamic common correlated effects through common factors; (iv) its suitable even in case of sample size; and (v) it gives reliable estimates in case of unbalance data and structural breaks (Ditzen 2016).

In the model specification, our primary purpose is to check the validity of the pollution haven hypothesis by taking ecological footprint as the dependent variable, and FDI is the leading independent variable. We also include some other crucial variables like energy consumption, real GDP, institutional quality, and the interaction term (FDI*INSQ) to prove the theory.

The following equation of DCCE can be written on behalf of the model specification:

$$Y_{it} = \alpha_i Y_{it-1} + \delta_i X_{it} + \sum_{p=0}^{pT} \gamma_{xip} \overline{X_{t-p}} + \sum_{p=0}^{pT} \gamma_{yip} \overline{Y_{t-p}} + \mu_{it} \quad (1)$$

Here, the dependent variable and lag of the dependent variable are Y_{it} and $Y_{it\text{-}1}$; and X_{it} denotes the independent variable; subscripts I and t show cross-sectional and time dimensions. The common unobserved factors are expressed by γ_{xip} and γ_{yip}. And P_T and μ_{it} show the lag of cross-sectional averages and the error term.

We further extend this in our variables for proving the pollution haven hypothesis by using ecological footprint as the dependent variable.

$$\text{LEF}_{it} = \alpha_i \text{LEF}_{it-1} + \beta_i X_{it} + \sum_{p=0}^{pT} \gamma_{xip} \overline{X_{t-p}} + \sum_{p=0}^{pT} \gamma_{yip} \overline{Y_{t-p}} + \mu_{it} \quad (2)$$

In the equation, LEF is the log of ecological footprint used as the dependent variable, and other explanatory variables log of FDI, log of GDP, log of EC, log of INSQ, and log of (FDI*INSQ) are reported by X_{it}. μ_{it} is the error term.

Test of cross-sectional dependence (CD)

For the cross-sectional dependence in panel data, the widely used method is the Lagrange multiplier (LM) test (Breusch and Pagan 1980) and expressed as follows:

$$y_{it} = \alpha_i + \beta_i x_{it} + \mu_{it} \quad (3)$$

$t = 1,2,\ldots,T$ and $i = 1,2,\ldots,N$ show the time and cross-sectional dimension. β_I and α_I symbolize countries individual slope coefficients and intercept.

Breusch and Pagan's (1980) LM test standard form is the following:

$$\text{LM}_{\text{BP}} = T \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} \hat{\rho}_{ij}^{2} \quad (4)$$

where $\hat{\rho}_{ij}^{2}$ denotes the pair-wise correlation coefficient estimates. This test is suitable for a significant period and a small number of countries and will not work if pair-wise correlation means are close zero (Pesaran 2004). So, Pesaran (2004) developed the following test based on the scaled version to cope with this issue and suitable for small T and large N.

$$\text{Scaled LM Test} = \sqrt{\left(\frac{1}{N(N-1)}\right)} \left[\sum_{i=1}^{N-1} \sum_{j=i+1}^{N} \left(T\rho_{ij}^{2} - 1\right)\right] \quad (5)$$

Next, Pesaran (2004) developed the cross-sectional dependence (CD) test, which is also suitable for small and large N.

$$\text{CD} = \sqrt{\left(\frac{2T}{N(N-1)}\right)} \left[\sum_{i=1}^{N-1} \sum_{j=i+1}^{N} \rho_{ij}\right] \quad (6)$$

The modified version of the LM test proposed by Baltagi et al. (2012) for accurate mean and variance of the LM statistics and formulation is as follows:

$$\mathrm{LM}_{\mathrm{adj}} = \sqrt{\left(\frac{2T}{N(N-1)}\right)}\sum_{i=1}^{N-1}\sum_{j=i+1}^{N}\rho_{ij}\frac{(T-k)\rho_{ij}^{2}-\mu_{Tij}}{\sqrt{\nu_{Tij}^{2}}} \tag{7}$$

${v^2}_{Tij}$ and μ_{Tij} are the variance and actual mean of $(T-k)\rho_{ij}^2$ tabulated by Baltagi et al. (2012).

Unit root test

The analysis employs two distinct types of unit root tests to determine the parameter's reliability. Unit root tests of the first generation, such as those in Maddala and Wu (1999), Levin et al. (2002), and Im et al. (2003), are insufficient since they do not account for parameter heterogeneity and cross-sectional dependence. These problems are dealt with by the second-generation unit root test (CIPS test), which is capable of resolving (Pesaran 2007)

Panel co-integration test

The traditional co-integration tests (Pedroni 1999; Kao 1999) are used to identify the co-integration among variables that often ignore the CD problem common in panel studies. Westerlund (2007) introduced the error correction–based co-integration test that copes up the issue and is reliable in case of structural breaks. It evaluates the co-integration in panel series by considering whether an error correction mechanism is present (Persyn and Westerlund 2008). Equation 8 is the mathematical form of the abovementioned panel co-integration test that was proposed by Westerlund (2007).

$$\Delta Y_{it} = {\delta^{/}}_{dt} + \alpha_i\left(Y_{i,t-1}-{\beta^{/}}_{i}x_{i,t-1}\right) + \sum_{j=-qi}^{qi} a_{ij}\Delta y_{i,t-1} + \sum_{j=-qi}^{qi}\gamma_{ij}\Delta x_{i,t-1} + e_{i,t} \tag{8}$$

Results and discussion

This study used BRICS countries' datasets to establish the hypothesis of pollution haven in the area. Table 2 provides a list of the critical data characteristics through descriptive statistics of variables LEF, LFDI, LGDP, LEC, LINSQ, and LFDINSQ.

Table 3 denotes the association between the variables that are used in this study through correlation matrix. Ecological footprint correlates substantially with all the independent factors (i.e., LFDINSQ, LINSQ, LFDI, LGDP, and LEC).

With macroeconomic variables and panel data in nature, cross-sectional dependence is prevalent. To this end, Table 4 reports the cross-sectional dependence results. The null hypothesis is that there is no cross-sectional dependence and abundant evidence according to experimental results of the study to refute the null hypothesis and conclude that cross-sectional dependency occurs between the cross-sectional elements.

The slope homogeneity test results are also presented in Table 4 that reject the null hypothesis which is slope coefficients of the models that are homogenous and accept the alternative hypothesis. The values of delta and adjusted delta express the *t*-stat of the slope homogeneity test. The findings show heterogeneity in our model.

This study conducts panel root unit tests (second generation) to avoid producing misleading results. The second-panel root test (Pesaran 2007), also known as the CIPS test, is summarized in Table 5. The second-generation unit root test is suitable despite traditional unit root tests because it considers cross-sectional dependence and heterogeneity among the series. Table 5 confirmed the stationarity of the variables at the first difference and no variable is stationary at 2nd difference. The confirmation of stationarity test leads to go for long-run association using the DCCE estimation method.

The Pedroni (1999) test is improper as many crucial matters such as heteroscedasticity, serial correlation, systemic disruptions, and cross-sector dependency of the countries or cross-cutting units are not discussed, whereas that of Westerlund (2007) is an advanced test of co-integration of variables as all of these problems are resolved. The previous studies ignore the serious issue of cross-sectional dependence and structural breaks that leads to misleading findings. Westerlund (2007) introduced the co-integration test that covers the aforementioned issues. The results of Table 6 have confirmed the evidence of long-run co-integration among the variables which are used in the study because the probability values of Gt, Ga, Pt, and Pa of the Persyn and Westerlund (2008) co-integration tests are lower than 0.05, that is, the proof of rejection of the null hypothesis of no co-integration. To check the co-integration among the variables, we employed xtwest command on STATA for Westerlund co-integration.

Table 7 reports DCCE data. According to empirical findings, all explanatory variables have a significant impact on the dependent variable. The LFDI component has a positive ecological footprint. The LFDI coefficient is 0.213 and statistically significant, which means a rise of 1% in FDI would degrade the atmosphere by 0.213%. The economic growth variable (LGDP) is statistically significant and 5% linked to ecology in the BRICS region. The value of 0.893 LGDP suggests that a uniting shift in the BRICS countries' GDP growth rates leads to a 0.893% rise in ecological footprints. Again, the energy consumption variable (ECV) makes a positive

Table 2 Statistical summary of the variables

	LEF	LFDI	LGDP	LEC	LINSQ	LFDINSQ
Mean	20.424	0.3836	27.811	5.9689	1.5149	0.7899
Median	20.422	0.7079	27.959	5.9074	1.5758	1.1099
Maximum	22.383	1.8224	29.881	8.0219	2.0115	3.0341
Minimum	18.646	−5.9931	26.098	4.4776	−4.44E-16	−4.8395
Std. dev.	1.0069	1.1720	0.8819	0.9685	0.3373	1.4668
Skewness	0.0402	−2.2091	−0.0564	0.2919	−1.5019	−0.8867
Kurtosis	2.4747	11.117	2.8047	2.2371	6.0513	3.8635
Jarque-Bera	1.4703	444.89	0.2649	4.8066	95.488	20.264
Probability	0.4794	0.0000	0.8759	0.0904	0.0000	0.00004
Sum	2553.1	47.950	3476.4	746.11	189.36	98.737
Sum sq. dev.	125.73	170.33	96.455	116.33	14.113	266.80
Observations	125	125	125	125	125	125

Table 3 Pair-wise correlation matrix

Correlation with *t*-stat						
	LEF	LFDI	LGDP	LEC	LINSQ	LFDIINSQ
LEF	1.0000					

LFDI	0.4349	1.0000				
	5.3569	-----				
LGDP	0.8762	0.5419	1.0000			
	20.1641	7.1511	-----			
LEC	0.9364	0.4141	0.8229	1.0000		
	29.6014	5.0452	16.0616	-----		
LINSQ	0.2572	0.5322	0.2774	0.3114	1.0000	
	2.9524	6.9725	3.2019	3.6347	-----	
LFDIINSQ	0.481792	0.9457	0.5846	0.4840	0.4733	1.0000
	6.097708	32.2686	7.9922	6.1346	5.9587	-----

contribution to this field. It is statistically significant at 1%. In BRICS, a one unit improvement is adding 0.889% to ecological footprints. The sign and magnitude of GDP growth and energy consumption in the BRICS area were almost the

Table 4 Panel unit root test for cross-sectional dependence

				Slope homogeneity test results	
	Pesaran CD	Pesaran scaled LM	Breusch-Pagan LM	Delta	Bias-adjusted delta
EF	8.62*** (0.00)	23.69*** (0.00)	120.95** (0.04)	3.19***	3.33***
FDI	11.63** (0.02)	5.36*** (0.00)	38.97*** (0.00)	3.75***	3.94***
GDP	15.12*** (0.00)	47.84*** (0.00)	228.93*** (0.00)	3.35***	4.53***
EC	9.58*** (0.00)	27.46*** (0.00)	137.82*** (0.00)	4.90***	5.19***
INSQ	12.43*** (0.00)	31.55*** (0.00)	156.09*** (0.00)	4.70***	4.50***
(FDI*INSQ)	5.43*** (0.00)	6.13*** (0.00)	42.42*** (0.00)	4.12***	425***

Note: *** and ** show the levels of significance at 1% and 5%, respectively

Table 5 Unit root (second generation) tests results

CIPS unit root		
Variables	Level	First difference
EF	−3.06**	−4.769***
FDI	−3.20***	−5.48***
GDP	−1.57	−2.92***
EC	−2.48	−3.37***
INSQ	−3.66***	−5.21***
(FDI*INSQ)	−3.15***	5.64***
Critical values	Level	First difference
10%	−2.73	−2.21
5%	−2.86	−2.33
1%	−3.1	−2.57

Note: *** and ** show the levels of significance at 1% and 5%, respectively

Table 7 Results dynamic common correlated effects (DCCE) estimation

Long-run results		
Regressors	Coefficient	*p* value
LEF (−1)	−1.261***	0.000
LFDI	0.213**	0.023
LGDP	0.893**	0.017
LEC	0.889***	0.000
LINSQ	−0.124**	0.031
L (FDI*INSQ)	−0.119**	0.029
Constant	2.675*	0.067

Note: ***, **, and * show the levels of significance at 1%, 5%, and 10%, respectively

same. The institutional quality variable (LINSQ) negatively contributes to the ecological footprint in the BRICS region. It is statistically significant at 5%. The institutional variable here shows that a one unit increase in institutional efficiency in the BRICS area contributes to a −0.124% improvement in the ecological footprint. It also indicates that institutional quality growth and productivity contribute to improving the environmental quality in the region. Finally, the interaction term FDI and institutional quality (INSQ) results are given in this table. Based on this interaction concept, it contributes negatively to the ecological footprint process in the BRICS region. This word is statistically meaningful at a level of 5%. The coefficient of this interaction term measures that an increase in one unit institutional efficiency and FDI in this area will help reduce the effect of ecological footprints by 0.119%. Therefore, it is concluded that institutional efficiency and FDI positively contribute to environmental change in the BRICS field. It also clarifies that the BRICS area is not a heave of emissions.

Furthermore, we calculate the marginal effect of interaction term numerically and graphically that shows the real impact and turning point at minimum, mean, and maximum level of institutional quality results reported in Table 8.

$$\delta \text{LEF}_t / \delta \text{LFDI}_t = 0.12 - 0.07 \text{LINSQ}_t$$

The marginal effect of FDI on ecological footprint evaluated at minimum, mean, and maximum level of institutional quality is 0.12, 0.014, and −0.021, respectively.

According to Fig. 1, the marginal impact of the interactional term is negative in the BRICS region over time. The constant of marginal effect is 0.12, while its coefficient is −0.07, respectively.

Table 6 Westerlund ECM panel co-integration tests

H_0: no co-integration	Value	*p* value
Gt	−4.39***	0.000
Ga	−10.74***	0.000
Pt	−5.64**	0.02
Pa	−9.58***	0.000

Note: *** and ** refer to the significance levels at 1% and 5%, respectively

Discussion

The analysis sought to establish the validity of the BRICS region's pollution haven hypothesis with the assistance of FDI and institutional consistency instruction (INSQ). To that end, the 24-year dataset of BRICS countries was analyzed using the DCCE model. Based on the empirical findings of this analysis, the FDI variable contributes positively to the process of environmental degradation in the BRICS region. It demonstrates that FDI alone is the cause of environmental degradation in the area. This statement confirms the hypothesis of pollution haven in the BRICS area. It does, however, make a negative contribution in the context of an association with institutional efficiency. Our findings are similar to the studies by Yilanci et al. (2020) which show the positive environmental impact of FDI. This effect is the response of the scale effect (in this respect, the deterioration of environmental quality as a consequence of economic activities) of the FDI and the increased energy consumption in the initial stage of growth in BRICS economies.

Moreover, interactional term empirical results show that institutional efficiency and FDI enable the BRICS area to

Table 8 Marginal effect

		Minimum	Average	Maximum
BRICS countries	Institutional quality	−4.44e–16	1.515	2.011
	Marginal effect	0.12	0.014	−0.021

mitigate the effect ecologically. FDI development and administrative quality enhancement are thus the contributing sources of the region's environmental improvement. Thus, the statement confirms that the pollution haven hypothesis can be inactive due to the interaction between FDI and institutional quality in the BRICS area. This definition is also consistent with the results of Mohsin et al. (2021), Mohsin et al. (2020) and Usman et al. (2021).

However, the relationship between the institutional quality and the ecological footprint is identified in this report. The findings showed that improving institutional efficiency helps to improve environmental conditions in the BRICS region. Our institutional efficiency results, including Danish et al. (2019), have negatively affected CO_2 emissions in BRICS.

Economic growth (LGDP) and energy use (LEC) continue to be positive in environmental degradation in the BRICS area. According to the empirical results, both variables contribute identically to the environmental degradation mechanism with coefficients 0.893 and 0.889, respectively. These findings are the same as Sun et al. (2020) and Rehman et al. (2021).

Conclusion and recommendations

This study used the empirical data collection from BRICS countries to assess the effect on ecological footprint conditions of institute quality with FDI in an interaction term. An econometric technique, known as dynamic common correlated effects, was employed in this area to describe the hypothesis of pollution haven. DCCE's results support the hypothesis that FDI degrades environmental quality in BRICS. In addition, the study also examined the moderating impact of institutional quality on the FDI relationship and ecological footprint. It established its threshold when the FDI effect on ecological footprint is negative. Because of this relationship between the institutional quality and FDI, this region's hypothesis of pollution haven has become inactive. Our findings of the interaction term suggest that higher institutional efficiency mitigates the adverse environmental impact of FDI at a certain institutional level. Other conventional variables such as GDP growth and energy use continue to be environmental sources of degradation.

Our study recommends that foreign direct investment policies continue because they enhance the climate and promote economic development in the presence of good institutional efficiency. Moreover, BRICS countries are expected to turn their investment inflow and technological change induced by FDI into sustainable development objectives (SDGs) with policy instruments. Additionally, the government should design good relationships with the neighboring countries and make more trade agreements to enhance FDI inflows in the countries. Furthermore, policymakers should formulate strict institutional regulations regarding environmental sustainability. The government must periodically review the presence of institutional quality in all the sectors of energy, especially in manufacturing and energy production. For the energy policy and actual GDP, the government should improve the environment and concentrate on renewable energy in the energy sector and growth phase. Furthermore, the government should promote renewable energy projects like solar and windmills and provide subsidy funds for the ease of implementation and installation.

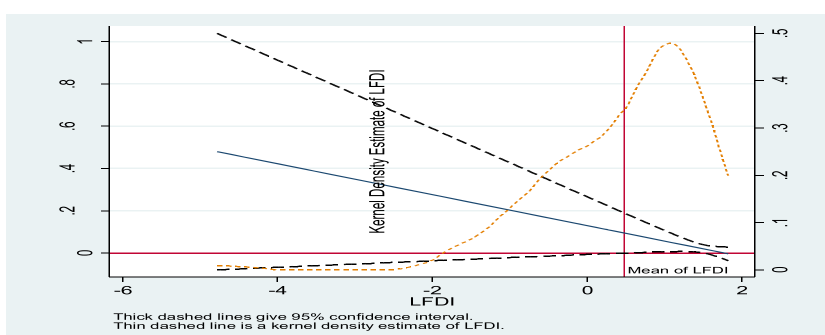

Fig. 1 The marginal effect of FDI on ecological footprint in BRICS. Note: The vertical axis represents the marginal effect, which is derivative of ecological footprint concerning forging direct investment

Author contribution This research paper is contributed by the abovementioned authors in the following way: Conceptualization is done by Imran Sharif Chaudhry and Qaiser Abbas; methodology is formed by Weihua Yin; software and validation and formal analysis are performed by Muhammad Faheem; investigation, resources, and data curation are performed by Syed Ahtsham Ali and Saeed Ur Rahman; writing—original draft preparation is done by Fatima Farooq; writing—review and editing, visualization, and supervision are done by Muhammad Faheem and Qaiser Abbas.

Availability of data and materials The datasets used and/ or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate The authors announce that the investigation described in this manuscript has not been affected by conflicting personal or financial concerns. We also announce that there is no human data or participation involved in this work.

Consent for publication We do not have any personal data in any form.

Competing interests The authors declare no competing interests.

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