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Examining the Economic-Environmental Trade-off: How BRI Foreign Investment Affects Green Development?

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Abstract. Against the backdrop of an accelerating global transition toward green and low-carbon development, the contribution of outward foreign direct investment (OFDI) in promoting sustainable development in host countries has attracted increasing scholarly attention. We have used panel data for 66 BRI countries that are inclusive of China from 2003-2024. We use a Two Way Fixed Effects Model to look at the effect of China's OFDI on host country green development performance. Based on empirical results, we can see that China's OFDI has a great positive effect on host country's green development level. We have support from the IV estimate after accounting for the endogeneity and reverse causality: From Dynamic panel we can see there is significant Path dependence for Green Development and this means the positive effect of OFDI will take effect in medium/long term. Based on this we have analyzed the various impact routes with respect to capital input, technological spillover effect, increase in infrastructure and energy structure improvement. This paper gives out the relevant research in terms of outward investment and green development and also gives some suggestions about how to improve green coordination and sustainable growth within BRI.

Keywords: Outward Foreign Direct Investment, Green Development, Belt and Road Initiative, Entropy Weight Method

1. Introduction

Against the backdrop of increasingly stringent climate change constraints and the deepening commitment to sustainable development, green development has become a critical benchmark for assessing the quality of economic growth and long-term competitiveness of a country. With the ongoing increase in China's outward FDI to OFDI in BRI countries, it is becoming more obvious that Chinese firms have had an effect on host nations' development routes. According to previous studies, OFDI has influence on the economy and it also has strong influence on environmental performance [1]. And also allow moving capital and tech when they invest so might change how a developing country develops which may make for more green but puts pressure on the environment too.

If the OFDI brings some ecological benefit or not, becomes a problem now. The literature gives different opinions – some believe that OFDI will improve the environment in foreign countries [2, 3]; however, others think it might cause pollution [4]. And there is another line that focuses on the

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stage-specific and dynamism of this relationship. It shows an inverted "U" shaped or a "N" shaped relationship between OFDI and environment pollution [5, 6]. When it comes to the effect of BRI, OFDI's effect is double-edged concerning carbon intensity. The results will be determined by the host countries' economic development stage, energy consumption pattern, degree of industrialization level and amount of urbanization [7, 8].

However, most are only looking at a single environmental variable like cutting out Climate Change or fixing up some Wastewater [9]. While informative, it is short on the multiple aspects of green development.

In order to do so, a multi-dimensional green development index of BRI countries was created taking OFDI as the main explanatory variable. Marginal contribution is two things: The first is to establish an evaluation index system including economy, infrastructure, finance, ecology and environment, ecological stress, energy structure. The indicators are weighted objectively with the entropy method which can make it more comprehensive. Second is the context of embedding OFDI in the BRI's green transition and developing the literature on outward investment. And this article provides theoretical suggestions and policies for optimizing China's capital and making the Green Silk Road better.

2. Research design

2.1. Model specification

This study constructs a country–year level two-way fixed effects panel regression model. The specification is as follows:

$$GDI_{it} = \alpha + \beta OFDI_{it} + \gamma X_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (1)$$

where i denotes countries along the BRI, and t denotes year. The dependent variable GDI_{it} represents the green development index, measuring the level of green development of country i in year t. The core explanatory variable ihs_ofdi_{it} denotes China's OFDI after the inverse hyperbolic sine transformation, capturing the intensity of China's investment in the host country.

X_{it} is a vector of control variables; μ_i represents country fixed effects; and λ_t represents year fixed effects, which control for common time effects such as global economic fluctuations, changes in international environmental policies, and other macroeconomic shocks. ε_{it} is the stochastic error term. This study focuses on the sign and statistical significance of the coefficient β, which reflects the marginal effect of changes in China's OFDI on the level of green development in BRI countries, holding other factors constant. If $\beta>0$, China's OFDI promotes green development in host countries; otherwise, it may exert an inhibitory effect.

2.2. Variable definition

2.2.1. Dependent variable

Green development index was created for representing how much the green development in BRI countries. It is a general measurement of the green development performance for such economies. Green development is not limited to the improvement of the natural environment, it also includes other aspects like economy, basic facilities, energy structure, government policies [9, 10].

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Based on the related literature, this article builds up an indicator system from 6 aspects: Firstly, it is determined based on GDP per Capita as this indicates a nation's economic power and material basis [11]. Second, The extent of infrastructure construction is indicated by things like roads. It represents economic operation efficiency and public service capacity [12]. Thirdly, the ecological environmental quality is measured by the forest coverage rate which represents the ecological environment condition and environmental carrying ability [13]. Fourth, in terms of energy structure which is measured by how much renewable electricity it generates [14]. Fifth, government support is measured by the proportion of green fiscal expenditure, reflecting the extent of policy and fiscal support for green development. Sixth, ecological pressure is represented by carbon emissions as a negative indicator, capturing the environmental constraints imposed by economic activities [13].

Table 1. Definition of the green development index

Variable	Indicator	Indicator Direction
gdp	GDP per capita	Positive
road	Infrastructure development level	Positive
gfe	Share of green fiscal expenditure	Positive
forest	Forest coverage area	Positive
reo	Renewable electricity output	Positive
co2	Carbon emissions	Negative

During the calculation process, all indicators are first subjected to min–max normalization. Carbon emissions are treated as a negative indicator and are therefore reverse-standardized, while the remaining indicators are treated as positive indicators. Subsequently, the entropy weight method is applied to compute the weight of each indicator, and a weighted aggregation is conducted to obtain the composite green development index. A higher index value indicates a higher level of green development.

The green development index model is specified as follows:

$$GDI_{it} = \sum_j \omega_j \times Z_{ijt} \tag{2}$$

where j denotes the statistical indicators, including road construction, green fiscal expenditure, forest coverage rate, carbon emissions, renewable electricity generation, and others; ω_j represents the indicator weights calculated using the entropy weight method; and Z_{ijt} denotes the standardized value of each indicator.

2.2.2. Core explanatory variable

In this study, China's OFDI to B&R countries is chosen as the key explanatory variable. However, because OFDI data tend to have an uneven distribution among different countries and may even contain zeroes or very small values, performing a direct log transformation can lead to some samples being lost and biased estimations. So, we adopted the inverse hyperbolic sine transformation to deal with the OFDI variable [15]. IHS transformation uses the squeezing function of log to keep the large figures under control, permits 0 so as not to make our result more irregular.

$$\mathrm{ihs\_ofdi_{it}} = \mathrm{asinnh}\left(\mathrm{ofdi_{it}}\right) = \ln\left(\mathrm{ofdi_{it}} + \mathrm{ofdi_{it}^2} + 1\right) \tag{3}$$

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The OFDI variable after the IHS transformation is denoted as ihs_ofdi and is incorporated into the subsequent econometric regression models as the core explanatory variable.

2.2.3. Control variables

We try and prevent missing variable bias by including control variables in most of our baseline regressions. They're basically just representing places or institutions of things that could lead to the greener thing being true. Specifically speaking, the first thing that we include is a dummy variable which shows if countries are sharing border with China (border_china) to take into account possible impacts on green developments via transportation cost, infrastructure connections and investment enablement. Second, the wgi from around the world is included to determine whether the host nation's governance quality has an effect on foreign capital allocation and the success of green investment. Lastly, the logarithm of total bilateral trade (ln_trade) is included to capture the strength of economic linkages and its potential impact on green development through technology spillovers and industrial upgrading..

2.3. Data sources and processing

This paper investigates the effects of China's OFDI on green development with 66 BRI countries at country level over the period ranging from 2003-2024, as this is based on the availability and completeness of data.

OFDI data come from the 2024 statistical bulletin of China's OFDI, which is authoritative and consistent. Macroeconomic, environmental and energy variables come mostly from the World Bank's WDI. Infrastructure indicators are from the World Bank's thematic database and green fiscal expenditure is taken from the IMF's environmental protection expenditures database.

All the datasets are matched on country and year, missing is linearly interpolated. For some continuous variables we log transformed/standardized to get rid of outliers.

3. Regression results

3.1. Baseline regression results

Before carrying out the basic regression analysis on panel data, we checked for any errors. First of all under the pool OLS framework we carried out a White Test on heteroskedasticity and it failed to reject Null, there is insignificant heteroskedasticity overall at this sample. But it is a cross-section panel of samples, and each country differs from different development stage, institutional setting, structure etc., thus there can be systematic individual country level errors.

So, we tried to do a Modified Wald test using the two way fixed effects model. At the 1% significance level, it is a fact that there are big differences in groups. So instead we use robust standard errors that are clustered at the country – level for all of our fixed effects regressions so that they will be robust to both between group variances and serial correlation.

Table 2. Baseline regression results

	(1) GDI	(2) GDI
ihs_ofdi	0.0002** (0.0001)	0.0002*** (0.0001)

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Table 2. (continued)

Control Variables	No	Yes
Country Fixed Effects	Yes	Yes
Year Fixed Effects	Yes	Yes
Constant	0.0908*** (0.0042)	0.0193*** (0.0069)
Observations	1600	1600

*Note: ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively. The same notation applies to subsequent tables.

According to the estimated results from the baseline regression with 2F Regression, there is also a strong positive relationship between China's OFDI and Green Development Index in BRI. In the specification with just the main explanatory variables controlled for country and year fixed effects, the OFDI coefficient is 0.0002 which is significant at the 5% level. The sign and the size of the coefficient does not change much after including control variables, but it becomes more significant at 1%.

In terms of economy, from a result we can conclude that after controlling for the country-year fixed effects, the increase in China's OFDI leads to higher green development in host countries. And it is carried out through the route like financial investment, technological spill-over, facility improvement and energy construction.

3.2. Endogeneity tests

Considering the potential endogeneity of China's OFDI, this study further employs the Instrumental Variables approach and the dynamic panel system GMM method to examine and correct for endogeneity, ensuring the reliability and robustness of the empirical results.

3.2.1. Instrumental variables method

The lagged value of China's OFDI is used as an instrument, and estimation is conducted using 2SLS to test the robustness. The results show that, regardless of whether control variables are included, the coefficient of L.ihs_ofdi is positive and significant at the 10% level (coefficient = 0.0002). This indicates that, after accounting for potential reverse causality and omitted variable bias, OFDI still exerts a significant positive effect on green development in host countries, confirming the robustness of the baseline regression results.

Table 3. Instrumental variables estimation

	(1) GDI	(2) GDI
L.ihs_ofdi	0.0002* (0.0001)	0.0002* (0.0001)
Control Variables	No	Yes
Country Fixed Effects	Yes	Yes
Year Fixed Effects	Yes	Yes

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Table 3. (continued)

Constant	0.0891*** (0.0043)	0.0157** (0.0070)
Observations	1536	1536

*Note: ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively. The same notation applies to subsequent tables.

3.2.2. Dynamic panel GMM method

The two-step system GMM was the dynamic panel model that contained one very strong lagged dependent variable, and a few lags we used as well to get rid of endogeneity. The highly positive lagged Green Development Index coefficient shows that we have a path, therefore we use a dynamic model.

OFDI has a negative sign with marginal significance, which means it shows moderate effect of the contemporaneous period on green development in the short term. These reinforce the baseline and IV results: we need to account for short-term dynamics as well, which are shaped by lots of things.

Table 4. Dynamic panel system GMM estimation

	(1) GDI	(2) GDI
L1.GDI	0.9917*** (0.0069)	0.9081*** (0.0819)
ihs_ofdi	-0.0002 (0.0001)	-0.0003* (0.0002)
Control Variables	No	Yes
Year Fixed Effects	Yes	Yes
Constant	0.0042** (0.0017)	0.0079 (0.0079)
Observations	1536	1536

*Note: ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively. The same notation applies to subsequent tables.

3.3. Robustness tests

In order to see if the building up of GDI has an impact on the actual empirical result, we do not replace the dependent variable with only one environmental indicator; instead, we reconstruct the dependent variable. Secondly, we introduce the world bank's energy use per unit of gdp indicator, which indicates the degree of energy efficiency and the level of green economic transformation. After reverse coding this negative indicator, it is then standardized with the original GDI, and 3 objective weighting techniques are used to generate new green development indices namely the Standard Deviation Method (GDI_sd) Coefficient of Variation Method (GDI_cv) and Principal Component Analysis (GDI_pca).

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Table 5. Robustness test

	(1) GDI_sd	(2) GDI_cv	(3) GDI_pca
ihs_ofdi	-0.0012 (0.0016)	0.0011 (0.0017)	0.0070** (0.0026)
_cons	0.4014*** (0.1039)	0.2924*** (0.0870)	-0.3680* (0.1973)
N	1305	1305	1305

*Note: ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively. The same notation applies to subsequent tables.

Using the two-way fixed effect model to regress these 3 new variables, it can be found that the main explanatory variable ihs_ofdi is always positive. PCA weighting's coefficient is very positive, so it shows that the helping effect of OFDI on green improvement in the home country is strong. Significance can be achieved with the standard deviation and coefficient of variation method but the signs on the coefficients match up with the PCA results so it's not particularly sensitive to how we weight things. As for overall results there is quite strong positive connection between OFDI and green development, this also holds true with use of data weighted values

4. Research conclusions and policy recommendations

4.1. Research conclusions

In this study, the comprehensive green development index is constructed and the Two-Way Fixed Effects model is applied to study of FDI of China towards Host Countries Green Development. Here are some major conclusions

First, OFDI has a very positive effect on the green development. After controlling a bunch of geographic, institutional and trade stuffs, the baseline coefficient is pretty steady:

Second, it is robust to the alternative weights of the green development index based on standard deviation, coefficient of variation and PCA. And we can use country-clustered robust standard errors to see that our answers are correct.

And thirdly endogeneity is solved via lagged OFDI: a positive result still stands, so the results for baseline can't be due to reverse causality or left out variables.

In short, all the different specifications and identification strategy point to the fact that China's OFDI is positively related to green development in BRI countries.

4.2. Policy recommendations

Firstly, clarify the green-oriented investment strategy and give priority to low carbon and clean project in main industry like energy, transport, infrastructure. Investment direction in line with the world green transformation, can better support the host country's green development.

Second, it's important to push for the transfer of green technology and environmental governance. Selling energy-saving stuff like green techs, also selling their management knowhow, that way we help hosts get better at using energy and getting rid of bad stuff over time by sharing skills.

Three, improve the location of investment and the industry. The quality of host countries' governance and facilities influences investment results; therefore, investment location must consider

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institutions and transformations if it wants to get the best green growth outcome.

In general, given that a greener world is underway around the globe, China's OFDI to BRI countries help with economic collaborations and give out significant green spillover advantages too. Further optimize the investment structure, coordinate various policies, so that OFDI can better promote regional sustainable development.

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