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Greening the Belt and Road with Four Underlying Mechanisms

BY XIAOLIN WANG, RAN JIN AND YAN WANG[1]

ABSTRACT

As the deadline for achieving the Sustainable Development Goals (SDGs) draws closer, international communities are searching for strategies and approaches that have worked. This study uses China's multifaceted approach to supporting green transformation in countries along the Belt and Road as an example and investigates its impact and underlying mechanisms. China's approach encompasses openness to trade, official development finance, outward foreign direct investment (FDI), technological transfers in renewable energy, digital economy and support for industrial upgrading. The study employs a difference-in-differences (DiD) model utilizing panel data from 139 countries spanning the period from 2013 to 2022. The findings indicate that Green Belt and Road Initiative efforts have significantly reduced the carbon emissions intensity per unit of GDP in countries along the Belt and Road. However, further analysis suggests that the intensity of China's outward

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foreign direct investment (OFDI) may partially offset the carbon reduction effects of the initiative. Moreover, the efficacy of carbon reduction varies depending on the economic development stage and the institutional capacity of partner countries, particularly their government efficiency and the rule of law. Multidimensional mechanisms such as the dissemination of low-carbon energy technologies, digital innovation, trade in digital services and industrial upgrading play crucial roles in facilitating the green transformation process in countries along the Belt and Road.

Keywords: Belt and Road Initiative; green transformation; China; carbon emissions

INTRODUCTION

At the time of writing, the global economy is confronted with strong headwinds, with turbulence in international trade, reductions in development aid and investment and a potential failure to reach the Sustainable Development Goals (SDGs). With five years to go before the SDG deadline, official statements have stressed that only 18 percent of the targets are on track, and many are going in reverse (UN 2025). The international development community and policymakers around the world are struggling to find approaches that help to combat climate change and other challenges.

China's green transformation is not simply about increasing environmental protection investment but systematically changing the factor endowment structure, investment structure and employment structure of the national economy (Tong et al. 2020). This paper takes the multifaceted approach that China and its partners have used to green the Belt and Road (B&R) as a case study and investigates its underlying mechanisms.

China's approach encompasses openness to trade, official development finance, outward foreign direct investment (OFDI) and technological dissemination in relation to renewable energy, digital economy and industrial upgrading. Previous studies have found significant achievements in poverty reduction, trade expansion, employment creation and infrastructure development, reinforcing the role of the B&R in fostering economic and social progress in countries along the B&R (Xie et al. 2023; Yang et al. 2024). However, given that most countries along the B&R[2] are middle-income and low-income economies, substantial investment in infrastructure—such as transportation, communication equipment and energy supply—is required to build a foundation for economic development. Consequently, infrastructure connectivity has been prioritized during the early stages of the Belt and Road Initiative (BRI). In the past, infrastructure construction was often associated with significant carbon emissions and environmental pollution. Scholars and civil society organizations have expressed concerns about its potential adverse environmental impacts, arguing that the BRI may lead to increased greenhouse gas emissions due to the expansion of transportation infrastructure and China's financing of coal-fired power plants (Zhang et al. 2017). Some scholars argue that the BRI could potentially contribute to habitat degradation, thereby resulting in biodiversity loss (Ascensão et al. 2018).

Despite the issuing of government guidelines on green and responsible investment in 2013 (MOFCOM and MEP 2013), prior to 2017, China had not yet introduced targeted policies for a green BRI, nor were there detailed regulatory frameworks in place to enforce them (Coenen et al. 2021). While enterprises were encouraged to comply with the laws and regulations of host countries, such compliance was largely voluntary in nature.

In pursuing the SDGs outlined in the 2030 Agenda (UN 2015), the government has increasingly integrated green development principles into the framework of the BRI (Xi 2017). In 2017, the Ministry of Environmental Protection (MEP, renamed the Ministry of Ecology and Environment in March 2018), the Ministry of Foreign Affairs (MOFA), the National Development and Reform Commission (NDRC) and the Ministry of Commerce (MOFCOM) of China jointly issued two key policies aimed at "greening the BRI." These policies advanced stronger environmental protection principles for the BRI, emphasizing support for low-carbon development, biodiversity conservation, climate change mitigation and the integration of the Green Belt and Road Initiative (GBRI) with the SDGs.

Existing studies on the carbon footprint of the BRI predominantly rely on data from before 2017. This paper explores whether the GBRI launched in 2017 can facilitate the green transformation of

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[2] Defined as those countries located along the Silk Road Economic Belt and the 21st-Century Maritime Silk Road.

countries along the B&R and examines the efficacy of this multifaceted approach. It contributes to the literature in two respects. First, it analyzes the influence of China's policy objectives and major cooperation content for promoting the GBRI since 2017. Second, it empirically evaluates the efficacy of the policy directives of 2017 on the carbon emissions intensity of countries along the B&R, and on four different mechanisms underlying the transformation to a low-carbon development in these partner countries.

LITERATURE REVIEW AND HYPOTHESES

Influence of the BRI on Green Development in Countries along the B&R

Most studies on the BRI have focused primarily on its geopolitical implications and economic impacts on countries along the B&R. The BRI is considered a component of a new phase of globalization in which China is assuming a more proactive role (Kolosov et al. 2017). The initiative contributes to enhancing the economic levels of participating countries (Ma 2022), alleviating poverty (Xie et al. 2023) and fostering employment (Yang et al. 2024). Collectively, the literature substantiates that the BRI has yielded positive economic outcomes for countries along the B&R.

In recent years, as global ecological and environmental issues have become increasingly prominent, scholarly attention has grown significantly regarding the environmental implications of the BRI. Tracy et al. (2017) argue that the BRI could introduce new environmental risks across the Eurasian continent, particularly in countries with weaker environmental governance records. Hughes (2019) contends that infrastructure projects under the BRI, especially those related to mining, may negatively affect biodiversity in participating countries. Other scholars suggest that the BRI might lead to increased carbon emissions in the countries along the B&R for two primary reasons. First, Chinese policy banks and state-owned commercial banks have provided substantial funding to the BRI for resource-intensive industrial and manufacturing activities that could influence regional carbon emissions. Owusu et al. (2025), using a panel dataset of China's direct investment in the manufacturing sectors of 34 African countries from 2003 to 2014, examine the impact of China's OFDI on low-carbon industrialization in Africa. Given that China's OFDI primarily targets labor- and resource-intensive manufacturing, it is believed that such investments have contributed to higher industrial carbon emissions in Africa.

Second, China extends the supply chains of its carbon-intensive products by exporting them to B&R countries. Xiao et al. (2023), analyzing data from 2003 to 2017, investigate the impact of China's direct investment on carbon dioxide emissions in B&R countries. Their empirical findings indicate that the BRI has increased the share of carbon-intensive products in China's exports by nearly five percent. This trend could, in turn, accelerate the growth of energy-intensive industries and energy consumption in China, thereby increasing total global carbon emissions.

Some scholars see the BRI as an opportunity for sustainable development. Both Ahmad et al. (2020), using data from 1990 to 2017, and Su et al. (2022), using data from 2003 to 2017, study the impact of China's direct investment on carbon dioxide emissions in countries along the B&R and find that it has led to a reduction. Mahadevan and Sun (2020) show that China's increased direct investment has a pollution halo effect in low-income countries along the B&R.

Increasing the share of electricity in the final energy mix is crucial to achieving global net zero emissions and reducing energy poverty, especially in developing countries. Zhou et al. (2025) use a difference-in-differences (DiD) model to test the impact of the BRI on the share of electricity versus that of other energy sources in 118 countries from 2009 to 2020. The results show that the share of electricity use in total energy consumption in countries along the B&R increased by about one percent compared with non-B&R countries during the study period, driven mainly by enhanced trade and investment and the promotion of imports of power equipment.

The literature review indicates that the impact of the BRI on the green development of countries along the B&R is multifaceted and complex. Most studies on the carbon footprint of the BRI rely primarily on data from before 2017. In 2017, China introduced policy directives to jointly build a green BRI. Treating this policy change as a quasi-natural experiment,[3] this study employs a DiD model and a larger panel dataset updated from 2013 to 2022, in order to investigate a richer set of mechanisms underlying the process spanning from low-carbon technology, digital economy and digital export to industrial upgrading in countries along the B&R.

More Active Environmental Governance: The New Policy Objectives and Cooperation Content of the GBRI

After the Chinese government launched the BRI as a regional cooperation platform in 2013, the core policy documents of the BRI were introduced, including the "Vision and actions on jointly building Silk Road Economic Belt and 21st-Century Maritime Silk Road," issued in 2015 (NDRC et al. 2015). This policy emphasizes that countries signed up to the BRI should enhance exchanges and cooperation in ecological protection. However, it lacks detailed regulatory provisions for achieving these objectives (Coenen et al. 2021). In response to growing international criticism, China proposed the GBRI in 2017 and formulated targeted policy documents. The MEP, MOFA, NDRC and MOFCOM jointly issued policies for the GBRI, including the "Ecological and environmental protection cooperation plan for the Belt and Road" (MEP 2017a) and the "Guiding opinions on promoting the construction of the Green Belt and Road" (MEP 2017b), demonstrating a stronger commitment to environmental protection in promoting the BRI. The reasons for China's green transformation of the BRI have been discussed internationally. Some scholars believe that it is driven by external criticism (Jiang 2019) while some regard it as driven by economic interests. Gallagher (2018) suggests that China developed the GBRI in order to promote strategic industries such as renewable energy abroad. In any case, China has indeed adopted a wider range of institutional norms and initiatives to govern the environment of the BRI since 2017, and more attention needs to be paid to the dynamics of its policies (Sun and Yu 2023; the policies are shown in Table 1).

Table 1: GBRI-Related Policies and Actions

Type	Title	Year
Policy	"Ecological and environmental protection cooperation plan for the Belt and Road"	2017
	"Guiding opinions on promoting the construction of the Green Belt and Road"	2017
	"Vision and actions for jointly building the Silk Road Economic Belt and energy cooperation of the 21st-Century Maritime Silk Road"	2017
	"Guidelines for ecological and environmental protection in overseas investment and cooperation projects"	2022
Action initiative	Green and efficient refrigeration action in the Belt and Road Initiative	2019
	Green lighting action in the Belt and Road Initiative	2019
	Green development partnership initiative in the Belt and Road Initiative	2021
	Beijing initiative for green development in the Belt and Road Initiative	2023

Source: Authors' elaboration based on the China's Belt and Road Initiative website. https://www.yidaiyilu.gov.cn.

[3] This is a quasi-natural experiment because participation in the treatment group is non-random. This is consistent with the DiD model as long as the parallel trend test and other tests are conducted and verified.

The GBRI is more than just a cosmetic strategy. In contrast to the limited regulation of the environmental impact of corporate overseas activities in the past, China has made significant policy changes to control the environmental impact of the BRI, including setting a wider range of cooperation content and policy goals (see Table 2). Previously, the BRI focused on infrastructure construction and trade. Currently, the GBRI focuses mainly on clean energy cooperation, digital technology support, environmentally friendly industry investment and cooperation platform construction. First, regarding clean energy cooperation, the "Guiding opinions on promoting the construction of the Green Belt and Road Initiative" (MEP 2017b) emphasizes that promoting energy conservation and environmental protection standards and practices in clean energy industries is among the key tasks for advancing the GBRI. This promotion will facilitate joint research, development, promotion and application of advanced ecological and environmental protection technologies.

Second, regarding support for green transformation through digital technologies, in May 2017 at the first Belt and Road Forum for International Cooperation, Chinese leader Xi Jinping emphasized that cooperation in areas such as digital economy should be strengthened to build a digital Silk Road of the 21st century. The "Ecological and environmental cooperation plan for the Belt and Road" ("the cooperation plan" hereinafter; MEP 2017a) proposes that member countries jointly establish a Belt and Road ecological and environmental protection big data service system, strengthen the sharing of ecological and environmental information and provide all-round environmental protection information support and guarantees for the construction of the GBRI.

Third, investment in environmentally friendly industries is projected to drive decarbonization. The cooperation plan (MEP 2017a) proposes the establishment of a number of green financial instruments for investment and trade projects to promote the flow of funds to environmentally friendly industries. It emphasizes that market means should be used to reduce impacts on the environment, including strengthening green supply chain management and driving the upstream and downstream of the industrial chain to take energy-saving and environmental protection measures.

Fourth, the construction of a diversified cooperation platform is seen as necessary to strengthen global governance. China is committed to giving full play to the existing bilateral and multilateral international environmental cooperation mechanisms, building an environmental cooperation network and strengthening ecological and environmental cooperation involving governments, think tanks, enterprises, civil society organizations and the public.

To promote environmental cooperation, China has used various policy tools. McDonnell and Elmore (1987) divide policy tools into four types according to policy objectives: command, incentive, capacity building and system change. We group China's policy tools into the first three of these groups. This is because system change refers to the government changing the environment for policy implementation by adjusting institutional structure, power relations, resource allocation methods, etc.: this plays a lesser role in international cooperation and we therefore believe it is less relevant in the BRI context than the other groups.

Table 2: GBRI's Policy Objectives, Tools and Cooperation Content since 2017

Type	Policy tool	Cooperation content	Policy objectives
Command	Industry standard Setting	Clean energy cooperation	Promoting joint research on and application of advanced ecological and environmental protection technologies
Capacity building	Technical support	Digital technology support	Building the Belt and Road ecological and environmental protection big data service system
	Communication	Building a diversified cooperation platform	Strengthening the participation of governments, enterprises, think tanks, civil society organizations, and the public in environmental protection cooperation
Incentive	Openness to trade and enhanced investment	Investment in environmentally friendly industries	Using market means including trade and investment to reduce the impact on the ecological environment

Source: Authors' elaboration based on the China's Belt and Road Initiative website. https://www.yidaiyilu.gov.cn.

Hypotheses

Combating climate change and preventing environmental pollution is a shared responsibility among all countries. The United Nations Conference on Trade and Development (UNCTAD) has urged developing countries to adjust their environmental, technological and industrial policies, prioritize investment in greener and more technologically advanced industries and provide incentives to redirect consumer demand toward more environmentally friendly products. However, countries that are still in the early stages of economic development face significant challenges in effectively utilizing green technologies independently. In the context of prioritizing economic growth, the success of environmental policies in developing countries hinges largely on green technology cooperation facilitated through international trade (UNCTAD 2021). In the early years of the BRI, China financed many coal-fired power plants, which led to a certain amount of CO_2 emissions and pollution (Clark et al. 2023). In the early stages of the development of the renewable energy market, renewable energy technologies were mainly imported from other developed countries rather than developed independently (Kim 2020). Through cooperation, cleaner and more efficient advanced green technologies can be transferred to host countries from abroad, thereby optimizing the host country's industrial structures—a phenomenon known as the pollution halo effect. This process contributes to reducing carbon dioxide emissions in host countries. The introduction of the GBRI helps to strengthen the foundation for ecological and environmental protection cooperation and establish a positive framework for such cooperation.

The BRI is typically associated with large-scale infrastructure loans from China's development banks. The literature review above found that existing studies have analyzed the impact of China's outward investment on carbon emissions in countries along the B&R, but the results are inconsistent. As discussed, China's GBRI employs a range of multidimensional measures to achieve green transformation. Chinese firms engage overseas through FDI, which may have distinct effects on emissions. We do not yet know whether the amount of Chinese outward investment influences the achievement of the GBRI's green transformation goals and measures. Based on this, Hypothesis 1 and Hypothesis 1a are proposed as follows.

Hypothesis 1: The Green Belt and Road Initiative (GBRI) is conducive to reducing carbon emissions intensity and enhancing the green development level of the countries along the Belt and Road.

Hypothesis 1a: The increasing intensity of China's outward investment has weakened the impact of the GBRI on the green development levels of the countries along the Belt and Road.

The report "China's green leap outward: The rapid scale-up of overseas Chinese clean-tech manufacturing investments" released by Net Zero Industrial Policy Lab shows that China's green technology manufacturers have accelerated their overseas investment, with investment soaring to more than US$220 billion in 2022 alone, covering areas such as solar energy, wind energy, new energy vehicles and green hydrogen (Xue and Larsen 2025). Countries along the B&R possess abundant renewable energy resources such as wind and solar power. Meanwhile, China has achieved rapid progress in clean energy technologies in recent years, establishing itself at the international forefront with significant technological advantages in areas such as photovoltaic power generation, wind power generation and nuclear power technology, all of which are at the international forefront. These complementary strengths in resources and technology have positioned B&R countries as crucial to China's energy technology exports and cooperation. For example, in 2021, the Turomoye Phase I Geothermal Power Station project in Ethiopia showcased the export of geothermal power generation technology. The transfer and transformation of green technologies in B&R countries will help these countries to achieve green and low-carbon energy development, thereby reducing carbon emissions. As the world's largest supplier of renewable energy equipment, China can help to unlock the vast renewable energy potential of these countries (Andrews-Speed and Zhang 2018; Chen, et al. 2019) and share its expertise in adjusting policy goals, reforming subsidy structures and minimizing power waste (Eyler 2019). China has rapidly transformed from a net importer and follower of low-carbon technologies to the world's largest net exporter and market leader. This shift has reshaped the global green technology supply chain, with the potential to have a dual impact on developing countries. On the one hand, they could access Chinese green technologies at lower costs; on the other hand, they might face the risk of being locked into the Chinese technology ecosystem, making it difficult to develop their own low-carbon industries (Gallagher et al. 2025). Policies such as those facilitating China's smooth trade with countries along the B&R make it more likely that these countries will obtain China's green technology at a lower cost. Based on this, Hypothesis 2 is proposed as follows:

Hypothesis 2: The GBRI boosts the level of green development in countries along the Belt and Road through low-carbon energy technology dissemination.

The Digital Silk Road initiative, which focuses on collecting and sharing Earth observation data, can strengthen environmental monitoring capabilities (Guo et al. 2018). China's accelerated promotion of digital transformation under the BRI has fostered the symbiotic development of green and digital advancements (Coenen et al. 2021). Digital technology plays a multifaceted role in facilitating green transformation and sustainable development. First, it enables agile governance. This refers to the rapid perception of and flexible response to governance challenges, which necessitates a versatile and customizable digital infrastructure to deliver value to businesses more swiftly and effectively (Luna et al. 2023; Mergel et al. 2021). The deployment of digital technologies, such as sensors and radio-frequency identification (RFID) for environmental data monitoring and real-time tracking of pollution sources, has proven instrumental in enhancing environmental performance (Chiarini 2021). Studies indicate that the digital economy significantly contributes to addressing pollution control issues in border regions. The underlying digital technologies can break down market segmentation among local governments and enhance the capacity for digital tracking and supervision.

Second, digital technology fosters information sharing. According to institutional collective action (ICA) theory, the costs associated with information collection and mutual distrust hinder interdepartmental collaboration (Feiock 2013). Post-digital transformation, national governance and enterprise operations generate vast amounts of data. When standardized and processed, this information facilitates efficient and seamless sharing across entities (Brynjolfsson and McElheran 2016). Whether within or between countries, advancements in digital technology promote the openness and sharing of environmental information, leverage national spatial and informational infrastructures and reduce the costs of collaborative environmental governance.

Third, digital technology optimizes resource allocation. At the micro level, the evolution of digital technology lowers enterprises' information search costs, logistics costs and inventory costs, thereby minimizing waste in production, distribution and transaction processes and reducing pollution emissions. At the industry level, digital transformation accelerates technological accumulation and significantly promotes green technological innovation in manufacturing enterprises (Dou and Gao 2023).

China places significant emphasis on collaborating with B&R countries to develop digital infrastructure, and its outbound investments in digital information technology have grown rapidly in recent years. According to data on the industry distribution of China's OFDI flows, the information transmission, software and information technology services sector reached US$2.28 billion in 2023, representing a 34.9 percent increase compared with the previous year. Additionally, the scientific research and technical services sector amounted to US$5.05 billion, marking a 4.8 percent increase from the prior year (MOFCO et al., 2023). The technology spillover effect, as a positive externality of technology diffusion (Tseng 2022), facilitates the dissemination of digital technologies to B&R countries by demonstrating China's technological advancements and collaborative research and development efforts. This contributes to providing intellectual and technological support for the construction of the GBRI. A recent International Monetary Fund (IMF) study on Africa–China linkages devoted a whole chapter to the impact of China's FinTech (digital payment systems) in Africa (Selassie et al. 2025). Based on these observations, Research Hypothesis 3 is formulated.

Hypothesis 3: The GBRI promotes the green development of countries along the Belt and Road by leveraging the spillover effects of digital technology advancement.

The advancement of industrial structure refers to an evolution through which industries with higher levels of production efficiency progressively replace those with lower levels of efficiency (Wang et al. 2025). One of the main areas of cooperation in the GBRI is to promote the movement of investment funds toward environmentally friendly industries (MEP 2017a, 2017b). Research has shown that the BRI significantly promotes global value chain reconstruction between China and B&R countries, with effects strengthening over time (Wang et al. 2025). The BRI can also significantly promote the upgrading of the industrial structure of these countries (Wang and Zhong 2021). Under the GBRI framework, synergistic effects can be generated through the complementary use and sharing of resources, technologies and markets within the supply chain, thereby facilitating the transformation and upgrading of industrial structures in B&R countries. The GBRI commits China to incorporating environmental protection requirements into free trade agreements, establishing dedicated funds for resource development and environmental protection and prioritizing support for ecological infrastructure, capacity building and green industry development projects in countries along the B&R. From this perspective, green trade and investment can serve as critical pathways for the BRI to contribute to achieving the SDGs. For countries predominantly reliant on large-scale, high-density carbon-emitting industries, the BRI, which advocates rapid green development, will accelerate the growth of the service sector, enhance their innovation output and promote the development of high-tech industries, thereby reducing carbon emissions per unit of output. Therefore, Hypothesis 4 is proposed.

Hypothesis 4: The GBRI promotes the green development of countries along the Belt and Road by leveraging the driving mechanism of industrial structure upgrading.

MODEL AND DATA

Model Setting

Our conceptual framework is based on a production function approach, following the tradition of Dailimi et al. (2000) and Lin (2011), where a country's endowments, natural capital, human capital and physical capital determine its industrial structure and its comparative advantages. These assets determine what the country can produce and trade, and they are affected by technological progress, public investments, openness and governance factors including government regulatory efficiency, corruption control and the rule of law. A country's level of green development, as measured by carbon emissions intensity (CO_2/GDP), is determined by the complex interactions among three key dimensions: natural and economic endowments; structural patterns of production, trade and investment; and institutions and policy frameworks. Therefore, these factors, including fixed capital *(K)*, education *(H)*, forest *(N)*, urbanization, openness, share of industrial employment and governance, enter our empirical model (Equation 1) as control variables. Alternative specifications and variables are employed in robustness tests and the analysis of mechanisms.

Carbon emissions intensity is selected as our dependent variable because it reflects the complex relationship between production and its side product, CO_2 emissions, and it allows us to keep a balance between various policy priorities of developing countries. A survey conducted by the Center for Global Development (Kenny et al. 2025) found that among 43 developing countries, fewer than six percent of respondents prioritized climate change: the majority ranked economic growth, education and job creation as their primary concerns. Previous studies have found evidence of the environmental Kuznets curve (EKC), which suggests that emissions initially rise with industrial development but eventually decline as economies mature and adopt cleaner technologies (Wang and Xu 2024).

This section treats the proposal of the GBRI as a quasi-natural experiment and investigates its impact on the green development of countries along the B&R using a DiD model. In accordance with the research question of the paper, two dummy variables are constructed. First, the treatment group dummy variable (the BRI): countries along the B&R (excluding China itself) are assigned a value of 1, representing the treatment group, while those not along the B&R are assigned a value of 0, representing the control group. Second, the policy time dummy variable (post): based on the year when the GBRI was proposed, this study sets 2017 as the policy shock year, assigning a value of 1 to years 2017 and after, and a value of 0 to years before 2017. Based on these constructions, the following benchmark regression model is established.

$$CO2_{i,t}=\alpha_0+\alpha_1\, greenDID_{i,t}+\Gamma Control_{i,t}+\mu_i+T_t+\epsilon_{i,t} \quad (1)$$

In Equation 1, i and t denote the country dimension and time dimension, respectively. $CO2$ represents the carbon dioxide emissions intensity of country i in year t, measured as the ratio of carbon dioxide emissions to GDP. $greenDID_{i,t}$ is the interaction term between the GBRI policy time and countries along the B&R, expressed as $greenDID_{i,t}=BRI_i\times Post_t$. The coefficient α_1 captures the emission reduction effect of the GBRI on countries along the B&R, which is the key parameter of interest in this study. $Control_{i,t}$ includes a set of control variables that vary by country and time and influence carbon emissions. μ_i denotes the country fixed effect, T_t denotes the time fixed effect and $\epsilon_{i,t}$ denotes the random disturbance term.

The selection of the treatment group is not entirely random. Countries along the B&R differ significantly from non-B&R countries in terms of economic development level, human capital, natural resource endowment and political background. Some of these differences predate the policy shock and are also key determinants of carbon dioxide emissions. To address these concerns, following the methodologies of Aller et al. (2021), Yang et al. (2024) and Xie et al. (2023), this study controls for a comprehensive set of variables. Specifically, we include economic factors such as per capita GDP growth rate *(gdpgrowth)*, fixed capital stock *(lnfixcapital)*, openness level *(openness to trade)* and proportion of industrial employment *(ind_employment*); social factors such as urbanization rate *(urban)* and average years of schooling *(education)*; natural condition factors such as the share of forest area in total land area *(forest)*; and political factors such as corruption control index *(corruption_control)*. The precise definitions and data sources for each variable are provided in Table 3.

Table 3: Variable Description and Data Sources

Variable type	Variable name	Variable description	Data source
Explained variable	*CO2*	Carbon dioxide emissions (in thousands of tons)/GDP (in million US$); takes the natural logarithm in the regression	Global Carbon Budget (GCB)
Explanatory variable	*greenDID*	Interaction item between treatment group dummy variable and GBRI policy time dummy variable	
Control variable	*gdpgrowth*	Annual growth rate of per capita gross domestic product (%)	World Bank Open Database
	lnfixcapital	Fixed capital stock (in 10,000 US$) calculated using the perpetual inventory method; takes the natural logarithm in the regression	World Bank Open Database
	Openness to trade	Proportion of total import and export of goods to GDP (%)	United Nations Commodity Trade Statistics Database
	ind_employment	Proportion of industrial employment rate to total employment rate (%)	ILO database
	urban	Proportion of urban population to total population	World Bank Open Database
	education	Average years of schooling	UNDP
	forest	Percentage of forest area to national land area	FAO
	corruption_control	Governance of corruption	Worldwide Governance Indicators (WGIs)

Source: Authors' elaboration.

Descriptive Statistics of Samples

The year 2013 marks the launch of the BRI. To minimize potential biases arising from differences before and after the BRI's announcement, this study sets the time dimension of the research sample to span from 2013 to 2022. After excluding observations with missing values for key variables, a final sample size of 1,200 is obtained, covering 139 countries in total, including 52 countries along the B&R and 87 non-B&R countries. The descriptive statistics for all variables are presented in Table 4.

Table 4: Summary Statistics

Variable	N	Mean	SD	Min.	Max.
CO2	1,200	5.82	0.595	4.58	8.33
greenDID	1,200	0.14	0.346	0.00	1.00
gdpgrowth	1,200	0.01	0.043	−0.30	0.23
lnfixcapital	1,200	23.23	2.152	18.28	29.16
Openness to trade	1,200	0.85	0.554	0.16	3.93
ind_employment	1,200	0.19	0.074	0.03	0.41
urban	1,200	0.60	0.223	0.11	1.00
education	1,200	8.67	3.397	1.18	14.26
forest	1,200	0.32	0.215	0.00	0.92
corruption_control	1,200	−0.04	0.977	−1.70	2.40

Source: Authors' elaboration.

EMPIRICAL RESULTS AND ANALYSIS

Baseline Regression Results

The regression results of the benchmark model are reported in Table 5. Column 1 presents the estimation results without control variables, while Column 2 includes all control variables. To improve the precision of the estimates, all regressions control for country and time fixed effects and robust standard errors are reported throughout. As shown in Columns 1 and 2, the coefficient of the *greenDID* term remains significantly negative regardless of whether control variables are included. This indicates that the GBRI has effectively reduced the carbon dioxide emissions intensity of countries along the B&R and positively contributed to their green development, thereby supporting Hypothesis 1. In Column 2, after incorporating all control variables, the regression coefficient is −0.059, which represents an improvement in model fit compared with Column 1. This suggests that the selected control variables are appropriate. The coefficient of the *greenDID* term implies that after controlling for other factors, the reduction in carbon dioxide emissions intensity for the treatment group (countries along the B&R) is 5.9 percent greater than that of the control group following the introduction of the GBRI.

Table 5: Baseline Estimation Results for CO_2

Variable	CO_2 (1) without control variables	CO_2 (2) with control variables
greenDID	−0.082**	−0.059*
	(0.035)	(0.033)
gdpgrowth		−0.097
		(0.137)
lnfixcapital		−0.005
		(0.057)
Openness to trade		−0.092
		(0.080)
ind_employment		1.301*
		(0.773)
urban		1.879*
		(1.094)
education		−0.009
		(0.021)
forest		−3.720**
		(1.530)
corruption_control		−0.107*
		(0.062)
Constant	5.862***	5.979***
	(0.015)	(1.569)
Country fixed	YES	YES
Year fixed	YES	YES
Observations	1,200	1,200
adj. R^2	0.067	0.146

Source: Authors' elaboration.
Note: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$; robust standard errors clustered at the country level are reported in parentheses.

The Moderating Effect of China's OFDI Intensity

To further investigate whether and how China's OFDI influences the relationship between the GBRI and carbon emissions intensity, this study calculates the ratio of China's outward direct investment flow to the net inflow of FDI in each country, thereby constructing a variable representing China's outward investment intensity ***(OFDI)*** (MOFCO et al., 2023). We construct the moderation effect model as shown in Equation 2. The variable ***OFDI*** and its interaction term with ***greenDID*** ***(greenDID*OFDI)*** are incorporated into the baseline regression model for re-estimation. If the regression coefficient of the interaction term between ***OFDI*** and ***greenDID*** is significantly negative, this would suggest that China's outward investment intensity enhances the promoting effect of the GBRI on the green development levels of recipient countries. Conversely, if the regression coefficient

of the interaction term is significantly positive, this would imply that China's outward investment intensity weakens the relationship between the GBRI and the green development levels of recipient countries. As shown in Table 6, the coefficient of the ***greenDID*OFDI*** interaction term is significantly positive, contrasting with the coefficient of ***greenDID***. This indicates that although the carbon dioxide emissions intensity of B&R countries has decreased following the launch of the GBRI, the increasing intensity of China's outward investment has weakened the overall impact of the GBRI on the green development levels of these countries. Hypothesis 1a is verified.

$$CO2_{i,t}=\alpha_0+\alpha_1\, greenDID_{i,t}+\alpha_2\, greenDID\times OFDI_{i,t}+\alpha_3\, OFDI_{i,t}+\Gamma Control_{i,t}+\mu_i+T_t+\epsilon_{i,t} \qquad (2)$$

Table 6: The Impact of China's Intensity of Foreign Investment

Variable	CO_2	CO_2
	(1) without control variables	(2) with control variables
greenDID	−0.076**	−0.070**
	(0.031)	(0.029)
*greenDID*OFDI*	0.250***	0.224***
	(0.036)	(0.034)
OFDI	−0.000***	−0.001***
	(0.000)	(0.000)
gdpgrowth		−0.152
		(0.162)
lnfixcapital		−0.005
		(0.064)
Openness to trade		−0.099
		(0.083)
ind_employment		1.761**
		(0.724)
urban		3.033**
		(1.203)
education		0.013
		(0.023)
forest		−1.122
		(1.530)
corruption_control		−0.049
		(0.057)
Constant	5.865***	4.195**
	(0.016)	(1.766)
Country fixed	YES	YES
Year fixed	YES	YES
Observations	1,011	1,011
adj. R^2	0.081	0.168

Source: Authors' elaboration, additional dependent variable, OFDI, sourced from MOFCO et al. (2023)
Note: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$; robust standard errors clustered at the country level are reported in parentheses.

MODEL VALIDITY TEST

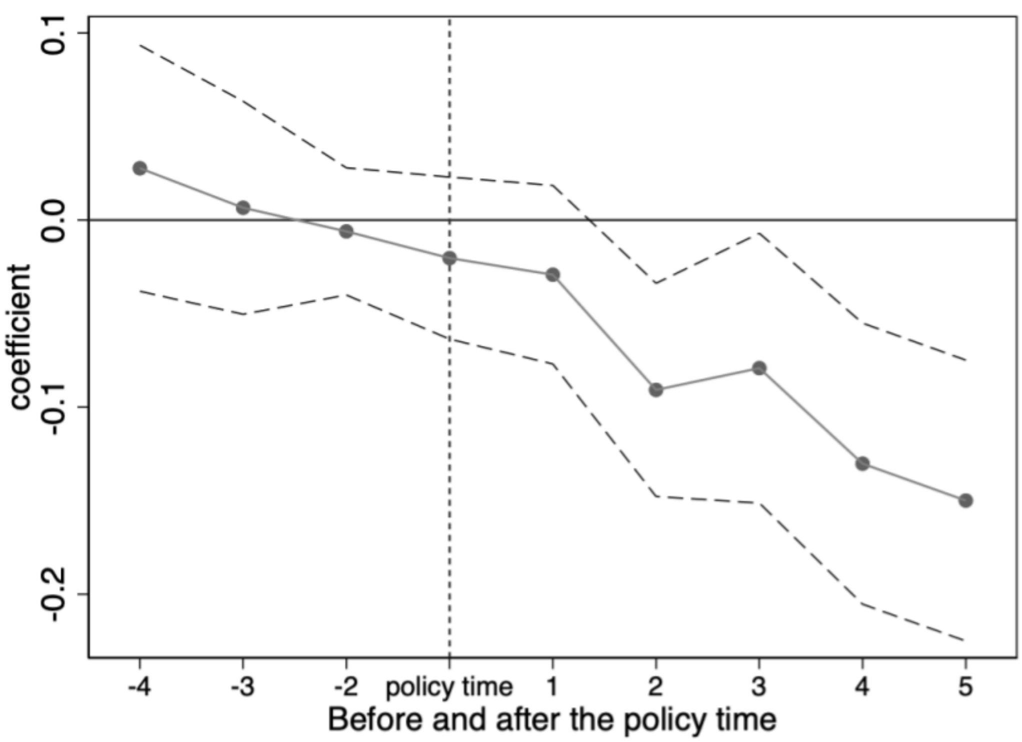
Parallel Trend Test

The application of the DiD method to estimate policy effectiveness relies on the assumption that the treatment group and the control group exhibit parallel trends in their outcomes prior to the implementation of the GBRI. Specifically, this implies that any differences in carbon emissions among countries along the B&R before and after the policy was introduced caused by factors other than the initiative itself should be comparable to the differences observed among non-B&R countries during the same period. To test whether the parallel trend assumption holds, this study constructs dummy variables for the years before and after the policy takes effect, following the methodology proposed by Cao and Chen (2022). The specific model is presented in Equation 3.

$$CO2_{i,t}=\beta_0+\sum\beta_k\, greenDID_{k,i,t}+\Gamma X_{i,t}+\mu_i+T_t+\epsilon_{i,t} \tag{3}$$

In Equation 3, the term reflects the difference between the treatment group and the control group before and after the policy implementation, serving as a dummy variable for the years before and after the policy takes effect. The results of the parallel trend test are presented in Figure 1. It can be observed that after setting the first year of the sample period as the reference group, there is no significant difference in carbon emissions per unit of output between the treatment group and the control group prior to the introduction of the GBRI. In the year when the policy was implemented, carbon emissions still showed no significant difference. This indicates that the GBRI has a lagged effect on carbon emissions. Starting from the second year after the policy's implementation, a significant difference in carbon emissions emerged between the treatment group and the control group.

Figure 1: Parallel Trend Test

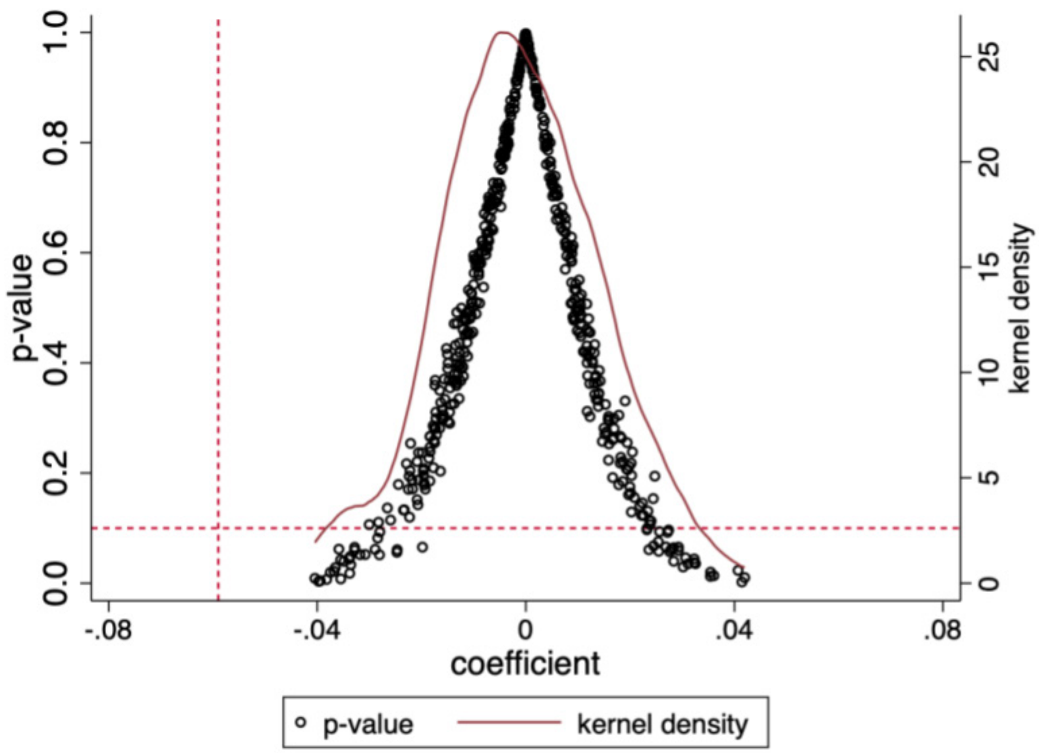


Source: Authors' illustration based on Table 3 data.

Placebo Test

Despite passing the parallel trend test, omitted variables and random factors may still introduce bias into the estimation results. Following the methodology of Chetty et al. (2009), we conduct a placebo test by replacing the treatment group countries with randomly selected virtual countries as the "pseudo-treatment group." The remaining samples are then treated as the control group and a virtual policy variable is constructed accordingly. Theoretically, the coefficient of the virtual policy variable on carbon emissions should center around 0. As shown in Figure 2, there is a significant difference between the true policy effect and the placebo test results. After constructing 500 random virtual treatment groups, the estimated coefficients of the virtual policy variable on carbon emissions are tightly clustered around 0 and are markedly distinct from the benchmark regression coefficients. This placebo test further mitigates the potential influence of unobservable factors on carbon emissions.

Figure 2: Placebo Test



Source: Authors' illustration based on Table 3 data.

ROBUSTNESS TEST

Replacing the Dependent Variable

Green development not only encompasses the reduction of carbon emissions but also necessitates consideration of changes in environmental pollution levels. In the robustness test conducted in this study, the dependent variable is substituted with the logarithm of annual average exposure to PM2.5 air pollution (measured in micrograms per cubic meter). The data of PM2.5 sourced from the World Bank's World Development Indicators (WDI) database. As indicated in Column 1 of Table 7, the coefficient of the *greenDID* term is significantly negative at the one percent significance level, thereby confirming the robustness of the original conclusion.

Table 7: Results of Robustness Tests

Variable	PM2.5	CO_2	Variable	CO_2
	(1) Replace the dependent variable	(2) Exclude the impact of the COVID-19		(3) Lag control variables by one period
greenDID	−0.053***	−0.058*	*greenDID*	−0.051*
	(0.014)	(0.032)		(0.030)
gdpgrowth	−0.056	−0.117	*lag_gdpgrowth*	−0.008
	(0.134)	(0.157)		(0.149)
lnfixcapital	0.008	0.006	*lag_lnfixcapital*	0.001
	(0.019)	(0.058)		(0.051)
Openness to trade	−0.011	−0.116	*lag_open*	0.008
	(0.040)	(0.076)		(0.083)
ind_employment	0.169	1.372*	*lag_ind_employment*	0.401
	(0.367)	(0.769)		(0.727)
urban	0.473	1.824*	*lag_urban*	1.905*
	(0.631)	(1.073)		(1.082)
education	−0.010	−0.006	*lag_education*	−0.040
	(0.021)	(0.022)		(0.026)
forest	−0.581	−3.739**	*lag_forest*	−3.652**
	(0.918)	(1.496)		(1.544)
corruption_control	0.021	−0.110*	*lag_corruption_control*	−0.087
	(0.029)	(0.060)		(0.060)
Constant	2.943***	5.741***	*Constant*	6.120***
	(0.706)	(1.567)		(1.443)
Country fixed	YES	YES	*Country fixed*	YES
Year fixed	YES	YES	*Year fixed*	YES
Observations	991	1,089	*Observations*	1052
adj. R^2	0.251	0.151	*adj.* R^2	0.121

Source: Authors' elaboration based on the World Bank's World Development Indicators (WDI) database.

Note: $^{*}\ p < 0.1$, $^{**}\ p < 0.05$, $^{***}\ p < 0.01$; robust standard errors clustered at the country level are reported in parentheses.

Excluding the Impact of COVID-19

The outbreak of the COVID-19 pandemic in 2020 is likely to have influenced the economic production activities of countries worldwide, potentially affecting their carbon emission levels and thereby introducing bias into the estimation results. To further strengthen the robustness of the estimates, we reconduct the regression analysis excluding all observations from the sample countries in 2020, based on the benchmark regression model. As shown in Column 2 of Table 7, the coefficient of the *greenDID* term remains significantly negative, thus reinforcing the original conclusion.

Lagging Control Variables by One Period

In constructing the benchmark regression model, this study controls for the current-period control variables. During the robustness test, all control variables are lagged by one period. As shown in Column 3 of Table 7, the coefficient of the *greenDID* term remains significantly negative, thereby confirming the robustness of the original conclusion.

FURTHER ANALYSIS

Heterogeneity Analysis

Despite China's efforts to strengthen and expand the institutional framework of the GBRI, the successful implementation of a truly green BRI hinges on effective environmental governance among BRI partner countries. The significant disparities among these countries in terms of economic development levels, political systems and other factors are likely to exert varying influences on the GBRI. This section examines the potential differential impacts of the GBRI across different types of countries from both economic and political perspectives.

Differences in Levels of Economic Development

Low-income countries may prioritize economic development over environmental protection, adopting lenient environmental standards to attract FDI (Gray 2002). The EKC posits that when a country's level of economic development is relatively low, the extent of environmental pollution tends to be minimal (Stern 2004). As per capita income rises, environmental degradation intensifies with economic growth; however, once economic development reaches a certain threshold, further increases in per capita income lead to a gradual decline in pollution levels and an improvement in environmental quality. Guided by this perspective, this section conducts regression analyses on country income groups classified by the World Bank according to income levels, aiming to examine country-specific differences in carbon emission effects. The regression results based on income groups are presented in Table 8. As the table shows, the GBRI exerts negative effects on both low- and high-income countries, whereas its impact on lower-middle- and upper-middle-income countries is statistically insignificant. This suggests that the GBRI exhibits country-specific income heterogeneity in terms of its green development impacts. Countries with lower levels of economic development tend to have relatively low carbon emissions, whereas in countries where industrialization has been completed and economic development is advanced, economic growth can gradually mitigate environmental pollution. For lower-middle- and upper-middle-income countries, the primary focus remains on fostering economic growth rather than reducing emissions. Consequently, countries experiencing an upward trend in per capita national income may be less influenced by the GBRI, aligning with the predictions of the EKC.

Table 8: Analysis of the Heterogeneity in Levels of Economic Development

Variable	CO_2 (1) low-income	CO_2 (2) lower-middle-income	CO_2 (3) upper-middle-income	CO_2 (4) high-income
greenDID	−0.258***	0.064	−0.026	−0.062*
	(0.086)	(0.066)	(0.024)	(0.036)
gdpgrowth	−0.143	0.301	−0.160	0.158
	(0.382)	(0.347)	(0.195)	(0.269)
lnfixcapital	0.131*	−0.003	−0.002	−0.377***
	(0.065)	(0.099)	(0.055)	(0.102)
Openness to trade	0.322**	−0.056	−0.124**	0.066
	(0.148)	(0.131)	(0.057)	(0.091)
ind_employment	2.697*	−1.488	1.081	2.119*
	(1.426)	(1.718)	(0.767)	(1.109)
urban	4.653	0.983	−1.154	−1.893
	(2.785)	(2.250)	(1.451)	(1.194)
education	0.158	−0.029	−0.045**	0.060
	(0.101)	(0.031)	(0.020)	(0.040)
forest	7.739*	−0.089	−5.209***	−2.921
	(3.715)	(2.671)	(1.049)	(4.368)
corruption_control	−0.215	−0.216**	−0.004	−0.030
	(0.186)	(0.101)	(0.048)	(0.059)
Constant	−1.461	5.903**	9.082***	16.179***
	(1.773)	(2.492)	(1.478)	(2.970)
Country fixed	YES	YES	YES	YES
Year fixed	YES	YES	YES	YES
Observations	142	350	324	384
adj. R^2	0.428	0.067	0.251	0.673

Source: Authors' elaboration; country income groups are classified by the World Bank.
Note: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$; robust standard errors clustered at the country level are reported in parentheses.

Differences based on Political System Background

The "Government Effectiveness" index in the Worldwide Governance Indicators (WGIs) from the World Bank reflects quality of public services, capacity for policy formulation and implementation and credibility of government commitments. The "Rule of Law" index measures the extent to which people have confidence in and abide by societal rules. Based on the median values of these indices, countries are categorized into two groups: those with high regulatory governance versus low regulatory quality, and those with high versus low levels of rule of law. The results presented in Columns 1 and 2 of Table 9 indicate that in countries with high government effectiveness and strong adherence to the rule of law, the GBRI has a more pronounced impact. The effectiveness of the GBRI therefore not only hinges on China's commitment to green development but also depends on the government effectiveness and rule of law levels in the BRI partner countries, which jointly determine their political will and capacity to enforce stringent green regulations.

Table 9: Analysis of the Heterogeneity in Political System Backgrounds

Variable	CO_2	CO_2	CO_2	CO_2
	Government effectiveness		Rule of law	
	(1) High level	(2) Low level	(3) High level	(4) Low level
greenDID	−0.057*	0.032	−0.106***	0.008
	(0.032)	(0.072)	(0.035)	(0.061)
gdpgrowth	−0.127	−0.080	−0.082	−0.033
	(0.173)	(0.195)	(0.161)	(0.202)
lnfixcapital	−0.254***	0.069	−0.160**	0.071
	(0.075)	(0.067)	(0.080)	(0.069)
Openness to trade	−0.028	−0.003	−0.151	0.007
	(0.093)	(0.098)	(0.112)	(0.089)
ind_employment	2.490***	−0.199	3.146***	−0.676
	(0.803)	(1.264)	(0.920)	(1.251)
urban	−0.233	2.478	−0.627	2.067
	(0.762)	(1.958)	(0.946)	(1.855)
education	−0.008	−0.002	−0.003	−0.007
	(0.029)	(0.033)	(0.026)	(0.031)
forest	−4.252	−1.215	−5.766	−1.829
	(2.896)	(1.972)	(3.478)	(2.019)
corruption_control	−0.007	−0.195**	0.027	−0.209**
	(0.052)	(0.082)	(0.054)	(0.090)
Constant	13.077***	3.463**	11.417***	3.814**
	(2.374)	(1.707)	(2.446)	(1.809)
Country fixed	YES	YES	YES	YES
Year fixed	YES	YES	YES	YES
Observations	599	601	599	601
adj. R^2	0.504	0.063	0.460	0.055

Source: Authors' elaboration.

Note: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$; robust standard errors clustered at the country level are reported in parentheses.

MULTIFACETED MECHANISM ANALYSIS

Dissemination Mechanim of Low-Carbon Energy Technology

Under the SDGs, countries worldwide have increasingly prioritized the development of low-carbon energy to replace traditional non-renewable energy sources such as coal for both production and daily life activities. Following the introduction of the GBRI, countries along the B&R have formulated diverse development strategies centered on "green co-construction." Mutual consultation and cooperation among these countries have provided a technical foundation for low-carbon transformation. Simultaneously, exchanges and mutual supervision among countries along the B&R have strengthened the consistency of their low-carbon transformation goals, thereby contributing to a reduction in total carbon emissions. To measure the substitution effect of low-carbon energy, this study utilizes renewable energy power generation data (in TWH, trillion watt-hours) sourced from Ember's Annual Electricity Data and the UK Energy Research Institute. Data is logarithmized prior to entering the model. Renewable energy sources are defined as hydropower, solar energy, wind energy, geothermal energy, biomass energy, wave energy and tidal energy. As shown in Column 1 of Table 10, the coefficient of ***greenDID*** is significantly positive, indicating that after the GBRI was launched in 2017, the utilization of low-carbon energy in the production processes of countries along the B&R increased significantly compared with non-B&R countries. This finding verifies Hypothesis 2.

Table 10 : Results of the Multifaceted Mechanism Analysis

Variable	Renewable energy generation capacity	Digital infrastructure	Digital services trade	Upgrading of industrial structure
	(1)	(2)	(3)	(4)
greenDID	0.078*	0.016**	0.022**	0.019**
	(0.042)	(0.007)	(0.011)	(0.009)
gdpgrowth	−0.105	−0.005	−0.166	−0.169**
	(0.143)	(0.026)	(0.101)	(0.075)
lnfixcapital	-0.003	0.003	0.005	-0.008
	(0.038)	(0.007)	(0.030)	(0.020)
Openness to trade	0.024	0.030**	−0.036	−0.019
	(0.089)	(0.012)	(0.044)	(0.023)
ind_employment	−2.742***	−0.247**	−0.692	−0.253
	(0.886)	(0.108)	(0.501)	(0.262)
urban	0.180	−0.258	−0.727*	0.025
	(1.355)	(0.201)	(0.371)	(0.290)
education	0.144**	0.009	−0.020*	0.004
	(0.056)	(0.008)	(0.010)	(0.010)
forest	−1.032	0.552**	0.206	0.194
	(2.199)	(0.233)	(0.546)	(0.538)
corruption_control	−0.007	−0.004	0.010	−0.005
	(0.061)	(0.008)	(0.031)	(0.018)
Constant	1.356	−0.041	0.668	2.413***
	(1.330)	(0.228)	(0.806)	(0.417)
Country fixed	YES	YES	YES	YES
Year fixed	YES	YES	YES	YES
Observations	1,153	1,146	1,082	1,192
adj. R^2	0.375	0.539	0.152	0.042

Source: Authors' elaboration.

Note: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$; robust standard errors clustered at the country level are reported in parentheses.

Spillover Mechanism of Digital Technology Development

Studies have demonstrated that the development of digital infrastructure significantly and positively influences the green transformation of urban economies, primarily through fostering green technological innovation and optimizing industrial structures to promote urban green transition (Qin et al. 2024). Digital infrastructure is a critical focus area in the BRI's infrastructure cooperation. In this study, the broadband penetration rate serves as a proxy variable for measuring the coverage and level of development of digital infrastructure. Digital service trade is quantified by the ratio of information and communication technology (ICT) service exports to GDP, with data sourced from the World Bank's WDI database. The regression results are presented in Columns 2 and 3 of Table 10. The coefficient of $greenDID$ is significant at the five percent level, suggesting that the GBRI not only facilitates the advancement of digital infrastructure in countries along the B&R but also stimulates their digital service trade. Combining this with the theoretical analysis from the preceding section, it can be concluded that the GBRI enhances the green development level of countries along the B&R through the driving mechanism of digital technology development. Thus, Hypothesis 3 is verified.

Promotion Mechanism for the Upgrading of Industrial Structure

The BRI influences the adjustment of industrial structures in countries along the B&R through industrial alignment and resource complementarity. Specifically, in international cooperation, it leverages the comparative advantages of both parties to achieve complementarity in resources, technology and markets. It promotes the transformation of industrial structures in countries along the B&R through routes such as investment and trade. This study uses the following formula to measure the advanced development of industrial structures:

$$\begin{aligned} &Proportion\ of\ primary\ industry\ output\ value\ in\ GDP * 1 \\ &\quad + Proportion\ of\ secondary\ industry\ output\ value\ in\ GDP * 2 \\ &\quad + Proportion\ of\ tertiary\ industry\ output\ value\ in\ GDP * 3. \end{aligned}$$

As shown in Column 4 of Table 10, the coefficient of $greenDID$ is positive and statistically significant, indicating that the GBRI has effectively promoted the advanced development of industrial structures in countries along the B&R. Combined with the theoretical analysis presented earlier, this conclusion demonstrates that the GBRI enhances the green development level of countries along the B&R through the promotion mechanism of industrial structure upgrading. Thus, Hypothesis 4 is verified.

CONCLUSION AND IMPLICATIONS

In the current global economic environment of lower growth, higher trade barriers and greater uncertainty, our study presents some gleams of hope. The multidimensional approach that China and its partners have employed to green the BRI has worked to some extent. Using data from 139 countries between 2013 and 2022, our quantitative analysis reveals that since the introduction of the policy directives aimed at greening the BRI, there has been a significant decrease in carbon emissions intensity (CO_2 emissions per unit of GDP) among countries along the B&R. However, in countries receiving substantial OFDI from China, the reduction in carbon dioxide emissions seems to be relatively smaller.

Generally, the impact of this initiative varies across countries, depending on their development levels and political contexts. The initiative significantly influences both low- and high-income nations. Low-income countries inherently produce fewer carbon emissions, while high-income countries, having completed industrialization, can gradually address environmental pollution and combat climate change. For lower-middle-income and upper-middle-income countries currently in an ascending phase of economic development, the influence of the initiative is less pronounced. These countries often prioritize economic development over emission reductions, as discussed in the literature on the EKC.

In nations characterized by high government efficiency and strong rule of law, the impact of the GBRI is more significant. The effectiveness of the initiative depends not only on China's commitment to low-carbon development but also on the governance capabilities and legal frameworks of partner countries.

Through multifaceted mechanisms such as the transfer of low-carbon energy technologies, the diffusion of digital innovations (including trade in services) and the promotion of industrial upgrading, the initiative fosters green transformation and sustainable development in countries along the B&R. Rather than relying on input variables such as investment amount, this study selects outcome variables from the partner countries in the analysis based on four mechanisms (Table 10). Although the selection of dependent variables has its limitations, the findings are consistent with the latest study by Ember (Jones 2025).

China's multifaceted approach to supporting partner countries through trade, investment, public infrastructure, green technology, digital connectivity (including FinTech) and industrial upgrading are quite unique. Because of its position as the largest trading partner and the largest manufacturing exporting country and its advanced stage in green technology and FinTech, it has the capacity and technological know-how to support countries along the B&R through all-encompassing approaches. Environment and climate were not strategic priorities in earlier stages of the BRI (for example, China financed many overseas coal-fired power plants, which worsened CO_2 emissions). However, China is adapting to impacts and criticisms in domestic policies and in the international development arena. This self-correcting process may provide policy learning experiences for other countries.

Our findings carry substantial policy implications for all developing countries. First, emphasis should be placed on the critical role of low-carbon energy technologies, the spillover effects of digital technology advancements, openness to trade and sustainable investment in the environmental cooperation and governance framework of the BRI. Developing countries are at an early stage of economic development and often struggle to independently harness green technologies effectively. Given their focus on economic growth, the success of environmental policies in these nations hinges largely on global cooperation facilitated through international trade. Through such cooperation, cleaner and more efficient advanced green technologies from abroad can be disseminated to host countries, thereby optimizing their industrial structures. Consequently, some of these countries can achieve a "leapfrog" in the green transformation process.

While the GBRI has proven effective, it is essential to scrutinize the impact of China's OFDI, adjust its structure toward low-carbon and low-polluting industries and mitigate the increase in carbon emissions associated with such investments. Simultaneously, beyond mere economic growth, consideration must be given to minimizing carbon dioxide emissions in countries who are experiencing ascending economic development but are characterized by low government efficiency and weak rule of law. Strengthening these aspects of governance is crucial to promoting the overall reduction of global carbon emissions.

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