frontiers | Frontiers in Environmental Science

TYPE Original Research
PUBLISHED 12 September 2022
DOI 10.3389/fenvs.2022.972977

OPEN ACCESS

EDITED BY
Qaiser Abbas,
Ghazi University, Pakistan

REVIEWED BY
Asad Ullah,
Shanxi Normal University, China
Muhammad Nadeem,
Nanjing University of Aeronautics and Astronautics, China

*CORRESPONDENCE
Xiaoming Zhou,
xiaoming725@gdufe.edu.cn

SPECIALTY SECTION
This article was submitted to Environmental Economics and Management, a section of the journal Frontiers in Environmental Science

RECEIVED 19 June 2022
ACCEPTED 25 July 2022
PUBLISHED 12 September 2022

CITATION
Wu C, Zhou X and Ali M (2022), Is the interaction of commercial regulation with foreign direct investment a source of Heaven or EKC hypothesis? An empirical investigation of the BRICS region.
Front. Environ. Sci. 10:972977.
doi: 10.3389/fenvs.2022.972977

RETRACTED: Is the interaction of commercial regulation with foreign direct investment a source of Heaven or EKC hypothesis? An empirical investigation of the BRICS region

Chenmu Wu[1], Xiaoming Zhou[2]* and Muhammad Ali[3]

[1]Sun Yat Sen University School of Law, Guangdong, China, [2]School of Law, Guangdong University of Finance & Economics, Guangdong, China, [3]Department of Economics, SAPM, Agriculture University, Rawalakot, Pakistan

It is generally agreed that the quality of institutions, the amount of energy consumed, and foreign direct investment are among the essential factors in sustainable development. On the other hand, these aspects are just as critical as the others when determining what causes environmental deterioration and how the climate changes globally. This research used the dataset of the BRICS countries, which are classified as emerging nations, intending to determine the nature of the relationship between foreign direct investment and institutional quality in terms of an interaction term, in addition to other independent variables and environmental quality. The objective of this study was to determine whether or not a Pollution Heaven or Environmental Kuznets curve (EKC) exists in the BRICS countries. To accomplish this objective, the Pooled Mean Group (PMG) technique of econometrics was utilized to estimate a 21-year dataset between 2000 and 2020. The Pollution Heaven theory was shown to be true after empirical research was conducted on the BRICS economies. In these economies, this finding verified the expansion of foreign direct investment and the proliferation of business rules were sources of environmental degradation. In addition, no evidence was discovered to support the presence of the EKC theory in any of the BRICS countries or areas. Based on these empirical outcomes, this research suggested that the introduction of appropriate commercial laws is required to translate the benefits of foreign direct investment into environmentally sustainable development.

KEYWORDS

commercial regulations, FDI, interaction term, pollution heaven hypothesis, environmental kuznets curve

1 Introduction

The topic of climate change has been brought to the forefront of the public consciousness due to its status as one of humanity's most significant concerns in the 21st century. The fight against this problem is being carried out jointly by several organizations and governments. The critical step in climate change negotiations is the Paris Agreement (COP 21), which establishes for the first time a common cause for every nation to undertake against climate change and attempts to limit the global temperature increase to 1.5°C (UNFCCC, 2020). However, the withdrawal of the United States from the agreement undermines the efficacy of these efforts. In addition, commitments were made to make these initiatives during the COP26 meeting in Glasgow (Bhattacharya and Stern, 2021). Finding out why developing countries are consuming so much fossil fuel and releasing so much greenhouse gas (GHG) is critical to halting climate change's devastating effects on the world's natural resources. It is believed that the BRICS (Brazil, Russia, India, China, and South Africa) would be a driving factor behind future global economic growth (Ndiaye and Djogbenou, 2018).

The level of Foreign Direct Investment (FDI) in developing countries has been tremendous, and it has contributed to each nation's total economic growth (Kaliappan et al., 2015). It has been demonstrated through several empirical studies that there is a positive correlation between FDI and Economic Growth. Furthermore, FDI is an essential element of the global growth engine; consequently, nations work to establish favorable conditions for the inflow of additional FDI into their respective economies. Therefore, identifying the primary factors determining FDI is essential; that is why a significant amount of research is being conducted in this area (Adegboye et al., 2020). For this purpose, policymakers are required to make the procedure easier to entice FDI. With these variables' help, policymakers can comprehend the magnitude and trajectory of FDI flows.

Since the 1970s, FDI inflows to BRICS economies have been on the rise. As governments continue to liberalize regulatory barriers to trade and investment, some of them even start vying for FDI, as it is becoming increasingly viewed as an essential component of their progress. The total value of FDI net inflows, expressed in current US dollars, increased from 10.17 billion in 1970 to 1.86 trillion in 2017. Because it has the potential to jumpstart economic expansion in a concise amount of time, inward foreign direct investment is significant for domestic construction in emerging countries. On the one hand, capital accumulation can generate positive externalities through the transfer of technologies, increases in productivity (due to a more effective manufacturing process), and new managerial abilities (Cavalcanti et al., 2014). On the other side, FDI can cause environmental degradation by investing in businesses that produce a high volume of pollutants or directly taking natural resources without providing enough recompense. As a result, public policy formulation ought to be predicated on an in-depth comprehension of the interrelationships between the economy, the environment, and the flows of FDI.

It was inferred in the pollution haven theory that disparities in the stringency of environmental rules are the primary driver of international trade and FDI. Multinational businesses (MNEs) tend to put their pollution-intensive commodities in developing nations with lesser environmental requirements, so less developed countries become the "haven" of "dirty goods," or even the trash dumps of advanced economies say pollution haven hypothesis (Alhassan et al., 2020). They conclude that more onerous environmental restrictions do not significantly impact the patterns of commerce. In addition, the expenses associated with environmental control are negligible in comparison to the costs of manufacturing.

The BRICS countries were responsible for 40% of the world's population and 25% of the earth's land surface (Kannaiah and Murty, 2017). It is anticipated that by the year 2050, BRICS will be in the lead as the leading supplier of manufactured goods, services, and raw materials due to the wide availability of low-cost labor and manufacturing. In addition, many businesses point to the BRICS nations as their sources of prospects for overseas development or FDI. These nations have prospective economies that have significant opportunities for flourishing FDI. As a result, the BRICS countries are likely to continue growing (Jurisevic, 2017). Because of their enormous populations and significance in global policy, their decisions will significantly impact the environment's future in the rest of the world.

The BRICS group was responsible for more than one-third of the worldwide carbon emission resulting from deforestation and other environmentally damaging land activities (Kouloukoui et al., 2021). When factors such as deforestation and the creation of carbon from land usage are considered, the size of the emission increases; for example, in Brazil, 75% of the country's total emissions were caused by unsustainable land-use practices. Deforestation has significantly reduced the country's capacity to operate as a carbon sink, leading to an increase in six billion metric tonnes (Khudyakova and Urumov, 2021). The International Energy Agency predicts that by the year 2050, coal consumption—which generates a great deal of pollution—will have more than doubled in China and India (Grudziñski, 2013). The current degree of industrialization in the BRICS nations depends on fossil fuel use, and this dependency is pronounced in China, India, and Brazil. The continued consumption of fossil fuels inside this bloc has damaging effects on the environment, specifically in the form of climate change. Considering that India's population is expected to grow by 300 million within the next 2 decades, this represents a significant risk to the world's ability to maintain adequate food supplies (Msangi et al., 2010). As a result, the BRICS countries were first disregarded and fell victim to the development of the west; but, in recent years, these nations have emerged as significant energy users and pollution

producers. It could result from many things, including increased FDI and trade liberalization.

According to the environmental performance index, the performance of the BRICS nations in terms of environmental performance index is not even close to satisfactory (Cipollone et al., 2012). It is even though the BRICS nations have a prominent position in creating world output. For example, the Russian Federation has the best overall performance of all these countries since it is now ranked 52nd globally. On the other hand, India has the unfortunate distinction of holding the position of the world's poorest performing nation, with a ranking of 177. It demonstrates that the BRICS group has a horrible record in terms of the environment (Bhaumik, 2017). When we include the Environmental Performance Index (EPI) for air pollution, South Africa, India, and Brazil all did very terribly, although China's performance is only fair.

The researchers argue that governance and institutions have a significant impact on investment decisions made by BRICS countries, as well as on economic growth (Ansari et al., 2019). It is important to note that good governance encompasses several political and institutional conditions that can negatively impact an investment company's operation or the business environment's general climate. Governance is regarded as the factor most susceptible to unpredictability in terms of FDI. Researchers' findings led them to conclude that international investors prefer to put their money into riskier markets with a low institutional quality (Ibrahim and Law, 2016), (Gyamfi and Sein, 2021). Several empirical studies have focused on the effect that the governance of the recipient country has on the total amount of FDI that flows into various geographic regions within developed and developing countries, as presented in, as well as within multiple groups of developing economies (Ross, 2019). Most of the studies concluded that inadequate institutions in the recipient were developing countries act as a deterrent to foreign direct investment (FDI). The current study contains a brief review to locate a void in the literature. The present research focuses on governance and institutions as predictors of foreign capital inflows. As a result, this research aims to investigate whether or not the pollution haven theory and the environmental Kuznets curve (EKC) apply to the BRICS nations. This study explores this theory by using the most recent data available for BRICS country groups from 2000 to 2020 to conduct a comparative panel data analysis. An inward FDI has a negative causal relationship with per capita energy consumption and a positive relationship with per capita carbon emissions in BRICS nations, supporting the pollution haven theory that FDI might harm host countries' environments.

The remaining parts of the paper are structured as described below. The second section reviews the relevant literature concerning the pollution haven theory and EKC. The data, as well as the technique, are discussed in Section 3. The empirical findings are discussed in Section 4, and Section 5 contains a summary and a discussion of the implications for public policy.

2 Literature review

Over the last few decades, the notion of pollution havens has garnered significant interest, and academics have employed a wide variety of approaches to investigate the validity of the hypothesis based on numerous study viewpoints (Singhania and Saini, 2021), (Mert and Caglar, 2020). Several studies have done on the pollution haven hypothesis, some of which employed foreign direct investment inflows as the dependent variable, while others used net exports (Nadeem et al., 2020). Similarly, these studies have no widespread consensus regarding the appropriate method for measuring environmental strictness. (Xie et al., 2020). used annual data on carbon dioxide total emission, total emission on particulate matters, increasing temperature, and total energy use to evaluate the impact that dirty FDI has on host economies. His evaluation is based on the findings of the study. (Yang et al., 2021). explores the actuality of the pollution haven hypothesis and whether or not it is true.

Because of this, no universal theory of FDI can thoroughly explain the presence of multinational corporations, worldwide production, and FDI. An individual company can have many motivations for engaging in FDI (Bauer, 2020). According to the capital-market perspective, the most critical factor contributing to capital flows is the difference in interest rates across other regions (Shekhawat and Kathuria, 2018). This theory also asserts that capital tends to flow toward areas with the highest investment return rate. According to the product life cycle hypothesis, companies established production facilities in other countries for goods that had previously been standardized and developed in their respective domestic markets (Blim, 2005). The factors that impact the flow of foreign money into emerging economies have been the subject of a significant amount of research. These studies focus on the economic, sociopolitical, and institutional aspects that influence FDI (Karmakar and Mukhopadhyay, 2008). The variables identified here are the economic determinants that determine market size, labour costs, economic openness, and economic stability.

According to several pieces of empirical study work, inefficient institutions are a barrier to foreign capital investment (Anwar and Iwasaki, 2021), (Drabek and Payne, 2002). Countries with higher-quality institutions are more likely to be successful in luring foreign direct investment into their industrial sectors (Ju and Wei, 2010). According to (Vogiatzoglou, 2016), institutional characteristics are the most important factors in determining foreign direct investment in developing nations. The domestic bureaucracy becomes less efficient due to corruption, which works as a tax on immigrants from other countries (Zheng et al., 2022). It has a bearing on the choice of a local partner and improves the value of utilizing a local partner to navigate the bureaucratic tangle (Yueh, 2010). Additionally, it lessens the adequate protection of the investor's intangible assets and reduces the likelihood that

conflicts between domestic and international partners would be resolved positively. Corruption also affects the decision and decreases inbound FDI. Nevertheless, (Drabek and Payne, 2002), discovered that corruption does not significantly influence FDI. In most cases, the quality of an institution is determined by how corrupt it is and how poorly it enforces contracts.

(Shao et al., 2019) studied the possibility of an environmental Kuznets curve (EKC), pollution haven theory, and business cycles for the BRICS nations. They came to various conclusions regarding the presence of pollution havens in China. Among the findings was the impact foreign direct investment has on carbon emissions and how it supports pollution havens in the BRICS countries. It was done using environmental Kuznets curves. Their findings present a complicated picture because the outcomes differ from one country to the next. According to the results of their study, the FDI had a sizeable beneficial impact on the population in the short term but had only a minor effect on the people in the long run. In an investigation of the EKC and pollution haven hypothesis, (Rana and Sharma, 2019), discovered that a cubic form of the model is the most suitable representation of the data. Their findings demonstrated a causal chain that ran in one direction from carbon dioxide to GDP, FDI, and energy consumption. The impact of pollution haven is magnified for businesses that operate in pollutant-intensive industries and have inadequate practices for corporate governance. Even when companies export pollution, in reaction to stringent environmental legislation in their home countries, those companies cut their emission levels.

A great quantity of empirical literature has been generated to evaluate the drivers of foreign direct investment (FDI) as a whole. However, the results of empirical evidence are mixed depending on the nation's choice, periods, and applied technique. Therefore, the existing body of research will be augmented by this investigation in two ways: A) To the best of our knowledge, there is a need for a comprehensive study on identifying the primary determinants of FDI as interactional terms with commercial rules. In addition, much research has not been done on the institutional and political factors that influence foreign direct investment in developing nations. As a result, the purpose of this study is to investigate, within the context of a more comprehensive model, the potential impact that economic considerations and institutional factors play in determining the amount of foreign direct investment (FDI) in developing economies.

3 Data and methodology

This study utilized the dataset of five major emerging economies for the period between 2000–2020. These economies are named Brazil, Russia, India, China, and South Africa (BRICS). This study aims to empirically test commercial regulations as the interactional term of foreign direct investment (FDI) as a source of the Heaven or EKC hypothesis. For this purpose, this study utilized the institutional quality of the BRICS countries as the proxy for commercial regulations (CL). Here, it has been assumed that the effectiveness of intuitional quality can help implement the commercial regulations (CL) for a sustainable environment. Thus, institutional quality (CL) has taken the form of panel principal component analysis from the International Country Risk Guide (ICRG). As part of the interactional term (CL_FDI), the study utilized the dataset of FDI (measured in net inflows % of GDP) and the dataset of GDP growth rate (GDP_g) (measure in constant 2010 US$) collected from World Bank Development Indicators (WDI). Furthermore, ecological footprint (measured in global hectares) has been generated from Global Footprint Network as the environmental quality (Env_Q) factor. Finally, the dataset of energy consumption (Eng_U) (measured in a million-tonne oil equivalent) was generated from British Petroleum (BP).

The Lagrange multiplier (LM) test is the most commonly used approach for determining the cross-sectional dependence in panel data. This test was developed by Breusch and Pagan in 1980 and can be given by the equation (Breusch and Pagan, 1980).

$$y_{it} = \alpha_i + \beta_i x_{it} + \mu_{it} \tag{1}$$

Here, β_i and α_i stand for the individual slope coefficients and intercept for each country, and t and i stand for the time passage and the data's cross-sectional dimensions. The following is the Breusch & Pagen formula in its conventional form:

$$LM_{BP} = T \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} \hat{\rho}_{ij}^2 \tag{2}$$

Where $\hat{\rho}_{ij}^2$ represents the estimated values of the pair-wise correlation coefficients. Therefore, to deal with this problem, (Pesaran, 2004) devised the subsequent test based on the scaled version, which is appropriate for both small T and big N.

$$\textit{Scaled}\ \text{LM Test} = \sqrt{\left(\frac{1}{N(N-1)}\right)}\left[\sum_{i=1}^{N-1} \sum_{j=i+1}^{N} \left(T\hat{\rho}_{ij}^2 - 1\right)\right] \tag{3}$$

Subsequently, Pesaran, 2004 created a test called the cross-sectional dependence (CD) test, which can be applied to both small and large N.

$$\text{CD} = \sqrt{\left(\frac{2T}{N(N-1)}\right)}\left[\sum_{i=1}^{N-1} \sum_{j=i+1}^{N} \hat{\rho}_{ij}\right] \tag{4}$$

The following is a description of the revised method of the LM test that Baltagi suggested to obtain accurate mean and variance results for the LM composition (Baltagi et al., 2012):

$$LM_{adj} = \sqrt{\left(\frac{2T}{N(N-1)}\right)}\sum_{i=1}^{N-1}\sum_{j=i+1}^{N}\widehat{\rho}_{ij}\frac{(T-k)\widehat{\rho}_{ij}^{2}-\mu_{Tij}}{\sqrt{v_{Tij}^{2}}} \quad (5)$$

v_{Tij}^{2} and μ_{Tij} are the variance and actual mean of $(T-k)\widehat{\rho}_{ij}^{2}$ tabulated. This study utilized the CIPS second-generation unity root that was suggested by Pesaran (2007) to determine whether or not the data are stationary. This method is reliable concerning both heterogeneity and cross-sectional dependency. However, utilizing this method for controlling reliance involves including lagging values. The CIPS exam is formatted as follows:

$$\Delta Y_{i,t} = \gamma_i + \gamma_i Y_{i,t-1} + \gamma_i X'_{t-1} + \sum_{i=0}^{P}\gamma_{it}\Delta Y'_{t-1} + \sum_{i=0}^{P}\gamma_{it}\Delta Y'_{it-1} + \epsilon_{it} \quad (6)$$

Where Y_{t-1} and ΔY_{t-1} denote the lagged value and first differences CADF test statistic

$$CADF = \frac{1}{N}\sum_{i=0}^{P}CIPS \quad (7)$$

Where the CADF is derived from the previous CIPS equation. The cointegration approach (Westerlund, 2007) was used to examine whether or not the dataset contained any instances of cointegration. This approach is superior to other cointegration methods since a not unifying factor does not constrain it. It is the primary reason for its advancement. In addition, this cointegration test tries to detect dependencies in the cross-section, which contributes to the check's strength compared to other cointegration strategies. The equation for the cointegration study can be written as follows:

$$\alpha_i(L)\Delta Y_{it} = \gamma_{1i} + \gamma_{2it} + \beta_i(Y_{it-1} - \alpha_i Y_{it-1}) + \lambda_i(L)v'_{it} + \eta_{it} \quad (8)$$

Where

$$\delta_{1i} = \beta_i(1)\theta_{2i} - \beta_i\lambda_{1i} + \beta_i\theta_{2i} \text{ and } \gamma_{2i} = \beta_i\lambda_{2i} \quad (9)$$

In Eq. 9, the cointegration relationship between the variables x and y is represented by an i. βi represents an ECM. A negative sign demonstrates the presence of long-run stability for the error correction. The following methods produce the group statistics:

$$G = \frac{1}{N}\sum_{i-1}^{N}\frac{\alpha_i}{Y(\alpha_i)} \quad (10)$$

$$G_i = \frac{1}{N}\sum_{i-1}^{N}\frac{T\alpha_i}{Y(1)} \quad (11)$$

Panel statistics

$$P_T = \frac{\alpha_i}{Y(\alpha_i)} \quad (12)$$

$P_T = T$

Various researchers contend that the emergence of CSD is a reaction to the unpredictable circumstances and causes present in economies at this growth stage. For this reason, pooled mean group estimation, also known as PMG estimation, is a practical approach for dealing with the problem of CSD and giving solid predictions. This method considers the CSD caused by unseen components and implies the features themselves are the common elements. This approach is founded on the notion of the mean group estimation (MG), which. Additionally, it makes use of common correlated effects (CCE).

To test the pollution haven and the environmental Kuznets curve (EKC) hypothesis, we use ecological quality as the dependent variable in the conceptual model (see Figure 2).

The pollution haven theory indicates that when large advanced economies want to establish production plants outside their country, they will typically look for the least expensive option available following the budget and labor that also offers the property and substance access they necessitate. On the other hand, this frequently comes at the price of environmentally destructive activities. It is typical for developing countries with access to inexpensive assets and labor to have less stringent environmental regulations. On the other hand, countries with stricter rules make things more expensive for businesses to operate because of the expenses associated with meeting these benchmarks. Therefore, firms who establish a geographical presence in a foreign nation typically (re)locate in the countries with the lowest environmental regulations or the least stringent implementation of such laws (see Figure 1).

According to a theory, economic production per capita has an inverted U-shape connection with various metrics of environmental stewardship. It is commonly referred to as the Environmental Kuznets Curve (EKC).

Therefore, this study utilized two models for this purpose. Model No.1 for testing the pollution heaven hypothesis:

$$Env\_Q = f(\text{GDPg}, CL, FDI, CL\_FDI, Eng\_U) \quad (13)$$

Here, Env_Q presents the environmental quality in the BRICS region, GDP_g is the gross domestic product growth rate, CL describes the commercial regulations, FDI is foreign direct investment, CL_FID is the interaction term of commercial rules with foreign direct investment, and finally, Eng_U is the energy consumption in the BRICS regions.

To fulfill the assumption of the EKC theory, model No. 2 is as follows:

$$Env\_Q = f(\text{GDPg}, \text{GDPg2}, CL, FDI, CL\_FDI, Eng\_U) \quad (14)$$

Here, we took the square term of gross domestic product to verify its trajectory for the EKC hypothesis. The following equations of PMG can be written on behalf of the models' specifications:

$$Y_{it} = \alpha_i Y_{it-1} + \delta_i X_{it} + \sum_{p=0}^{p_T}\gamma_{xip}\bar{X}_{t-p} + \sum_{p=0}^{p_T}\gamma_{yip}\bar{X}_{t-p} + \mu_{it} \quad (15)$$

To prove the pollution haven hypothesis, we use ecological footprint as a predictor variable.

TABLE 1 Variables' statistical summary.

Variable	Std.Dev	Skew	Kurto	Mean	Median	Max	Min	J.Bera	Prob	Sum	S.Sq	Obs
lGDP$_g$	0.78	−0.25	2.26	25.15	25.56	29.03	25.75	0.27	0.00	89.26	220.03	105
lGDP$_g^2$	0.56	0.02	2.14	29.25	27.46	30.26	26.28	0.02	0.05	2013.7	130.36	105
lCL	0.35	−1.05	5.59	1.48	1.47	1.91	−3.31	91.02	0.00	178.22	123.05	105
lCL_FDI	1.65	−0.71	3.36	0.88	1.20	3.10	−3.31	22.25	0.02	91.29	242.23	105
lFDI	1.01	−2.01	10.12	0.26	0.69	1.28	−4.51	405.05	0.01	044.15	062.95	105
lEng_U	0.89	0.31	2.32	6.02	6.01	7.97	4.51	3.36	0.04	648.48	119.28	105
lEnv_Q	1.06	0.27	2.29	18.25	20.36	19.32	15.56	1.21	0.04	2258.3	122.20	105

$$Env\_Q_{it} = \alpha_i Env\_Q_{it} + \beta_i X_{it} + \sum_{p-0}^{pt} y_{xip}\overline{X_{t-p}} + \sum_{p-0}^{pt} y_{xip}\overline{X_{t-p}} + \varepsilon_{it} \tag{16}$$

In the equation, Env_Q_{it} is the environmental quality used as the dependent variable, and other explanatory variables FDI, GDP$_g$, CL, *CL_FDI*, and Eng_U reported by X_{it}. μ_{it} is the error term.

Furthermore, for the testing of the EKC hypothesis, the following equation has been generated:

$$Env\_Q_{it} = \alpha_i Env\_Q_{it} + \beta_i GDPg_{it} + \beta_i GDP2g_{it} + \sum_{p-0}^{pt} y_{xip}\overline{X_{t-p}} + \sum_{p-0}^{pt} y_{xip}\overline{X_{t-p}} + \varepsilon_{it} \tag{17}$$

4 Results

This study aimed to examine the relationship between the interaction terms of commercial rules with FDI and the environmental quality of the economies as mentioned above. For this purpose, five emerging economies' datasets were used between 2000 and 2020. The empirical findings are shown below regarding the goals mentioned above and objectives. To begin, this research produced a statistical overview of the highlighted factors that can be found in Table 1.

According to the statistical summary of the highlighted parameters, the dataset contains no unexpected fluctuations and follows a normal distribution across all variables. Therefore, it was determined that these data were suitable for the operational task of regression. In addition, the researchers utilized a correlation test to assess the degree to which two variables are related.

Table 2 determines the correlation coefficient, which offers a linear link between two parameters and reveals how much one variable changes when the other does. For example, the correlation coefficient may be found by looking at the results in Table 2. The test findings indicate that there is only a weak correlation among the variables; hence, there is no correlation problem between the underlying parameters.

In addition, panel data may be affected by persistent cross-sectional dependence, which occurs when all of the units that are contained within the same cross-section are correlated. It is mainly ascribed to the action of specific undetected common characteristics, which are common to all units and affect each of them, even though how they are concerned may vary. For this reason, the cross-sectional dependence can be seen in Table 3. The assumption that there is no cross-sectional reliance is known as the null hypothesis, and this assumption leads to the conclusion that cross-sectional interdependence does exist between the cross-sectional parts.

Under the findings of the cross-sectional dependency assessment, this investigation utilized the second generation-panel root test, also referred to as the CIPS-test and detailed in Table 4 (Pesaran, 2007). The enhanced cross-sectional analysis is an example of this second-generation panel unit root test type. Pesaran included an undetected unique common element in the regression model that was utilized for testing to explicitly consider the connection between data cross-sections. The dependency of the variables on the cross-sectional area will be considered, and those results indicate that factors have a stationary order at the level, but nobody has a stationary order at the second discrepancy.

Table 5 presents the findings of the cointegration test that was conducted by (Westerlund, 2007). This table investigates the cointegration of long-term parameter values. The results of the Westerlund test disprove the alternative null hypothesis of cointegration and identify the components involved in the dynamic that occurs over the long term.

Table 6 reports PMG estimation outcomes. The results of the haven hypothesis and the environmental Kuznets curve (EKC) hypothesis are presented in the two distinct parts of Table 6. The results of the heaven hypothesis were derived without taking the GDP square value into account. The results of testing the heaven hypothesis indicate that the long-term GDP growth rate (GDP$_g$), foreign direct investment (FDI), and energy usage (Eng_U) of the BRICS economies all have a positive and significant impact on

TABLE 2 Pair-wise correlation matric.

	lGDP$_g$	lGDP$_g^2$	lCL	lCL_FDI	lFDI	lEng_U	lEnv_Q
lGDP$_g$	1						
lGDP$_g^2$	0.5489	1					
lCL	0.0254	0.4783	1				
lCL_FDI	0.3657	0.3458	0.2135	1			
lFDI	0.3254	0.3697	0.3145	0.2698	1		
lEng_U	0.5281	0.4781	0.4365	0.3670	0.3359	1	
lEnv_Q	0.4921	0.0587	0.5041	0.4580	0.5198	0.4457	1

TABLE 3 Results of cross-sectional-dependence.

		lGDP$_g$	lGDP$_g^2$	lCL	lCL_FDI	lFDI	lEng_U	lEnv_Q
Pesaran CD	coffi	14.25**	12.59**	10.23***	4.45***	10.56***	8.79***	7.79**
	prob	0.02	0.02	0.00	0.00	0.00	0.00	0.05
Pesaran scaled LM	coffi	49.45***	50.47**	29.89**	5.18***	4.58**	25.59**	22.93**
	prob	0.00	0.04	0.01	0.00	0.04	0.02	0.03
4	coffi	220.02***	241.01**	155.24**	39.36***	33.74***	125.8**	119.45***
	Prob	0.00	0.05	0.04	0.04	0.00	0.04	0.00

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

TABLE 4 CIPS unit root.

		lGDP$_g$	lGDP$_g^2$	lCL	lCL_FDI	lFDI	lEng_U	lEnv_Q
Level	coffi	−1.06	−2.58*	10.23***	4.45***	10.56***	8.79***	7.79**
	prob	0.10	0.02	0.00	0.00	0.00	0.00	0.05
First Difference	coffi	49.45***	50.47**	29.89**	5.18***	4.58**	25.59**	22.93**
	prob	0.00	0.04	0.01	0.00	0.04	0.02	0.03

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

TABLE 5 Westerlund ECM panel cointegration tests.

H$_0$: No cointegration	Value	*p*-value
Gt	−3.63**	0.034
Ga	−09.44**	0.036
Pt	−4.45***	0.000
Pa	−8.74**	0.013

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

environmental degradation. This finding suggests that the level of environmental deterioration in the economies is proportional to the gross domestic product, foreign direct investment, and energy usage. In addition, commercial regulation (CL) and interactional terms of it (CL) together with foreign direct investment (FDI) are positively and considerably contributing to the process of environmental deterioration in the long run of the BRICS economies as well. It shows that foreign direct investment (FDI) and its interactional link with commercial regulations are increasing further pressure on the environmental quality of the BRICS countries over time. Consequently, the findings of the empirical research point to the existence of the heaven hypothesis in the BRICS region. It also suggests that these economies have inadequate commercial regulations, which encourage foreign direct investment (FDI) to create environmental hazards in these countries.

The results of the empirical tests of the EKC hypothesis are presented in the second portion of Table 6. Even while the GDP growth coefficient of the square term (GDP$_g^2$) exhibits a negative

TABLE 6 Results of empirical analysis based on PMG.

Long-run relationship				
Heaven hypothesis			**Environmental kuznets curve hypothesis**	
	Coefficient	**Probability**	**Coefficient**	**Probability**
$lGDP_g$	0.587**	0.039	0.478**	0.029
$lGDP_g^2$	—	—	−0.921	0.496
lCL	0.549***	0.000	0.436***	0.001
lCL_FDI	0.438***	0.001	0.658**	0.030
lFDI	0.261**	0.041	0.315**	0.021
lEng_U	0.528***	0.000	0.436***	0.001
Short-run relationship				
Coin-01	0.441***	0.000	0.357***	0.000
$DlGDP_g$	0.325***	0.000	0.435***	0.000
$DlGDP_g^2$	—	—	−0.578**	0.021
DlCL	−0.541**	0.030	−0.437***	0.001
DlCL_FDI	−0.359**	0.039	−0.471***	0.000
DlFDI	−0.843**	0.022	0.581***	0.002
DlEng_U	0.0423***	0.000	0.067***	0.000
C	2.05	0.057	2.501	0.045

sign (a prerequisite for the EKC hypothesis), this finding is not statistically significant over the long run for the economies of the BRICS nations. In light of these findings, it can be deduced that the impact of a nation's GDP growth rate on foreign direct investment (FDI), commercial rules, and the energy consumption is a source of environmental degradation in BRICS countries.

The results of testing both hypotheses over a short period are shown in Table 6. The short-term effects are not only quite surprising but also very interesting. In this case, the interaction term between commercial rules and FDI results are statistically significant with a negative sign. It suggests that commercial regulation in the interaction of FDI is contributing negatively to the process of environmental deterioration. In the EKC hypothesis, the results of the GDP growth rate square term (GDP_g^2) are statistically significant with a negative sign as well. It proves that the EKC theory's underlying assumption that economic expansion will, in the course of development, contribute to ameliorating environmental circumstances is correct. On the other hand, these short-term effects have a more miniature bearing on the long-term outcomes.

In addition, the study calculates the marginal effect of interaction terms, demonstrating the real impact at the lowest, average, and maximum levels of commercial regulations. The results of this calculation are provided in Table 7.

TABLE 7 Marginal effect.

	Commercial regulations	**Marginal effect**
Minimum	0.001	0.319
Average	2.251	0.002
Maximum	2.591	−0.009

$$\frac{\partial \text{Env\_Q}_t}{\partial \text{FDI}_t} = 0.319 - 0.438\,\text{CL\_FDI}_t$$

5 Discussion

With the support of foreign direct investment and commercial regulations, the research endeavored to determine whether or not the pollution haven hypothesis or the EKC theories regarding the BRICS region are valid. According to the findings of this investigation, foreign direct investment (FDI) is a factor that significantly contributes to carbon emission in the BRICS economies. Therefore, this validates that FDI is the sole factor responsible for the deterioration of the ecosystem in the region. The fact that this statement validates the premise that the BRICS region is a pollution sanctuary. However, it does provide

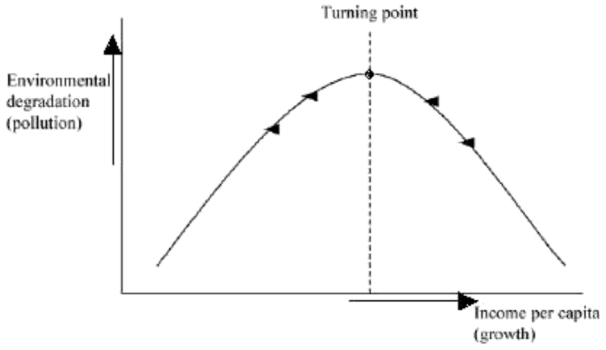

FIGURE 1
Environmental kuznets curve hypothesis.

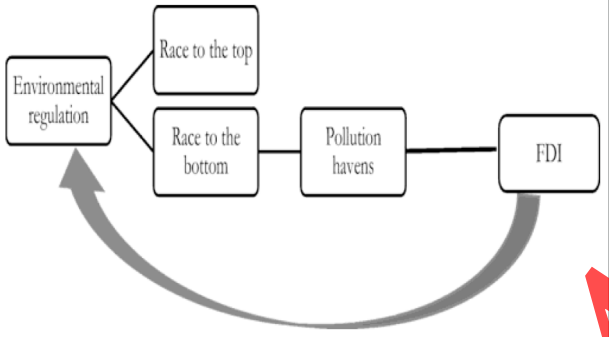

FIGURE 2
Pollution heaven hypothesis.

an additional positive contribution when considering commercial regulations. Our findings are consistent with those of other studies (Abdulmohsen Alfalih, 2019) that demonstrate the affirmative effects of FDI on the ecosystem. The scale effect refers to the deterioration of environmental quality due to economic activities.

In addition, the econometric findings of interactional terms suggest that commercial regulations and foreign direct investment make it possible for environmental degradation in the BRICS area. Thus, the region's ecological degradation can be attributed to an increase in foreign direct investment (FDI) and growth in bureaucratic integrity. A pollution haven theory may be functional in member nations because of the interplay between foreign direct investment and commercial norms. Both the findings of the study supported by Jacur's results (Jacur, 2018). On the other hand, this research establishes a connection between the business restrictions and the ecological footprint. According to the findings, tighter commercial regulations have the potential to contribute to an improvement in the environmental circumstances of the BRICS region. The effects of our commercial rules have had a detrimental impact on CO_2 emissions in BRICS countries.

In the BRICS region, environmental deterioration's effects are still exacerbated by economic expansion and increased energy consumption. The results of the square term of GDP show insignificant results in the long run, which shows that during the period mentioned above, the possibility of improving environmental conditions based on the theoretical concept of EKC theory is minimal. It is demonstrated by the fact that the results of the square term of GDP show insignificant results in the long run. On the other hand, the short-run effects are practically reciprocal to the long-run. According to these findings, the EKC theory applies in the BRICS regions. The foreign direct investment (FDI) and its interactional terms with commercial regulations are contributing constructively to improving environmental conditions in the BRICS region.

6 Conclusion

This study investigated the relationship between foreign direct investment and commercial regulation-led interaction for the BRICS region's pollution heaven hypothesis or environmental Kuznets curve hypothesis. The GDP growth rate, foreign direct investment, commercial regulation, and energy consumption datasets for 21 years, from 2000 to 2020, were applied for the aim of this study. In addition, this research utilized PMG for an individual evaluation of the pollution heaven hypothesis and the EKC hypothesis. The empirical findings suggest that conditions consistent with the pollution heaven theory prevail over the long run in the BRICS countries. According to the findings, foreign direct investment is contributing favorably to the BRICS region's process of environmental degradation. In this regard, the empirical results of commercial restrictions likewise follow the same pattern. The study indicated that foreign direct investment (FDI) coupled with commercial regulations positively influenced environmental degradation in these economies. As a result of this interaction term study, the researchers discovered that week commercial rules could be advantageous to FDI to cause more environmental difficulties in these economies.

Additionally, the EKC theory was put to the test by this investigation. The study's empirical findings indicate that the increase in GDP is not helping improve environmental conditions in the BRICS region. Furthermore, it demonstrated that the GDP growth rate does not, in the long run, follow the trajectory of the EKC hypothesis since it continues to exacerbate the environmental problem in these economies. However, the short-run results are consistent with the EKC hypothesis.

In the long-run scenario, there is no indication that the EKC hypothesis exists in these economies; nevertheless, the pollution heaven hypothesis is found to live in the BRICS region. It is based on the information and empirical analysis that is now accessible.

As a result, the findings of this study imply that the BRICS region should reconsider its commercial legislation and its strategy for environmental protection management. The governing bodies of these economies ought to have an understanding of the connection that exists between foreign direct investment and the commercial regulations of this region. In the absence of adequate laws, foreign direct investment (FDI) should be regarded as a contributor to this region's deterioration of the environment. According to the EKC hypothesis, the BRICS nations do not have an autocorrect system that is the restoration of the environment's effect on the economy. It is something that should be taken into consideration. Therefore, the only remedy that can be considered is stringent compliance with commercial regulations.

Data availability statement

The original contributions presented in the study are included in the article/Supplementary Material, further inquiries can be directed to the corresponding author.

Author contributions

This research paper contributed equally by CW, XZ, and MA in all aspects.

Conflicts of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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