Impact of Chinese OFDI on Developing the Green Economy in Countries Along the Belt and Road

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Abstract: Since the inception of the Belt and Road Initiative, the green economy of countries along the route has undergone continuous development, and China's outward direct investment (OFDI) has played an instrumental role in promoting the development of green economy in these countries. This paper utilizes entropy weight-TOPSIS to assess the degree of green economy development in 52 sample countries along the Belt and Road from 2011 to 2021. The study utilizes a panel regression model to examine the impact of OFDI on the green economy's development in these countries. The study also examines the heterogeneity of economic income and regional differences. Furthermore, the study delves into the non-linear impact of the labor force's level on OFDI's promotion of green economy development. The findings of the study indicate that OFDI can substantially encourage the green economic development of countries along the route, exhibiting significant heterogeneity between specific regions and low-income and lower-middle-income countries. As the labor force expands, the role of OFDI in influencing the impact of green economic development becomes more significant.

Keywords: Green Economy; Belt and Road; Threshold Effect; Outward Direct Investment;

1. Introduction

Amid global ecological challenges and rising "anti-globalization," coordinating economic opening with environmental protection is critical. The green economy, aligned with sustainable development, enhances national competitiveness and supports balanced economic-social progress[7]. Over the past decade, this initiative has driven investment, connectivity, and trade facilitation along its routes. However, traditional development models often neglect environmental protection, and climate change threatens human survival. In March 2022, China's National Development and Reform Commission issued guidelines promoting green development in the Belt and Road, encouraging green financing and supporting green bonds by international organizations in China.

As a key participant, China has expanded economic cooperation through outward foreign direct investment (OFDI) along Belt and Road routes. In this regard, a substantial body of literature has examined the trade implications of China's OFDI on direct investment in the countries along the routes (Wang Yan et al., 2023; Tian Siyuan and Wang Xiaosong, 2024)[34,35]. However, few scholars have investigated the economic impact of China's OFDI on the development of the green economy in these countries. Since the inception of the Belt and Road Initiative, China's investment in the initiative has been critiqued as a potential "environmental threat theory" within the context of international relations. Concerns have been expressed regarding the potential ecological and natural implications of China's OFDI along the designated routes. In addition to the fact that people are easily influenced by the media and internalize the induced views, this phenomenon seriously affects the further development of the Silk Road economy (Tan Chang, 2015; Jiang Zuoli and Jiang Meiling, 2022)[36,40]. Therefore, the purpose of this study is to examine the correlation between China's OFDI and the development of green economies in countries along the "Belt and Road" initiative. A critical question that merits rigorous examination is whether China's "Belt and Road" OFDI exerts a substantial positive or negative influence on the green economic development of the countries along its routes. Answers to the aforementioned inquiries can assist in clarifying the ambiguities experienced by the international community and can provide the necessary theoretical underpinnings and practical guidance for the construction of a high-quality green "Belt

and Road."

This study examines China's OFDI and green economy development in Belt and Road countries from 2011–2021, measuring green economy levels and analyzing OFDI's impacts, including regional and economic heterogeneity. Labor force level is used as a threshold variable to assess OFDI's marginal positive effects on green growth. The study contributes by: (1) enriching OFDI's economic effect literature with empirical evidence; (2) innovating green economy indicators using 12 metrics across green energy, governance, and economy, weighted by entropy; and (3) identifying labor force level as a new threshold variable, enhancing theoretical frameworks.

2. Literature Review

2.1 Drivers of China's OFDI in Belt and Road Countries

Since the launch of the Belt and Road Initiative (BRI), China's outward foreign direct investment (OFDI) in participating countries has significantly increased (Yajun Cao and Ting Hu, 2021)[1]. Scholars have extensively explored the driving forces behind this trend. Rising economic and trade policy uncertainty has paradoxically encouraged greater Chinese investment in BRI countries (Zhang Xinyue, 2023; Chen Kai et al., 2024)[2,3]. Moreover, regional development characteristics influence OFDI flows-neighboring country effects are pronounced in Southeast, South, Central and West Asia, and Europe, while weaker in central regions (Ning Danhong and Qiao Yuanbo, 2016)[4].

Institutional factors in host countries also play a vital role. Improved investment facilitation, institutional quality, and business environments significantly boost Chinese OFDI (Yang Dongxu, 2021; Wu J et al., 2020)[10,12], while cultural differences can deter investment (A. K. M. Mohsin et al., 2021)[13]. Financial openness positively impacts investment flows (He Junyong et al., 2021)[11]. Additionally, under the joint influence of the BRI and bilateral investment treaties (BITs), countries with relatively poor business conditions may attract more Chinese OFDI (Wu Jun and Han Yun, 2022)[10].

2.2 Impact of China's OFDI on Economic Structure and Development

China's OFDI has had multifaceted effects on the economic development of BRI countries. Empirical studies show that OFDI has promoted industrial structure upgrading, contributing to economic transformation and optimization (Tian Hui et al., 2021)[5]. It has also helped reduce corporate investment risks, particularly under uncertain global conditions (Fang Hui and Song Yujie, 2021)[6], and supported inclusive growth in host countries (Jia Xiaoyan and Li Gang, 2024)[14].

China's investment has enhanced the green innovation capacities of BRI countries by introducing advanced technologies and management practices (Len Xiaobo and Han Yun, 2022)[9]. However, its impact on carbon emissions is nuanced: while OFDI contributes to emissions, the financial development level of the host country introduces single and double threshold effects (Zhao Jun and Wang Xiaochen, 2021)[8]. Further studies also indicate that the effects of China's OFDI vary depending on the recipient country's level of economic development, industrialization, energy consumption, and urbanization, leading to potential "double-edged" outcomes (Wang M J et al., 2023)[20].

2.3 China's OFDI and the Advancement of Green Economy

Under the Green Belt and Road Initiative, China's OFDI has played a significant role in promoting green development in participating countries. The expansion of investment has generated substantial green technology spillovers and strengthened the role of BRI countries in global value chains (Ma Shuqin, 2021)[16]. Green development has been further promoted through enhanced energy utilization, green technology industries, and green trade (Huang et al., 2020)[17]. Nonetheless, barriers to green trade persist in terms of regional and industrial distribution (Li Fangfang, 2021)[18].

Green financial instruments such as green bonds have contributed positively to the green transformation of the BRI (Yang Yan, 2022)[19], while policy coordination mechanisms have fostered sustainability, technological spillovers, and improved livelihoods (Wei Dongming et al., 2024)[15]. Furthermore, the level of economic development significantly affects the green performance of China's OFDI (Du Li and Ma Yao Yao, 2022)[21]. The construction of regional green economic communities under the BRI

framework can enhance competitiveness and foster ecological cooperation (Chen Jian, 2021)[22].

Although substantial research exists on sector-specific green impacts such as technology spillovers (Lun and Han Yun, 2022; Qu et al., 2022)[9,24], few studies have directly assessed the overall contribution of China's OFDI to green economy development in BRI countries. Future research should explore these broader effects in varying national and regional contexts.

3. Theoretical Assumption

As a significant form of international capital flow, China's outward foreign direct investment (OFDI) plays a pivotal role in providing financial support and project financing for the development of the green economy in countries along the Belt and Road Initiative. This support is facilitated through various investment modalities, including the transfer of cash, physical goods, and intangible assets, thereby contributing to the economic growth and sustainability of these nations. In this process, technology spillovers and knowledge transfer mechanisms serve as the core drivers of green technology renewal and upgrading. According to the theory of technology diffusion, Chinese enterprises primarily export technology through three distinct pathways. First, they engage in collaborative research with domestic and host-country scientific research institutes and enterprises to jointly develop green technologies. Second, they implement localized adaptations of mature clean energy technologies, with an emphasis on energy-saving and emission-reduction processes. Third, they cultivate localized technical teams by establishing systematic skills training programs and knowledge transfer frameworks, ensuring the sustainable application of green technologies. Additionally, the co-construction of R&D centers, tailored to the practical needs of host countries, facilitates the establishment of joint innovation platforms that accelerate the research, application, and diffusion of green technologies, thereby promoting their integration into local industries[23].

The advanced management practices and high-level technologies brought by technology spillovers and knowledge transfer can further promote the development of a green economy through two primary channels: industrial linkage effects and resource allocation optimization. At the industrial linkage level, the clean production, energy-saving[27], and emission-reduction technologies exported by Chinese enterprises can directly reduce energy consumption and pollution in local industries. Moreover, these technologies can stimulate upstream and downstream enterprises to undertake green transformations through forward and backward linkages. This process facilitates the formation of green industrial clusters and enables a systematic transition from isolated technological upgrades to comprehensive green transformation across the industrial system. Regarding resource allocation, China's OFDI is distinguished by its strategic consideration of disparities in national resource endowments[28]. It promotes green economic development by aligning China's financial and technological advantages with the host country's natural resources and market potential, thereby operationalizing the theory of comparative advantage. This integrative approach improves resource utilization efficiency, alleviates environmental pressures, and lays a solid material foundation for the sustainable growth of a green economy.

The "duality" characteristic of China's OFDI (Kong Qunxi et al., 2019)[39] has been shown to inject institutional momentum into the development of the green economy. Reverse-gradient outward foreign direct investment in developed countries facilitates the acquisition of advanced green technologies and management practices through technology-seeking investments. In contrast, down-gradient OFDI targeting developing countries enables the optimal allocation of production factors and resources. This differentiated investment strategy reinforces the leading role of Chinese enterprises in global resource coordination. It is crucial to recognize the pivotal contribution of China's OFDI in promoting environmental protection standards on a global scale. These initiatives have exerted considerable regulatory pressure, prompting host-country enterprises to improve their technological capabilities and production processes in order to meet the requirements of integrating into the global industrial value chain[29]. As a result, more stringent environmental management systems have been established within host countries, highlighting the proactive role of OFDI projects in advancing environmental sustainability. This mechanism-facilitating the transmission of

technical standards into institutional restructuring-provides institutional guarantees for the growth of the green economy. Ultimately, the integration of industrial linkages, technological spillovers, and institutional innovations enables Chinese enterprises to elevate their strategic positioning and accelerate transformation and upgrading. This contributes to advancing the green economy under the framework of the Belt and Road Initiative, while simultaneously driving the coordinated development of related industrial chains and fostering a virtuous cycle of green economic progress[30].

H1: China's outward direct investment has a significant positive impact on the development of the green economy in Belt and Road countries.

The present study examines the implications of the dual context comprising the deepening implementation of the "Belt and Road" Initiative and the ongoing global green transformation for enhancing the overall quality of the labor force. This enhancement, in turn, exerts a substantial influence on industrial upgrading and the advancement of green economic development (Cai Wenbo et al., 2020)[38]. First, the level of the labor force reflects the overall quality and educational attainment of workers in a given region. In contexts where the labor supply is limited, the capacity for technological absorption and the efficiency of conceptual transformation are restricted, thereby hindering the effective integration with the green development paradigm facilitated by OFDI. Such constraints may diminish the direct impact of OFDI on green economic development in participating countries. In contrast, a highly skilled labor force is better positioned to rapidly assimilate advanced technologies and green development concepts introduced via OFDI. This facilitates capital flows toward green industries and enhances the efficient utilization of renewable resources. Second, the strong adaptive capacity of a high-quality labor force enables a more precise and flexible alignment between OFDI and locally advantageous or characteristic industries. This accelerates the integration of foreign investment with regional development priorities and improves the innovation capabilities and managerial efficiency of local enterprises. Consequently, this dynamic contributes to the high-quality development of green economies in countries along the Belt and Road.

H2: An improved labor force level significantly enhances the impact of OFDI on the development of green economies in Belt and Road countries.

4. Research Design

4.1 Data Sources and Sample Selection

This study uses data from 52 Belt and Road countries (2011–2021), excluding regions with significant missing data (Table 1). China's OFDI data are sourced from the Statistical Bulletin of China's Outward Foreign Direct Investment (2011–2021). Green economy development (GED) is calculated using 12 indicators across green energy, governance, and economy from databases like WDI, IEA, IRENA, UNSD, and WHO, applying the entropy weight-Topsis method. Control variables (Ind, Gov, City, Lab) and Institutional Quality are from WDI and WGI, with City logarithmically processed and missing data interpolated[32].

Table 1. Sample of Studies on Countries Along the Belt and Road Route

Region	Number of samples	Country
Asia	19	Philippines, Kazakhstan, Qatar, Malaysia, Mongolia, Bangladesh, United Arab Emirates, Myanmar, Saudi Arabia, Thailand, Oman, Turkmenistan, Brunei, Uzbekistan, Iran, Indonesia, Jordan, Viet Nam, Pakistan
Africa	11	Algeria, Equatorial Guinea, Ghana, Libya, Mozambique, South Africa, Nigeria, Tanzania, Tunisia, Angola, Sudan
Europe	14	Bulgaria, Poland, Russia, Czech Republic, Croatia, Luxembourg, Romania, Portugal, Serbia, Ukraine, Greece, Italy, Austria, Belarus
Americas and Oceania	8	Bolivia, Cuba, Argentina, Peru, Trinidad and Tobago, New Zealand, Chile, Papua New Guinea

The green economy prioritizes environmental protection and clean energy, unlike traditional models ignoring externalities (Xu et al., 2021)[37]. This study establishes a green economy development (GED) indicator system for Belt and Road countries (Table 2), covering

green energy (electricity, renewable resources, energy consumption), green governance (air transport, emissions, environmental management), and green economy (natural gas, oil, forest, and total resource rents).

Table 2. Indicator System for the Level of Green Economy Development

Primary Indicator	Secondary Indicator	Indicator Variable Explanation	Attribute
Green energy	Electricity supply	Access to electricity (per cent of population)	+
	Renewable internal freshwater resources per capita	Renewable internal freshwater resources per capita (cubic metres)	+
	Renewable energy consumption	Renewable energy as a percentage of total energy use	+
	Total primary energy consumption	Primary energy consumption as a percentage of total final consumption	-
Green governance	Air transported goods	Total goods transported by air	-
	Nitrous oxide emissions from agriculture	Nitrous oxide emissions from agricultural production	-
	Methane emissions from agriculture	Methane emissions from agriculture	-
	Carbon dioxide gas combustion emissions	Total carbon dioxide emissions	-
Green economy	Natural gas rents	Rental income received by the state from natural gas resources	-
	Oil rents	Rental income received by the state from oil resources	-
	Forest rents	Rental income to the state from forest resources	+
	Gross natural resource	Rents gross rental income received by the state from all natural resources	+

To account for varying indicator impacts on green economy development, this study employs the entropy weight-TOPSIS method to measure each country's development level, minimizing subjective bias. The entropy weight method determines indicator weights using information entropy, while TOPSIS ranks countries by their proximity to optimal and inferior solutions. Normalisation:

$$Y_{ij} = \frac{x_y - min(x_j)}{max(x_j) - min(x_j)} \quad (1)$$

$$Y_{ij} = \frac{max(x_j) - x_{ij}}{max(x_j) - min(x_j)} \quad (2)$$

where the value P_{ij} is calculated as follows:

$$P_{ij} = \frac{Y_{ij}}{\sum_{i=1}^{n} Y_{ij}} \quad (3)$$

Entropy weighting method to determine indicator weights:

$$E_j = -\frac{1}{\ln n} \sum_{i=1}^{n} P_{ij} \ln P_{ij} \quad (4)$$

Defined if P_{ij}=0:

$$P_{ij} \to \infty = lim P_{ij} \ln P_{ij} = 0 \quad (5)$$

Calculation of the weights of the indicators by means of the obtained information entropy values:

$$W_j = \frac{1 - E_j}{\sum_{j=1}^{m} (1 - E_j)} \quad (6)$$

Multiply the weights of the indicators with the standardised normative matrix to construct a weighted normative decision matrix and determine the positive ideal solution (R^+) and the negative ideal solution (R^-)

$$R^+ = \{max(R_{ij}) | j = 1, 2, ..., m\} \quad (7)$$

$$R^- = \{min(R_{ij}) | j = 1, 2, ..., m\} \quad (8)$$

TOPSIS ideal distance solution calculation: The Euclidean spatial distance to the positive ideal solution (D_i^+), the Euclidean spatial distance to the negative ideal solution (D_i^-), and the relative fit of the ratings of each evaluation object (C_i) are calculated by equations (9), (10), and (11).

$$D_i^+ = \sqrt{\sum_{j=1}^{m} (R_{ij} - R_j^+)^2} \quad (9)$$

$$D_i^- = \sqrt{\sum_{j=1}^{m} (R_{ij} - R_j^-)^2} \quad (10)$$

$$C_i = (D_i^-)/(D_i^+ + D_i^-)(i = 1, 2, ..., n) \quad (11)$$

Table 3 presents green economy development levels for 52 Belt and Road countries

(2011–2021) using the entropy weight-TOPSIS method. Qatar, Luxembourg, and the UAE show rising trends, while Algeria, Poland, and others exhibit fluctuating increases. Bolivia and Croatia decline. Russia ranks first, driven by natural resources and strong policy support, enhancing its green economy.

Table 3. Ranking of the Level of Green Economy Development of the 52 Countries Along the Route (in 2011, 2014, 2017 and 2021)

Country/year	2011		2014		2017		2021	
	level	rankings	level	rankings	level	rankings	level	rankings
Algeria	0.2946	26	0.2765	31	0.2593	34	0.3577	14
Bulgaria	0.2411	42	0.2483	39	0.2511	38	0.2388	46
Poland	0.2289	47	0.2286	44	0.2301	45	0.2751	37
Bolivia	0.3751	10	0.3620	12	0.3134	22	0.3226	23
Equatorial Guinea	0.3666	12	0.3403	17	0.3742	9	0.4483	5
Russian Federation	0.5445	1	0.5412	1	0.5929	1	0.6377	1
Philippine	0.2669	36	0.2637	35	0.2532	37	0.2523	43
Cuba	0.2478	40	0.2571	36	0.2554	36	0.2487	45
Kazakhstan	0.2675	35	0.2388	41	0.2338	41	0.3174	25
Ghana	0.3490	16	0.3510	15	0.3542	13	0.2866	33
Czech Republic	0.2267	48	0.2261	46	0.2278	47	0.2217	50
Argentina	0.2976	25	0.2997	23	0.2919	25	0.2728	39
Doha	0.3616	13	0.3739	10	0.4114	7	0.5679	2
Republic of Croatia	0.2722	33	0.2756	32	0.2752	30	0.2269	48
Libya	0.2473	41	0.2396	40	0.2000	50	0.3454	18
Luxemburg	0.2388	44	0.2538	37	0.2779	29	0.2979	30
Romania	0.2239	49	0.2233	48	0.2238	49	0.2966	31
Malaysia	0.3421	18	0.3553	14	0.3517	15	0.3646	10
Mongolia	0.2879	30	0.2385	42	0.2361	40	0.2502	44
Bangladesh	0.1961	52	0.1891	52	0.1962	52	0.2763	36
Peru	0.3678	11	0.3602	13	0.3526	14	0.2917	32
United Arab Emirates	0.4335	5	0.4910	3	0.4988	3	0.5327	4
Myanmar	0.3365	21	0.3318	18	0.3201	21	0.3621	12
Mozambique	0.3786	9	0.3819	8	0.4138	6	0.3597	13
South Africa	0.3092	22	0.3099	21	0.3126	23	0.3213	24
Nigeria	0.2841	31	0.2714	33	0.2721	31	0.2575	42
Portugal	0.3457	17	0.3472	16	0.3436	16	0.3090	27
Serbia	0.2839	32	0.2859	27	0.2858	27	0.2731	38
Saudi Arabia	0.4255	6	0.4203	6	0.3936	8	0.3706	9
Sudan	0.2898	29	0.2858	28	0.2610	33	0.3538	16
Thailand	0.3586	15	0.3680	11	0.3634	11	0.3630	11
Tanzania	0.4447	4	0.4268	5	0.4272	5	0.3350	20
Oman	0.3404	20	0.3152	19	0.2814	28	0.3576	15
Trinidad and Tobago	0.4549	3	0.4273	4	0.3307	19	0.3314	22
Tunisia	0.2634	37	0.2644	34	0.2667	32	0.2681	40
Turkmenistan	0.3615	14	0.2802	29	0.2429	39	0.2620	41
Brunei Darussalam	0.2910	27	0.2873	26	0.3040	24	0.3073	29
Ukraine	0.2353	45	0.2225	49	0.2311	43	0.2160	52
Uzbekistan	0.2525	38	0.2088	51	0.1987	51	0.2806	35
Greece	0.2211	50	0.2282	45	0.2288	46	0.2833	34
New Zealand	0.4124	7	0.4008	7	0.4536	4	0.3534	17
Iran	0.2685	34	0.2780	30	0.3213	20	0.3907	6
Angola	0.3415	19	0.2969	25	0.3728	10	0.3344	21
Italy	0.3038	24	0.3063	22	0.3355	17	0.3089	28

Indonesia	0.2907	28	0.3115	20	0.3310	18	0.3793	7
Jordan	0.2295	46	0.2255	47	0.2253	48	0.2201	51
Vietnam	0.3056	23	0.2981	24	0.2860	26	0.3390	19
Chile	0.3883	8	0.3792	9	0.3588	12	0.3736	8
Austrian	0.2505	39	0.2537	38	0.2557	35	0.3132	26
Papua New Guinea	0.4934	2	0.4955	2	0.5376	2	0.5516	3
Pakistan	0.2405	43	0.2384	43	0.2310	44	0.2247	49
Belarus	0.2125	51	0.2176	50	0.2333	42	0.2326	47

Figure 1 shows green economy development levels across Asia, Africa, Europe, Oceania, and the Americas. Oceania and the Americas lead but show a declining trend, possibly due to local green policies. Europe lags but, with rising economic levels, Asia, Africa, and Europe drive green technology and renewable resource updates, trending upward. By 2021, Asia surpasses Africa, with most continents nearing similar levels, except Europe.

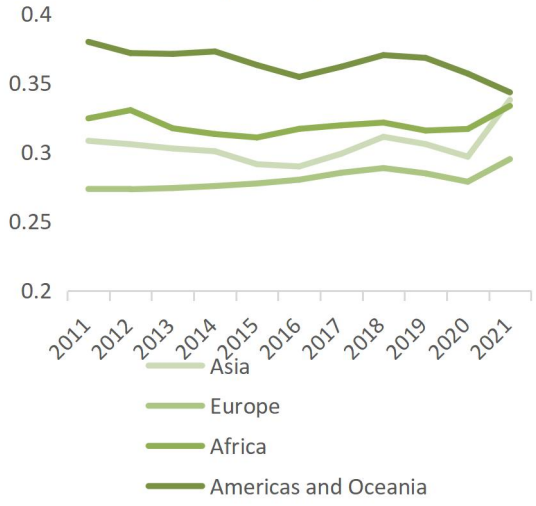

Figure 1. Trends in the Level of Green Economy Development by Continent

4.2 Core Explanatory Variables

China's outward foreign direct investment (OFDI). Considering that flow data represents the change of investment within a certain period of time, while stock data represents the cumulative total amount of investment at a certain point in time, which can better reflect the long-term trend and the overall scale, this paper selects the stock data of China's OFDI as an explanatory variable to study its impact on the level of green development of the countries along the "Belt and Road"[33].

4.3 Control Variable

Following existing research (Qi Junyan and Ren Yida, 2020; Lun Xiaobo and Liu Yan, 2022; Chen Bin et al., 2024)[25,26], this study controls for industrial development (Ind), urbanization (City), government behavior (Gov), and institutional quality (WGI) alongside OFDI to assess green economy development. Ind reflects industrial value added to GDP, City indicates urban population share, Gov measures government expenditure as a GDP share, and WGI averages six governance indicators, which includes political stability and absence of terrorism, government efficiency, control of corruption, regulatory quality, rule of law, and discourse and accountability, per Zang, Xin, and Yao, Xiaowen (2018), capturing government efforts in fostering green development.

4.4 Threshold Variables

Labour force level (Lab). The labour force level (Lab), expressed as the total labour force participation rate as a percentage of the total population aged 15-64 years, is a measure of the abundance of human resources in the host country, as estimated by the simulation of the International Labour Organization (ILO), and can lead to an increase in the level of development of the green economy by contributing to the growth of green total factor productivity (Hipoten Purple et al., 2019).

4.5 Benchmark Regression

In order to test the impact of China's outward FDI on the level of green economy development in each country, the benchmark regression model is constructed as follows:

$$GED_{it} = a_0 + a_1 OFDI_{it} + a_2 Controls_{it} + \gamma_t + \varepsilon_{it} \quad (12)$$

Where GED_{it} denotes the level of green economy development in the i country t year, and $OFDI_{it}$ denotes the stock of Chinese direct investment in the i country t year. The right i and t subscripts, country and year respectively, $Controls$ indicate a range of control variables that may affect the level of green economy development, including level of industrial development (Ind), level of urbanisation $(City)$,

government behaviour (Gov), and institutional quality (WGI). a_0 is a constant term, a_1 is the regression coefficient for the core control variable, a_2 is the regression coefficient obtained for a series of control variables, γ_t indicates year fixed effects, and ε_{it} indicates a random error term.

4.6 Threshold Test

Since different labour levels in the host country affect the home country's investment in the locality, and also when the labour level exceeds a specific value, it may make OFDI the impact on the level of green economic development even greater, a non-linear threshold regression equation is established as follows:

$$GED_{it} = \beta_0 + \beta_1 OFDI_{it} I(Lab_{it} > \gamma) + \beta_2 Controls_{it} + \epsilon_{it} \quad (13)$$

Where Lab_{it} denotes the i country's labour force level, β_0 is a constant term, β_1 is the threshold effect coefficient, γ is the threshold value, $I(\cdot)$ is the indicative function, is 1 if the condition is met in parentheses and 0 otherwise, and ϵ_{it} denotes the random error term.

5. Empirical Analysis

5.1 Descriptive Statistics

The results of descriptive statistics for the main variables are shown in Table 4. The results show that the mean value of the green economy development level is 0.3106, the median is 0.2921, the maximum value is 0.6377, and the minimum value is 0.1836, in which the mean and median are close to each other, and the standard deviation is small, which indicates that the distribution of the green economy development level of each country is close to the mean and more concentrated. The mean value of outward direct investment is 206998, the maximum value is 2008048, and the minimum value is 90, which shows that the value of direct outward investment from China varies greatly among different countries.

Table 4. Selection and Description of Indicators

Variable name	Variable code	Sample size	Mean	Median	Maximum	Minimum	Standard deviation
Green economy development level	GED	572	0.3106	0.2921	0.6377	0.1836	0.0816
Outward Foreign Direct Investment	OFDI	572	206998	75632.5	2008048	90	314280.3
Level of industrial development	Ind	572	0.3249	0.3029	0.7996	0.0737	0.1310
Level of urbanisation	City	572	63.7364	68.0515	99.2780	12.9780	18.7679
Institutional quality	WGI	572	-0.1809	-0.2332	1.8524	-1.9096	0.7995
Labour force level	Lab	572	66.3011	67.2630	88.8600	38.0580	10.9767
Government behaviour	Gov	572	32.2407	31.7710	97.3200	9.6220	13.7521

5.2 Benchmark Regression

Table 5 presents regression results using a progressive strategy. Column (1) shows OFDI's positive effect (0.057) on green economy development (1% significance) without controls. Columns (2)–(5) confirm robustness after adding controls (1% significance). VIF (1.32) indicates no multicollinearity. Industrial development positively impacts green economy (1% significance), reflecting reduced emissions and green energy growth. Urbanization negatively affects it (5% significance) due to congestion in some countries. Government behavior negatively impacts (1% significance), prioritizing traditional industries.

Table 5. Benchmark Regression Results

Variable name	(1) GED	(2) GED	(3) GED	(4) GED	(5) GED
OFDI	0.0570***	0.0505***	0.0574***	0.0593***	0.0602***
	(0.0163)	(0.0159)	(0.0161)	(0.0160)	(0.0164)
Ind		0.129***	0.133***	0.137***	0.138***
		(0.0237)	(0.0237)	(0.0235)	(0.0239)
City			-0.135**	-0.139**	-0.141**
			(0.0558)	(0.0555)	(0.0557)
Gov				-0.000715***	-0.000718***

				(0.000250)	(0.000250)
WGI					-0.00311
					(0.0109)
Constant	0.311***	0.265***	0.811***	0.852***	0.856***
	(0.00350)	(0.00906)	(0.227)	(0.225)	(0.226)
Fixed effect	YES	YES	YES	YES	YES
Observations	572	572	572	572	572
R-squared	0.090	0.140	0.150	0.164	0.164

Note: *, ** and *** represent significant at the 10 per cent, 5 per cent and 1 per cent levels, with standard errors in parentheses.

5.3 Robustness Test and Endogeneity Test

To ensure the reliability of the regression results, this paper tests the following aspects:

5.3.1 Substitution of explanatory variables

OFDI may have a time-delayed effect on the green economy, and the lagged one-period of OFDI is used as a proxy variable in the benchmark regression, a step designed to rule out potential endogeneity issues while capturing the possible lagged effect of OFDI on the green and low-carbon transition in agriculture. As the results are shown in Table 6, using the lagged period of OFDI as the core explanatory variable is still positively significant at the 5 percent significance level, and the conclusions remain robust.

5.3.2 Replacement of research methodology

To ensure regression stability, this study validates the fixed effects model with OLS, GLS, and ML random effects models (Table 7). OLS shows OFDI's coefficient at 0.318 (1% significance). GLS and ML models yield a coefficient of 0.0699 ($p<0.01$, 1% significance). Control variables' coefficients vary, except for industrial development. Consistent OFDI coefficients across methods confirm its positive effect on green economy development, indicating robust results.

Table 6. Results of Replacing Explanatory Variables

Variable name	(1) GED
lag_OFDI	0.0450***
	(0.0189)
Ind	0.155***
	(0.0260)
City	-0.143***
	(0.0647)
Gov	-0.000727***
	(0.000261)
WGI	0.00111
	(0.0122)
Constant	0.862***
	(0.263)
Fixed effect	YES
Observations	520
Number of id	52
R-squared	0.169

Note: *, ** and *** represent significant at the 10 per cent, 5 per cent and 1 per cent levels, with standard errors in parentheses.

Table 7. Results of the Replacement of the Research Methodology

Variable name	(1) OLS	(2) GLS	(3) ML
	GED	GED	GED
OFDI	0.138***	0.0699***	0.0699***
	(0.0203)	(0.0143)	(0.0143)
Ind	0.229***	0.146***	0.146***
	(0.0252)	(0.0213)	(0.0212)
City	-0.0547***	-0.0287	-0.0287
	(0.0100)	(0.0234)	(0.0231)
Gov	-0.000196	-0.000765***	-0.000764***
	(0.000271)	(0.000233)	(0.000232)
WGI	0.0233***	0.00506	0.00524
	(0.00437)	(0.00841)	(0.00844)
Constant	0.457***	0.399***	0.399***
	(0.0374)	(0.0967)	(0.0955)
Observations	572	572	572
R-squared	0.218		

Note: *, ** and *** represent significant at the 10 per cent, 5 per cent and 1 per cent levels, with standard errors in parentheses.

5.3.3 Endogenous treatment

Table 8. Results of Endogenous Treatment

Variable name	(1) IV	(2) OLS
	GED	GED
OFDI	0.145***	
	(0.0371)	
Ind	0.235***	0.237***
	(0.0254)	(0.0255)
City	-0.0536***	-0.0538***
	(0.0143)	(0.0143)
Gov	-0.000148	-0.000185
	(0.000236)	(0.000230)

WGI	0.0232***	0.0238***
	(0.00525)	(0.00521)
lag_OFDI		0.153***
		(0.0388)
Constant	0.447***	0.450***
	(0.0561)	(0.0560)
Observations	520	520
R-squared	0.221	0.222

Note: *, ** and *** represent significant at the 10 per cent, 5 per cent and 1 per cent levels, with standard errors in parentheses.

To address potential endogeneity in OFDI's impact on green economy, we use one-period lagged OFDI as an instrumental variable and apply 2SLS with robust standard errors, following Zhao Xianghao et al. (2024). The robust score test (p=0.5045) and regression test (p=0.5349) indicate no endogeneity at 1% significance. Table 8 shows OFDI's significant effect on green economy (1% significance), confirming reliable results.

5.4 Heterogeneity Analysis

5.4.1 Heterogeneity in levels of economic development

The 52 Belt and Road countries are classified by World Bank income levels: high-income (GDP per capita >$14,005), upper-middle-income ($4,516–$14,005), and lower-middle/low-income (<$4,515). Table 9 shows heterogeneity results. OFDI significantly promotes green economy development in lower-middle/low-income countries (coefficient 0.125, 5% significance), bringing technology and capital, but not in high/upper-middle-income countries. Industrial development positively impacts high/upper-middle-income countries, enhancing employment and efficiency. Urbanization positively affects green economy in high/middle-income countries (coefficient 0.273).

Table 9. Results of Heterogeneity in Levels of Economic Development

Variable name	(1) GED	(2) GED	(3) GED	(4) GED
OFDI	0.0580***	0.0471	0.0234	0.125**
	(-0.0165)	(-0.037)	(-0.0193)	(-0.0562)
Ind	0.133***	0.123**	0.188***	0.0404
	(-0.024)	(-0.0597)	(-0.0279)	(-0.0688)
City	-0.135**	-0.0715	0.273**	-0.224**
	(-0.056)	(-0.185)	(-0.125)	(-0.0967)
Gov	0.00188***	0.00236*	0.000103	0.00183
	(-0.000603)	(-0.00122)	(-0.000839)	(-0.00137)
WGI	-0.00168	-0.00401	0.01	-0.0218
	(-0.011)	(-0.0283)	(-0.0151)	(-0.0208)
Constant	0.196	-0.188	-0.943**	0.461
	(-0.212)	(-0.692)	(-0.431)	(-0.384)
Fixed effect	YES	YES	YES	YES
Observations	572	187	209	176
R-squared	0.15	0.108	0.378	0.097

Note: *, ** and *** represent significant at the 10 per cent, 5 per cent and 1 per cent levels, with standard errors in parentheses.

5.4.2 Regional heterogeneity

Table 10 shows regional heterogeneity results for OFDI's impact on green economy development across 52 Belt and Road countries, categorized by geography: Asia (2), Africa (3), Europe (4), and Oceania/Americas (5). OFDI significantly promotes green economy in Asia (0.0622, 1%), Europe (0.0487, 5%), and Oceania/Americas (0.198, 10%), driven by rich ecological resources, green finance, and cooperative policies. Africa shows no significant OFDI impact, with urbanization negatively affecting green development due to non-green infrastructure focus and limited green industry support (Liu Bingyu, 2020)[31].

Table 10. Regional Heterogeneity Results

Variable name	(1) GED	(2) GED	(3) GED	(4) GED	(5) GED
OFDI	0.0580***	0.0622***	-0.079	0.0487**	0.198*
	(-0.0165)	(-0.0232)	(-0.127)	(-0.0194)	(-0.112)

Ind	0.133***	0.108**	0.179***	0.159	0.659***
	(-0.024)	(-0.0453)	(-0.0367)	(-0.099)	(-0.0865)
City	-0.135**	-0.117	-0.727***	-0.329**	0.131
	(-0.056)	(-0.0894)	(-0.144)	(-0.162)	(-0.355)
Gov	0.00188***	0.00403***	0.0102***	0.00312***	-0.00256*
	(-0.000603)	(-0.00114)	(-0.00188)	(-0.000862)	(-0.00141)
WGI	-0.00168	-0.0692***	0.0698***	0.00752	0.0345
	(-0.011)	(-0.0207)	(-0.0244)	(-0.0161)	(-0.0268)
Constant	0.196	-0.817**	-0.109	0.666	0.312
	(-0.212)	(-0.396)	(-0.409)	(-0.529)	(-1.277)
Fixed effect	YES	YES	YES	YES	YES
Observations	572	209	121	154	88
R-squared	0.15	0.285	0.382	0.285	0.647

Note: *, ** and *** represent significant at the 10 per cent, 5 per cent and 1 per cent levels, with standard errors in parentheses.

5.5Threshold Effects

5.5.1 Threshold estimates

This study uses labor force level as the threshold variable to assess its impact on OFDI's effect on green economy development. Table 11 shows a single threshold of 35.32 (10% significance), while double (49.317) and triple (85.157) thresholds are insignificant, indicating a significant single threshold effect of labor force level on OFDI's influence on green economy development.

Table 11. Results of Threshold Estimation

Threshold types	Threshold value	F-values	P-values	Threshold value		
				10%	5%	1%
Single	45.282	35.32	0.0633	29.9767	42.9224	59.9008
Double	49.317	18.4	0.1467	21.1992	33.2954	49.1098
Triple	85.157	11.67	0.3333	21.3148	29.6345	55.7101

Note: *, ** and *** represent significant at the 10 per cent, 5 per cent and 1 per cent levels, with standard errors in parentheses.

5.5.2Threshold model estimation

Table 12 shows threshold regression results using labor force level as the variable. Below 45.282, OFDI's impact on green economy development is 0.0652 (1% significance); above 45.282, it is 1.5 (1% significance), indicating a stronger effect at higher labor levels. Following Wang Xianghui (2023), lagged OFDI confirms a single threshold (49.66, p=0.08, 10% significance), with coefficients of 0.0521 and 1.666 (1% significance), reinforcing robustness. Higher labor force levels enhance OFDI's green economy impact by efficiently channeling technology to green industries.

Table 12. Threshold Regression Results

Variable name	(1) GED	(2) GED
0b._cat#c.OFDI	0.0652***	
	(0.0169)	
1._cat#c.OFDI	1.500***	
	(0.285)	
0b._cat#c.OFDI_lag		0.0521**
		(0.0202)
1._cat#c.OFDI_lag		1.666***
		(0.254)
Constant	0.258	0.0577
	(0.351)	(0.394)
Control variables	YES	YES
Observations	572	520
R-squared	0.172	0.182

Note: *, ** and *** represent significant at the 10 per cent, 5 per cent and 1 per cent levels, with standard errors in parentheses.

6. Conclusions

Using 2011–2021 data from 52 Belt and Road countries, this study applies entropy weight-TOPSIS to measure green economy development and examines OFDI's impact. Findings show: (1) Asia, Africa, and Europe's green economy levels rise, while Oceania and the Americas decline; (2) OFDI significantly promotes green economy development, robust after tests; (3) OFDI's effect is strongest in Oceania/Americas, then Asia; (4) OFDI significantly impacts low/middle-income countries; (5) labor force level enhances OFDI's

effect, with a single threshold amplifying impact above 35.32.

Based on empirical findings, we propose: (1) Enhance risk prevention and policy coordination to ensure green-compliant investments, reducing uncertainties. (2) Develop region-specific strategies leveraging local advantages to promote inclusive green growth. (3) Increase education and green industry investments to boost human capital and green technology innovation. (4) Strengthen OFDI policies to encourage green energy and technology investments while facilitating trade for mutual benefits along the Belt and Road.

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