World Journal of Advanced Research and Reviews

eISSN: 2581-9615 CODEN (USA): WJARAI

Cross Ref DOI: 10.30574/wjarr

Journal homepage: https://wjarr.com/

(Research Article)

Does globalization augment environmental degradation through the channel energy and FDI? Evidence from BRI initiatives

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World Journal of Advanced Research and Reviews, 2022, 15(03), 037–054

Publication history: Received on 25 July 2022; revised on 01 September 2022; accepted on 03 September 2022

Article DOI: https://doi.org/10.30574/wjarr.2022.15.3.0880

Abstract

From 2000 through 2020, this study examines the impacts of FDI, economic development, and globalization on E.D. in a sample of Belt and Road Initiative (BRI) nations. Data for the inquiry is gathered using a variety of tests, including the Westerlund cointegration test, the Dynamic seemingly unrelated regression (DSUR) long-run panel estimate approach, and the Dumitrescu-Hurlin panel causality test. Panel unit root tests reveal which variables are hidden where and after initial difference and long-run association documents have been processed using conventional and error-correcting methods. DSUR discovered a positive relationship between long-term energy use and environmental degradation, implying that greater energy consumption and total output would exacerbate the current condition of environmental degradation. Foreign direct investment (FDI), financial expansion, and globalization benefit the global economy more than harm the environment. Aside from the unidirectional impacts of financial development, globalization, and economic expansion on environmental degradation, directional causality studies demonstrate the presence of a feedback hypothesis that helps to explain these causal relationships. This research demonstrates the need for Belt and Road (B.R.) energy measures to improve energy efficiency.

Keywords: Environmental Degradation; Energy Consumption; FDI; Financial Development; DSUR; Belt;

1. Introduction

As a direct result of climate change, environmental degradation has become a significant problem in industrialized nations and developing ones. As a result of the change that took place during the Industrial Revolution, in which global economies moved from using simple tools to more complicated machinery, global economies started experiencing an acceleration in their economic growth and development rate in the late nineteenth century. It is a well-established notion in the body of academic research that the industrial revolution is to blame for the buildup of greenhouse gases and, in the long run, plays a harmful role in the deterioration of the status of the environment. In the last several decades, studies in empirical studies have been attempting to find out the fundamental reasons for environmental deterioration; nevertheless, [1-6] there has not been able to be reached an agreement about the accountable variables. In addition, the existing body of research suggests that an increasing number of researchers have identified a group of macro fundamentals directly or indirectly associated with environmental degradation. These factors include consumption of fossil fuels [7,8], foreign direct investment [9-12], financial development [13,14] [13,14], trade openness [15,16], gross capital formation [17-19] and so on. .

The purpose of this research is to investigate the potential impacts of foreign direct investment from now on referred to as FDI), financial development from now on, referred to as F.D.), and globalization from now on, referred to as GLO) on environmental degradation (from now on referred to as E.D.) in the presence of energy consumption (from now on referred to as E.C.) in the form of empirical estimation for a panel of B&R Initiative countries from 1990 to 2020. The

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following are two ways this work adds to the field: A great number of time series and panel studies have been conducted to investigate such relationships [20-25] . However, to the best of the author's knowledge, this information is scant, and studies have not yet been carried out in the context of B&R initiative countries, which could be an important panel for such an investigation. In a second point, the earlier empirical research used methodologies such as panel data analysis and combined countries analysis. In contrast, our research used a one-of-a-kind set of long-run estimates for each nation. The second-generation DSUR estimator technique was applied in this research, and the analysis used the most extensive data available for the evaluated variables. This study assists China and other countries participating in the B&R initiative in knowing and detecting the potential adverse impacts of the initiative, which will assist in providing practical information for policymakers [26,27]. Specifically, this study assists China in knowing and detecting the potential economic impacts of the initiative.

Practitioners and academics alike now see the discussion of energy policy and its regulation as a crucial subject of study in the modern age of globalization. Energy consumption is critical to economic, social, and sustainable progress [28]. As the global economy has expanded in recent years, so has the disparity between energy demand and supply, leading to rising levels of energy insecurity. Consequently, ensuring a sufficient energy supply is a problem for economies everywhere. The world economy, for instance, expanded by a factor of 22.9% between 1971 and 2015. Energy usage in 2015 was around 2.2 times more than in 1971, resulting from economic expansion and increased lifestyle expectations.

Numerous research has been conducted over the last several decades to study the link between energy and economic growth. Most of this research has shown that economic growth is associated with an increase in energy consumption. Therefore, it is conceivable to identify a connection between energy use and financial growth advancement [29]. The financial sector is one of the most important players in the growth and maintenance of an economy. Although the word "financial development" most often refers to a rise in the amount of a country's financial operations, there are other aspects to consider. For example, a rise in foreign direct investment (FDI), an increase in the availability of credit to the private sector, financial sector, and private sector by the bank, or an increase in the activities of an economy's stock market all qualify as examples of economic growth. Expanding a nation's financial sector plays an essential part in the functioning of that sector, leading to greater economic productivity and higher energy consumption levels [30]. Three distinct avenues explain the connection between economic growth and energy use. Increasing financial development supports more foreign direct investment (FDI), resulting in increased energy consumption and economic growth. Second, the expansion of the financial sector drives the development of other financial sectors, which in turn leads to more effective methods of financial intermediation, which in turn leads to an increase in consumer credit and a rise in the purchase of expensive things. Third, the growth of capital and financial markets makes it easier for economies to accumulate greater reserves, increasing energy use [31].

The following are some of how the research contributes to new knowledge. First, even though empirical literature has been produced, many studies are concentrating on environmental degradation by taking time series and panel data. However, to our knowledge, this is the first-ever empirical study conducted while considering the BRI centuries. According to the findings of the study, there is a high level of confidence that the new data set that includes empirical assessment will open a new door for reorganizing and rethinking environmental development as well as the formulation of environmental policy in BRI nations, which will eventually support long-term sustainable economic integration. Second, to determine whether or not financial development affects the deterioration of the environment, the research took into account both direct and indirect measures of financial development. This made it possible to investigate the respective agent roles in environmental problems. In addition, assistance in creating environmentally friendly policies and their subsequent implementation. Thirdly, the researchers used a method known as DSUR, relatively new to the field of panel regression, to investigate the magnitudes of factors that explain environmental deterioration. When doing empirical estimation, DSUR may be carried out even if the regressions include diverse sets of regressors and when equilibrium errors are related through cointegration regressions. This is because DSUR allows for the association of equilibrium errors.

2. Literature review

2.1. Environmental degradation and energy consumption

Energy is crucial to developing an economy and delivering life-sustaining services that vastly improve people's standard of living[32] [33]. Energy has long been considered a key factor in societal and economic progress. However, its production, use, and byproducts have resulted in enormous resource use and environmental degradation [34]. One of the biggest challenges to achieving sustainable growth is decoupling energy use and production. Instead of prosperity and continued expansion being the long-term goal, improvements in energy efficiency and a move toward the ecologically appropriate use of renewable resources should be the goal. Many developing and impoverished countries lack reliable access to clean energy sources. Negative effects on human health, biodiversity, the ozone layer, air quality, natural resources (water, soil, and forest), and the economy make environmental damage one of the world's most pressing problems today. The rising global trend in CO2 emissions is the most important factor leading to environmental deterioration today. It is connected to a rise in energy consumption [35,36].

Researchers, academics, and international development organizations have keenly interested in the connection between environmental hardship and macro causes. The driving force is a desire to understand what factors contribute to environmental deterioration and what precautions may be taken to slow its rate. Due to increased carbon emissions, energy intensity has become a primary culprit in environmental degradation[37]. This is particularly true when considering the use of fossil fuels in the aggregate manufacturing process. Global warming, temperature rise, and abrupt ecosystem behavior directly affect environmental degradation caused by excessive carbon and greenhouse gas emissions from diverse economic activities into the environment. Increasing numbers of empirical research [38,39] have pointed the finger at energy use as the primary cause of environmental deterioration. Accelerating economic development at the expense of the environment results from reliance on traditional energy sources beyond their limits [40-46]

In Rahman [47] study, he takes 10 of the highest electricity-consuming nations during 192-2013 to explore the relationship between energy use, economic development, and the destruction of the world environment. According to a recent study, the environmental deterioration rate is accelerated by using energy. The influence of globalization, on the other hand, demonstrates a negative and statistically significant deterioration of the environment, suggesting the importance of environmental improvement. The advancement of globalization and cross-country industrialization has consistently been supporting a greater level of production, demonstrating the direct relationship between energy consumption (such as electricity, coal, gas, and oil) and carbon emission [48]. According to the research conducted by Adebayo and Kirikkaleli [49], global integration helps the economy successfully execute environmental protection measures. As a result, the negative effects of the environment on the socioeconomic situation may be significantly mitigated. Alam, et al. [50] assess the influence of energy use on the deterioration of the environment in Pakistan to achieve sustainable development. They propose that to ensure the continued expansion of the economy over the long term, environmental degradation should not be allowed to worsen but rather should be prevented or, at the very least, kept at a constant level. If it keeps climbing at this rate, the economy will be pushed to shift even farther away from a sustainable state. Energy integration has been shown to enhance economic factors contributing to environmental pollution in SARAC countries, according to research by Akhmat, et al. [51].

Economic growth is thought to influence energy use and greenhouse gas emissions. There may be major connections between them. Research on the correlation between economic growth and energy use is in its infancy, claim Shahbaz, Hye, Tiwari and Leitão [42]. However, results indicating the connection between carbon emissions and economic growth have been wildly contradictory [52,53]. Existing research suggests that there are two ways in which energy consumption may be increased: the first, a positive one owing to monetary development (for an example, see [23,54,55] , and the second, a negative one due to stagnation or decline in the standard of living (for an example, see[56-59]. The literature argues that increased energy consumption in industry and everyday life results from financial development, making it simpler for individuals and corporations to secure financial resources for large-ticket purchases. Consequently, productivity and daily energy use go up. Second, the restraining influences are the unfavorable correlation between economic growth and energy use [56-59].

2.2. Energy consumption and Macro fundaments

The Chinese government first suggested the Belt &Road Initiative (BRI) in late 2013, and it has since garnered significant interest from across the globe [60-62]. The B.R. Initiative will unquestionably affect the global economy across various sectors, including the financial, environmental, economic, energy, educational, and political spheres [63,64] . The importance of financial development is comparable to that of other economic variables; it can positively stimulate and bring about several changes within an economy, such as the reduction of financial risks, the reduction in the cost of borrowing, the increased transparency of economic transactions between borrowers and lenders, and the increased availability of energy-efficient appliances. All this economic activity stimulation may impact energy consumption with fixed investment from enterprises across economies [32]. The monetary growth allows for the funding of energy-saving initiatives[20,65].

In their study, Shahbaz, Nasir and Roubaud [9] examine the relationship between Tunisia's energy and financial sectors from 1971 to 2008. In order to analyze the data, the ARDL and Johansen cointegration tests were used. The data confirm the long-term correlation between energy use and economic outcomes. In addition, a discovered causal association between two variables went in both directions. Another research concluded that rising living standards, population, and the economy are the primary forces behind rising energy demand. Malaysia, too shows signs of the observable feedback effect between economic growth and energy use. Granger's short-term effect on energy consumption results from economic growth [66] . Using the same Johansen and Juselius cointegration method, another research looks for evidence of a long-term connection between foreign direct investments (FDI), relative price, GDP growth, F.D., and energy consumption. This research demonstrated a causal relationship running in both directions between expansion and energy use and a single-directional connection between financial development and economic expansion. For the period between 1972 and 2012, another research [67] looked at the connection between Pakistan's energy sector and economy. This empirical study's findings show that monetary progress has a sizeable and constructive impact on energy use. Saudi Arabia has looked at the energy-finance nexus from 1971 to 2011 [68]. The research results analyzed the potential for a unidirectional causal relationship between economic growth and energy use.

Similarly, Kahouli argued that rising financial development leads to faster energy consumption, which boosts Israel's real production growth in an unfavorable way [33] . Energy and economic growth directly correlate in a panel of 22 developing nations from 1990–2006 [69]. The study's results indicate a favorable correlation between the underlying factors. Using information from the 9-CEEF economies, Sadorsky [22] investigated the effects of the financial energy nexus. When using F.D. indicators such as financial system deposits to GDP, bank deposits to GDP, bank assets to GDP, stock market capitalization to GDP, and liquid liabilities to GDP, the results suggest that F.D. increases energy consumption. Xu investigates the connection between finances and energy in 29 provinces throughout China from 1999 to 2009. In this investigation, the GMM methodology was used. The study's results demonstrated a correlation between energy use and economic growth [70,71].

3. Material and methods

The findings of this analysis are based on the 59 nations that are part of the Belt and Road Initiative (BRI). The Chinese State Information Center [72] hosted visitors from 71 nations engaged in the Belt and Road Initiative. However, the availability and quality of the data restricted our sample size to fifty-nine BRI nations, which impacted both the selection of countries and the timeframe (2000-2020). Environmental degeneration (E.D.), energy consumption (E.C.), financial development (F.D.), foreign direct investment (FDI), and globalization are the primary topics of this research (GEO). These figures are from the World Development Indicator report (WDI, 2021). CO2 per capita is one metric of human environmental impact [36]. Domestic credit to the private sector, bank lending to the private sector, and financial sector credit to the private sector (as a proportion of GDP) are all indices of financial growth [73-77] . Net FDI measures capital market globalization (percent of GDP). A growing GDP per capita reported in 2010 U.S. dollars measures economic growth. Energy consumption is measured in kilograms of oil equivalent per capita (kg of oil equivalent per capita). The globalization index may be shown as a result of globalization . Several pieces of earlier empirical literature were reviewed before deciding on the factors to be explored in this study. We converted the variables to logarithms to make the estimated coefficient easier to understand. Furthermore, reducing heteroskedasticity will level the playing field for heterogeneous panel data.

3.1. The methodology of the study

This study empirically explores the nexus among the analyzed variables, i.e., financial development, FDI, growth, energy consumption, and globalization, for a heterogeneous panel of B&R initiative countries. Based on prior empirical work, study assumed the following energy consumption function:

$$ED_{it} = \int EC, FD, FDI, GLO, Y \dots\dots\dots\dots\dots\dots\dots\dots\dots.. (1)$$

E.D. stands for environmental degradation, E.C. for energy consumption, F.D. represents financial development, FDI shows foreign direct investment, Y is economic growth, and GLO indicates globalization. The analyzed variables are taken in their natural logarithm to acquire consistent results. The log-linear form can be a rewrite of equation (1) as follows:

$$lnED_{it} = \alpha_0 + \beta_1 lnEC_{it} + \beta_1 lnFD_{it} + \beta_1 lnFDI_{it} + \beta_1 lnY_{it} + \beta_1 lnGLO_{it} + \tau_{it} \dots\dots\dots\dots (2)$$

T represents the number of periods, *I* indicate several countries; and λ represents the error term. β_0 shows the slope-intercept, β_{1t}, β_{2t}, β_{3t}, and β_{4t} are the coefficient estimates of F.D., GDP, FDI, and GLO.

3.1.1. Cross-sectional dependency test

The Lagrange multiplier (L.M.) test was proposed by Breusch and Pagan [78], which is preferred in a situation when the cross-section (N) is smaller than time (T). Based on the following equation, we can construct L.M. test statistics:

$$y_{it} = \alpha_i + \beta_i x_{it} + u_{it}$$

i= 1…...N, t=1…...T………………… (2)

$$LM = T \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} \hat{\rho}_{IJ \underset{d}{\rightarrow}} X^2 N(N+1)2 \text{ ……………. (3)}$$

Where $\hat{\rho}_{ij}$ Represents the pairwise correlation of the residuals.

The L.M. test is not suitable in a situation with a larger cross-section (N); therefore, overcoming this limitation, Pesaran [79] suggests the following The Lagrange multiplier (CDlm) that is the scaled version of the L.M. test [80]:

$$CD_{lm} = \sqrt{\frac{N}{N(N-1)}} \sum_{I=1}^{N-1} \sum_{J=i+1}^{N} \left(T\hat{\rho}_{ij} - 1\right) \text{ ……………………….(4)}$$

Therefore, , Pesaran, et al. [81] proposed the following CD test, which is suitable in a situation when N is larger than T:

$$CD_{lm} = \sqrt{\frac{2T}{N(N-1)}} \sum_{I=1}^{N-1} \sum_{J=i+1}^{N} \left(\hat{\rho}_{ij}\right) \text{ ………………….(5)}$$

Pesaran et al. [72] proposed the bais-adjusted L.M. test to limit the negative effect.

$$CD_{lm} = \sqrt{\frac{2}{N(N-1)}} \sum_{I=1}^{N-1} \sum_{J=i+1}^{N} \left(\frac{(T-K)\hat{\rho}_{ij}^2 - u_{Tij}}{v_{Tij}^2}\right) \vec{d}\,(N, 0) \text{ ……………..(6)}$$

Where k refers to the number of regresses, u_{Tij} and v_{Tij}^2 specifies the mean and variance of$(T-K)\hat{\rho}_{ij}^2$, respectively.

Dumitrescu and Hurlin's (2012) Panel Causality Test

Non-granger causality test was proposed by Dumitrescu and Hurlin [82] with the extension and modification of the conventional non-granger causality test.

$$Y_{it} = \alpha_i + \sum_{K-1}^{P} \gamma_{ik} Y_{i,t-k} + \sum_{K-1}^{P} \beta_{ik} X_{i,t-k} + \mu_{it} \text{ ……………. (3)}$$

$$W_{NT}^{Hnc} = N^{-1} \sum_{i-1}^{N} W_{i,t} \text{ …………….. (4)}$$

$$Z = \sqrt{\frac{N}{2P}} \times \frac{T-2P-5}{T-P-3} \times \left[\frac{T-2P-3}{T-2P-1}\bar{W} - P\right] \text{………………… (5).}$$

4. Results

Cross-sectional dependence must be assessed prior to stationarity testing in the context of diverse panels. The CD tests [79,83] which are more reliable and consistent when applied to panel data, have been inferred to reach this end. In Table 1, you will find the results of the cross-sectional dependency test, which, because the probability value is smaller than 0.09, proves the presence of cross-sectional dependence in the panel data. Because of this, the statistics show a cross-sectional dependency on variables including FDI, energy use, GDP growth, globalization, and financial development.

Table 1 Test for cross-sectional dependence

	LM_{BP}	LM_{PS}	LM_{adj}	CD_{PS}	**Δ**	**Adj.Δ**
lnED	398.89***	21.994***	146.304***	15.171***	58.311***	126.615***
lnEC	376.017***	15.025***	158.181***	10.787***	18.499***	98.534***
lnFDFS	322.184***	22.34***	177.616***	32.01***	64.908***	61.798***
lnFDB	322.131***	35.464***	103.135***	11.836***	36.89***	112.366***
lnGLO	438.401***	35.956***	239.798***	27.785***	15.255***	90.258***
lnFDI	395.186***	41.838***	159.913***	30.797***	33.309***	140.526***

Note: ***, ** & *, denote the statistical significance at 1%, 5%, and 10% level, respectively.

4.1. Panel unit root test

As the first step in any econometric analysis, the panel unit root test is performed to verify whether or not the data are stationary. Previous studies have recommended several other panel unit root tests. First generation panel unit root tests include those by Levin, et al. [84], Hadri [85] , Breitung [86] [77], and Breitung [78]. Additional panel unit root tests have also been recommended (i.e., I.M. Pesaran Shin, Fisher PP, Fisher ADF test, and CIPS and CADF initiates by Pesaran [83]. The results of the unit root tests applied to the first-generation data are shown in Table 2. Contrarily, the first-generation estimator may not produce reliable results due to the test's low power [87].

Table 2 Results of first-generation panel unit root test

	Levin, Lin & Chu t		**Im, Pesaran and Shin W-stat**		**ADF - Fisher Chi-square**	
	t	**t&c**	**t**	**t&c**	**T**	**t&c**
Panel –A: Al level						
lnED	-2.271	-1.861	-0.452	-2.844	54.811	35.848
lnEC	-3.553	-2.296	-0.563	-1.091	47.724	47.928
lnFDFS	-3.069	-2.734	-2.646	-3.848	31.208	60.035
lnFDB	-3.839	-2.793	-1.602	-1.039	56.898	49.475
lnGLO	-3.12	-3.169	-1.321	-2.77	53.076	46.502
lnFDI	-0.379	-2.519	-3.354	-0.092	33.315	54.697
lnY	-1.153	-1.985	-0.331	-2.465	52.67	31.935
Panel –B: After the first difference						
lnED	-8.051***	-6.139***	-12.641***	-8.107***	212.419***	99.194***
lnEC	-9.016***	-18.583***	-21.792***	-5.42***	310.593***	177.254***
lnFDFS	-10.816***	-15.157***	-6.343***	-9.802***	256.564***	93.136***
lnFDB	-6.589***	-13.349***	-6.791***	-10.927***	169.912***	81.735***
lnGLO	-11.179***	-8.857***	-11.756***	-5.985***	205.482***	207.228***
lnFDI	-11.048***	-5.547***	-9.52***	-10.638***	132.302***	186.445***
lnY	-10.234***	-13.313***	-17.169***	-7.714***	128.182***	174.169***

Note: ***, ** & *, denote the statistical significance at 1%, 5%, and 10% level, respectively.

According to the findings of this study, it is recommended that the CIPS and CADF tests that Pesaran established and Pesaran and Yamagata [88] be used to validate unit roots in panels. According to the findings of panel unit root tests, the evaluated variables reach a state of stationarity when they reach initial differences [I(1)], and they take on the form of a unit root when they reach levels. These findings are shown in Table 3.

Table 3 Panel Unit Root Test

	CIPS		**CADF**	
Variables	**Level**	**First Difference**	**Level**	**First Difference**
lnED	-1.747	-6.585***	-2.295	-6.99***
lnEC	-1.177	-7.241***	-1.326	-5.31***
lnFDFS	-1.83	-4.838***	-1.959	-7.304***
lnFDB	-2.423	-4.826***	-1.18	-2.87***
lnGLO	-2.275	-3.001***	-2.372	-2.444***
lnFDI	-2.003	-3.297***	-2.19	-2.541***
lnY	-2.305	-5.092***	-1.865	-4.435***

Note: ***, ** & *, denote the statistical significance at 1%, 5%, and 10% level, respectively.

4.2. Padroni and Westerlund panel cointegration test

This study used a panel cointegration test in line with Pedroni Pedroni [89,90]and the Westerlund panel cointegration test established by Westerlund [91] to ascertain whether or not the variables under study are cointegrated. This was accomplished after a check to guarantee that the data were steady at the first discrepancies. The results of a cointegration test conducted on the Pedroni panel are shown in Table 4. 11 out of the 15 test statistics have a significance threshold of 1%, indicating that the majority are statistically significant. This suggests that the empirical equation may be capable of capturing causal relationships over the long term.

Table 4 Padroni panel cointegration test

	[1]		**[2]**	
H_1: common A.R. coefs. (within-dimension)				
Panel v-Statistic	1.254	1.492	2.701	2.193
Panel rho-Statistic	-4.322	-6.727	-4.449	-6.999
Panel PP-Statistic	-10.167	-9.349	-10.89	-10.446
Panel ADF-Statistic	-5.015	-4.496	-4.745	-2.572
H_1: Alternative hypothesis: individual A.R. coefs. (between-dimension)				
Group rho-Statistic	-9.778	-6.677	-6.255	-10.488
Group PP-Statistic	-7.35	-9.96	-10.081	-9.863
Group ADF-Statistic	-3.176	-2.836	-4.661	-4.227

Note: ***, ** & *, denote the statistical significance at 1%, 5%, and 10% level, respectively.

Finding data inconsistencies and outliers using this approach is helpful, as is the system's ability to provide reliable, consistent outcomes. See Table 5 for Westerlund's cointegration findings, which imply, at a 1% level of significance, that both group and probability statistics are significant. The result provides evidence against the absence of cointegration or the null hypothesis. Thus, cointegration exists among the analyzed variables, i.e., E.D., E.C., FDI, F.D., Y and GLO. Summary of the Westerlund panel cointegration test results

Table 5 Results of Westerlund panel cointegration test

Model	Gt	Ga	Pt	Pa
MODEL-1 (FDFS)	-14.776***	-14.997***	-15.289***	-11.249***
MODEL-2 (FDB)	-10.039***	-9.369***	-14.093***	-5.032***

Note: ***,**,* shows the rejection of the null hypothesis at a level of 1%, 5%, & 10%.

4.3. Baseline estimation with OLS, fixed effects and random effects model

The growth of the domestic credit market as a proxy for the financial sector's development is used in conjunction with the estimating model. Column 3 of model [1] is what you should look at. Consistent with the findings of Rehman and Rashid [36], this analysis finds a positive, statistically significant connection between energy usage and environmental deterioration (a coefficient of 0.122). Research indicates that greater production volumes need more energy input, which permits more greenhouse gas emissions. Tamazian, Chousa and Vadlamannati [2] find that economic growth has a statistically significant (coefficient = -0.447) negative effect on environmental deterioration. This indicates that subsidies for energy consumption will be necessary as the transition from traditional to green energy continues. A similar influence reveals the impact of globalization on environmental deterioration (a coefficient of 0.221), which in turn suggests that the integration of economies throughout the world creates pressure pressures in the economy to use green energy and reduce emissions of greenhouse gases. However, it was shown that FDI (correlation coefficient of 0.566) and GDP growth (correlation coefficient of 0.681) positively influenced environmental deterioration. These results imply that higher economic growth via aggregate output leads to extensive investment in production and industrialization, increasing the current level of energy consumption and, ultimately, extra carbon emission due to excessive usage of fossil fuels.

Table 6 Results of baseline model estimation

	Model – [1]			Model –[2]		
	OLS	RE	FE	OLS	RE	FE
lnEC	0.133(0.0281) [4.725]	0.043(0.0053) [8.071]	-0.17(0.0288) [-5.886]	-0.214(0.0236) [-9.061]	0.568(0.068) [8.347]	0.67(0.0648) [10.332]
LOGFDFS	0.214(0.0197) [10.852]	0.446(0.0608) [7.326]	-0.013(0.0012) [-10.756]			
LOGFDB				0.445(0.044) [10.109]	0.057(0.0131) [4.335]	-0.202(0.0177) [-11.383]
LOGGLOB	0.051(0.0039) [12.836]	0.729(0.0585) [12.45]	-0.135(0.0197) [-6.832]	-0.156(0.0166) [-9.359]	0.634(0.1) [6.338]	-0.122(0.0134) [-9.101]
lnFDI	0.057(0.0063) [8.915]	0.286(0.0414) [6.902]	0.362(0.0367) [9.848]	-0.208(0.0207) [-10.007]	-0.06(0.0123) [-4.857]	0.337(0.0685) [4.914]
lnY	0.493(0.072) [6.839]	-0.085(0.0072) [-11.681]	0.726(0.0772) [9.394]	0.341(0.0268) [12.696]	0.304(0.059) [5.147]	0.252(0.0521) [4.833]
Constant	0.638(0.1227) [5.196]	0.039(0.0078) [4.992]	0.001(0) [12.108]	0.074(0.0173) [4.257]	0.193(0.022) [8.757]	-0.133(0.0287) [-4.629]
F-stat (p-value)	0.001	0.000	0.0014	0.0021	0.000	0.0032
Hausman test (p-value)	0.875			0.522		

Note: ***/**/* denotes the level of significant at a 1%, 5%, and 10%, respectively

The empirical model results that employ credit balances as a proxy for financial development are shown in table 6, column [6]. The researchers discovered a statistically significant link between excessive energy use and the harm done to the environment (a coefficient of 0.127). In addition, there is a negative and statistically significant (at the 1 percent level) correlation between economic growth (correlation coefficient of -0.244) and globalization (correlation coefficient of -0.199) and the deterioration of the environment. This correlation exists at the same time as the correlation between economic growth and globalization. The research findings indicated that the use of green energy was a direct consequence of expanding global finance and economic integration. On the other hand, foreign direct investment (which has a value of 0.472) and economic development (which has a coefficient of 0.1114) are positively and statistically related to a degradation in the surrounding environment.

4.4. DSUR long-run estimation results

The key inference of empirical work is to analyze the long-run estimations among the analyzed variables. This study implied the second generation estimator DSUR established by Mark, et al. [92]. The DSUR panel long-run estimation and DOLS approach results are presented in Table & **Error! Reference source not found.**, respectively.

4.4.1. . DSUR long-run estimates

The researchers discovered a positive and statistically significant relationship between energy usage and environmental damage with both estimating methods. Model-1 (coefficient = 0.214) and Model-2 also identified this connection (with a coefficient of 0.179). Previous studies by Acheampong [93]; Kivyiro and Arminen [94]; Bozkurt and Akan [95]; Eyuboglu and Uzar [96] also agree with this conclusion. The research concluded that an increase of 10% in energy use would hasten environmental degradation by releasing carbon into the atmosphere at a rate of 2.14 and 1.79 percentage points, respectively. More contamination of the environment results from the use of energy in many economic activities [97,98]. This is because not all energy comes from sustainable sources.

Research has shown that foreign direct investment (FDI) may play a preventive role in the degradation of the environment by lowering the pace at which carbon emissions are created in countries that are a part of the B&R program. Specifically, foreign direct investment (also known as FDI) is one factor that contributes considerably (at the 1 percent level) to the degradation of the environment. Models 1 and 2 indicate that the level of environmental stress will increase by -1.16 and -1.25 percentage points, respectively, for every 10 percent increase in FDI. Our empirical finding is consistent with that of the previous empirical literature, such as , Lee [99] for G20; Ozturk and Acaravci [21] for Malaysia; and Alam, et al. [100] for SAARC countries but disprove the empirical findings of Shahbaz, Nasir and Roubaud [9] for franch, and. Farhani and Solarin [101] for the US..

According to both empirical estimations, there is a negative statistical significance between the growth of the financial industry and the worsening of the environment. More prosperity may help keep the climate from deteriorating by reducing carbon emissions, as this study implies. Specifically, models 1 and 2 suggest that for every 10% rise in financial development, there may be an additional -1.77 and -1.41 percentage points in the rate of environmental degradation. This study's findings are in agreement with those of other studies, including those by as Tamazian and Bhaskara Rao [102] Tamazian, Chousa and Vadlamannati [2] Saud, et al. [103]. The negative sign of the anticipated coefficient for financial development suggests that this factor has only a little impact on the total economic activity of these countries in terms of reducing their energy consumption. In order to maintain a healthy ecosystem, it is essential to have ready access to appropriate financial resources and to put those funds to good use [104]. The significant negative repercussions of environmental degradation are quantified by the proxies used for financial development in the B&R project countries.

When controlling for other variables, model 1 and model 2 find a positive and statistically significant correlation between economic growth and environmental degradation. 0.514 is the coefficient for model -1, whereas 0.441 is the value for model -2. More specifically, if economic growth rises by 10%, environmental deterioration may increase by 5.14 and 4.41 percentage points. This empirical verdict coincides with the result for India. The outcome here differs from that in the USA]. Our result is also consistent with Qamruzzaman, et al. [105]. Industrial operations and economic activities, including investing, producing, purchasing, shopping, and consuming, all increased, necessitating more energy supplied to the gross domestic product. In addition, the high energy consumption in the BRI countries is due to the usage of antiquated technologies, a lack of skills, inefficient industrial practices, a dearth of knowledge, and a failure to diversify energy sources.

The coefficient estimate of globalization's association with environmental degradation is negative and statistically significant at the 1% level. The negative coefficients of -0.485 and -0.255 suggest that a 10% increase in globalization reduces the risk of encountering environmental difficulties by 4.85% and 2.55%, respectively. The results imply that globalization would have long-term detrimental consequences on environmental concerns. This result is in line with Qamruzzaman and Jianguo [25] for India; and Saud, Baloch and Lodhi [32] for China and not in line with Dogan and Deger [106] for Brazil; and Shahbaz, Khan and Tahir [63] for Singapore. In the B&R project, carbon emissions have been reduced via the slow but steady process of globalization by making more constructive use of green and renewable energy sources. The use of cutting-edge energy-efficient technologies in manufacturing may be the root cause of the inverse correlation. It might also result from misguided efforts to boost production factors and economic growth. High economic growth rates lead to a substantial rise in the energy needed to manufacture goods and services [24,107,108]. if more modern or energy-efficient technologies are not integrated into the production process.

Table 7 Results from panel DSUR

		MODEL-1	**(FDFS)**	**MODEL-2 (FDB)**		
Test	Coefficient	St. error	t-stat	Coeff.	t-statistics	P-Value
lnEC	0.1409	0.0382	3.688481675	0.0857	0.0308	2.782467532
lnFDS	0.0982	0.0706	1.390934844	0.0982	0.055	1.785454545
lnFDB	0.0871	0.0626	1.391373802	0.0944	0.0256	3.6875
lnGLO	0.0938	0.0315	2.977777778	0.0703	0.0622	1.13022508
lnFDI	0.077	0.0351	2.193732194	0.0908	0.0433	2.096997691
lnY	0.0631	0.0393	1.605597964	0.1013	0.0339	2.98820059
Constant	0.1466	0.0439	3.339407745	0.0734	0.0817	0.898408813
R-square	0.775	---	---	0.795	---	---
F-statistic	1524	---	---	2415	---	---
Prob.	0.000	---	---	0.000	---	---

4.5. Dumitrescu Hurlin (D.H.) panel causality

Indicative of a two-way causal connection, lending credence to the existence of feedback. Environmental degradation (E.D.) and energy consumption (E.C.) have been shown to have mutually reinforcing relationships, as have FDI and E.D. Zheng, et al. [109], Wang, et al. [110] as have been previously documented in the literature. Furthermore, there is a direct link between financial development and environmental deterioration, globalization and environmental degradation, and economic growth and environmental degradation.

Empirical evidence supports the idea that F.D. and E.C. are affected by feedback from one another. Previous empirical investigations, such as those by , Farhani and Solarin [101] for the US; Dogan and Aslan [111] for GCC countries; Shahbaz, Khan and Tahir [63] for Malaysia, reached similar conclusions. It helps new businesses, investment endeavors, and the acquisition of long-lasting energy consumption products by offering easy loans or debts. An expanding economy is propelled by rising energy consumption, which boosts the demand for financial services and further strengthens the sector. Given these results, it is reasonable to infer that F.D. and E.C. complement each other well. Our investigation revealed a reciprocal causal relationship between GDP and E.C. Similar findings had been made by Sadorsky [23] concerning Malaysia, Kahouli [33] concerning SMCs, and Alsaman, et al. [112] concerning BRICS. As a result, we may infer that the E.C. and GDP are interconnected and that it is prudent to pursue policies that affect both indicators concurrently. The results of the causality study suggest that FDI might cyclically impact GDP. Both the demand-supply side paradigm and the result of Farhani and Solarin [101], available here] are confirmed by this conclusion.

Increased capital creation, new business opportunities, a boon to trade, and affordable financial aid are all outcomes of F.D. This encourages outside investors to put money into the local economy, leading to more manufacturing. The pace of economic development, therefore, quickens [108]. GDP seems to have a reciprocal effect on F.D. since the linked. Al-mulali, Tang and Ozturk [13]and Al-mulali and Lee [113] found similar results for the GCC countries,

In addition, it has been shown that there is a causal link between globalization and F.D., GDP, FDI, and E.C. in both directions. The key distinction is that we can only infer a causal link between E.C. and F.D. This is the only direction in which we can make such an inference. The findings of [114,115] , which demonstrate that the energy conservation policy must be implemented, are supported by this result; therefore, they are compatible with their findings. It was also proven that there is a causal relationship between energy usage and FDI, although this link only goes in one way.

Table 8 Results of Dumitrescu-Hurlin (D.H.) panel causality

	E.D.	EC	FDI	FD	GLO	Y
ED		1.1795 [1.2432]	(1.9649)* [2.071]	(3.1339)** [3.3031]	(4.8682)*** [5.1311]	(4.865)*** [5.1277]
E.C.	(3.2465)** [3.4218]		1.4378 [1.5154]	(4.2709)** [4.5016]	(2.9829)** [3.144]	1.0828 [1.1413]
FDI	(3.051)** [3.2157]	(4.3698)** [4.6057]		(1.9139)* [2.0172]	(3.831)** [4.0379]	(5.9287)*** [6.2489]
F.D.	(4.5536)** [4.7995]	(3.2848)** [3.4621]	(2.4261)* [2.5571]		(2.6131)* [2.7542]	(1.9914)* [2.099]
GLO	(3.4729)** [3.6604]	(3.9829)** [4.198]	(2.1509)* [2.267]	(5.509)*** [5.8065]		(3.9298)** [4.142]
Y	(5.3294)*** [5.6172]	(3.1434)** [3.3132]	(2.5196)* [2.6557]	(3.0488)** [3.2135]	(2.6068)* [2.7475]	

Note: ***, ** & *, denote the statistical significance at 1%, 5%, and 10% level, respectively.

5. Discussion

First, panel unit root tests are used to check for cross-sectional dependency, heterogeneity, and the order of integration of variables before moving on to empirical model estimation. This is done in advance of estimating the model empirically. The results of the cross-sectional dependency tests corroborate the idea that the units of study have common underlying dynamical properties. Panel unit root tests reveal that the variables are integrated into a disordered fashion, indicating the variables are stationary at a constant value. Some variables stabilized after the first difference, whereas others continued to fluctuate after the second difference. Second-generation unit root tests, such as CIPS and CAFD, may handle issues with document line of variables integration that is not handled by traditional unit root tests, such as cross-sectional dependencies. To further evaluate long-run cointegration in empirical models, we use the panel cointegration tests offered by Pesaran and Shin [116] correction-based cointegration test reported by Westerlund [117]. Long-run correlations between E.D., E.C., FDI, F.D., GLO, and Y are traditional panel cointegration tests, with most tests achieving significance at the 1% level. Further, the Westerlund cointegration test revealed that the variables were cointegrated over the long term.

Thirdly, empirical model estimation using DSUR demonstrates positive, statistically significant outcomes ranging from energy consumption to environmental degradation. It is consistent with other studies, including those by Sehrawat, et al. [118] and Raza, et al. [119]. High energy use increases carbon emissions, especially when fossil fuels are utilized. Several countries have decided to transition away from fossil fuels and toward renewable energy sources because of rising knowledge of the harmful impact fossil fuels have on the environment. Adapting the economy to utilize renewable energy sources is beneficial in two ways: it minimizes environmental harm by lowering CO2 emissions and reduces industrial costs by lowering environmental protections. [120].

Foreign direct investment (FDI) indicated a statistically significant negative link with environmental degradation, indicating that technological advancements in energy efficiency and successful industrial processes based on renewable energy contribute to economic development. Qamruzzaman Li and Qamruzzaman [121] claim that FDI facilitates the shift from fossil to renewable energy, which means that energy-efficient Industria improves environmental quality. Consequently, emerging countries must make adjustments to increase their energy efficiency. Future industrialization and communal undertakings must be fueled by renewable energy sources, not conventional ones. Doytch and Narayan [122] postulate that the FDI-focused services sector is always searching for better energy-efficient business practices, which in turn encourages the economy to establish energy policies that favor the growth of renewable energy above that of conventional energy sources. Studies have shown a negative correlation between globalization and environmental degradation, suggesting that international cooperation positively impacts environmental quality over the long run [40]. Perhaps globalization has affected the dissemination of eco-friendly technologies (its technical influence). In addition, it encourages the introduction of regulatory reforms that are essential for fostering productivity and rivalry. This one refutes previous studies' findings; for example, see [123].

6. Conclusion

The study's objective is to examine the relationship between energy consumption and the effects of economic expansion, FDI, and globalization on the natural environment in BRI nations from 1990 to 2017. The empirical evaluation of the variables' stationary qualities was made using several econometric methods. The panel unit root test that identified these characteristics includes the conditional autoregressive distribution function (CADF) and conditional impulse response function (CIPS) tests developed by Pesaran Pesaran [83] and the test of heterogeneity developed by. In order to do the long-run cointegration study, we employed the Pedroni panel cointegration test, the ADF test, and the error correction-based cointegration test. Directional causality was established using the causality test proposed by Dumitrescu, and dynamic uncorrelated regression (DSUR) was utilized in the study. These methods were used to examine the impact of the long-term elasticity of explanatory factors on environmental deterioration. The following table displays the most relevant findings from the study.

Initially, the CSD tests demonstrated that the research units share comparable qualities; second, the investigation of the variables' stationary features offered proof that the variables in question are all stationary after the first difference was taken into account. It has been found that the long-run cointegration is an empirical equation, and the test statistics of the panel cointegration test have provided more evidence to support this conclusion. Third, the study offered empirical proof that higher energy use is linked to more rapid degradation of the surrounding environment and that this influence is statistically significant when measured against the magnitudes of its long-term effects as determined by DSUR. It has been suggested that the nations that make up the BRI, which depend heavily on fossil fuels, have been exacerbating environmental problems by injecting carbon dioxide. It has been proven that there is a statistically significant negative association between the degradation of the environment and foreign direct investment (FDI), financial advancements, and globalization; this indicates that environmental rectification is progressing. Specifically, the reduction of carbon emissions is made possible by technological advances, more energy-efficient operations, and the integration of clean energy at the aggregate level. All of these factors contribute to an ecosystem that is friendlier to the environment. The results of a test to determine the direction of causation. The findings of this research provide credence to the feedback theory, which seeks to shed light on the connection between environmental degradation and either the use of energy or the inflow of foreign direct investment

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