

The Nexus between Foreign Direct Investment, Green Taxation, Green Technological Innovation and the Low-Carbon Development in China's Tourism Sector

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Abstract: Foreign direct investment (FDI) serves as a pivotal external driver for the low-carbon transition in developing host countries. However, its environmental impact remains theoretically contested between the “pollution halo” and “pollution haven” hypotheses. While prior studies have predominantly examined its effects in manufacturing and energy sectors, limited attention has been given to its impacts on service industry. This study fills the existing research gap by applying a panel threshold model with two-way fixed effects, using provincial panel data from 30 Chinese provinces spanning 2007-2022. It investigates the nonlinear relationship between FDI and the low-carbon development in tourism (LCDT), with a particular focus on the moderating roles of green taxation (GTAX) and green technological innovation (GTI). The empirical findings reveal that: (1) FDI, GTAX, and GTI each significantly promote the LCDT; (2) GTI positively moderates the relationship between FDI and LCDT, whereas GTAX exhibits a negative moderating effect; and (3) these moderating effects demonstrate regional heterogeneities. Theoretically, this research extends the environmental impact literature of FDI to the service sector and uncovers the multifaceted mechanisms driving LCDT. Practically, it offers scientific basis for guiding the refined design and adjustment of GTAX policies, optimizing regional low-carbon governance plans, thereby supporting China's tourism sector in leveraging opportunities from the restructuring of global green supply chains.

Keywords: Foreign Direct Investment, Low-Carbon Development in Tourism, Green Taxation, Green Technological Innovation, Heterogeneity.

1. INTRODUCTION

In recent years, there has been a growing global consensus on achieving carbon neutrality and sustainable development. Major international organizations such as the United Nations, the World Bank, and the International Energy Agency have spearheaded a series of frameworks and initiatives that play a pivotal role in driving the green transition (Mastrucci *et al.*, 2025). The 2024 COP29 conference focused on key issues including energy transition, carbon market development, and climate finance (Arora, 2025), while COP16 emphasized the strong interlinkages between ecosystem conservation, sustainable tourism, and low-carbon economic models (Peeters & Papp, 2024), which underscores the international community's increasing attention to the low-carbon transformation of industries such as tourism, which bears both economic and environmental significance.

Against this backdrop, China has systematically incorporated green and low-carbon principles into its national strategy, implementing a suite of policy instruments-including green taxation (GTAX) and cleaner production initiatives-targeting key sectors such as tourism (Radulescu *et al.*, 2024). The government has placed particular emphasis on strengthening ecological compensation mechanisms, refining green fiscal systems, and facilitating the low-carbon

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transition of environmentally sensitive industries as tourism. Furthermore, green development indicators have been embedded into regional performance evaluation frameworks to enhance policy accountability and effectiveness (Huang *et al.*, 2022). The National Action Plan for Green tourism explicitly outlines strategies to increase the proportion of low-carbon projects, promote the adoption of clean energy in scenic destinations, develop “zero-carbon” demonstration zones, and accelerate the integration of green technologies, carbon accounting systems, and internationally recognized sustainability certifications (Islam, 2025).

Since China launched its reform and opening-door policy, foreign direct investment (FDI) has not only provided critical financial resources but has also played a catalytic role in promoting low-carbon development in the tourism sector (LCDT) through green technology spillovers and the introduction of advanced management practices (Shang *et al.*, 2024). Empirical studies indicate that FDI facilitates the localization of green technologies, thereby improving environmental performance and enhancing energy efficiency and emissions reduction outcomes (Liu *et al.*, 2024). Moreover, the higher environmental standards upheld by foreign-invested enterprises have spurred domestic firms to improve their green governance capabilities (Zhang *et al.*, 2024). As such, gaining more insight into the pathways through which FDI influences resource allocation, technological diffusion, and green transformation is critical for achieving LCDT (Balaguer *et al.*, 2022).

In addition, GTAX and green technological innovation (GTI) play critical roles in advancing LCDT. On one hand, GTAX can incentivize high-emission tourism enterprises to enhance their environmental compliance, increase their willingness to adopt green technologies, reduce energy consumption, and facilitate their green transformation (Fang *et al.*, 2023). Well-designed GTAX systems have also been shown to significantly improve firms’ green total factor productivity, thereby guiding service sectors such as tourism toward a high-quality and low-carbon development trajectory (Zhang *et al.*, 2024). On the other hand, GTI provides essential support for LCDT, particularly in urban tourism destinations, where such innovation enhances efficiency and reduces carbon emissions (Ren *et al.*, 2023). Furthermore, the integration of green digital technologies and green human resource management can also contribute to the green upgrading of the tourism sector.

To further extend the analytical framework, this study introduces green taxation (GTAX) and green technological innovation (GTI) as moderating variables to examine how outward foreign direct investment (FDI) influences low-carbon development in tourism (LCDT). Accordingly, the study seeks to address the following research questions:

1. Does FDI promote the LCDT?

This question aims to identify whether and how FDI contributes to the advancement of low-carbon development in the tourism sector.

2. Do GTAX and GTI independently contribute to the LCDT?

This question explores whether green taxation mechanisms and green technological progress can directly drive low-carbon development in tourism by creating financial incentives and fostering eco-innovation.

3. In what ways do GTAX and GTI moderate the impact of FDI on LCDT?

This question investigates the moderating roles of GTAX and GTI in shaping the FDI and LCDT nexus, particularly whether stronger green tax and innovation capacity can strengthen or offset FDI’s contribution to low-carbon outcomes.

4. Do these relationships exhibit heterogeneity across provinces with varying levels of development and geographical characteristics?

This question examines whether the strength and direction of the above relationships differ across regions, reflecting variations in economic structure, resource endowment, and environmental policy enforcement.

The key contributions and innovations of this research are summarized as follows:

First, this study constructs a comprehensive analytical framework that integrates outward foreign direct investment (FDI), green taxation (GTAX), and green technological innovation (GTI) to explain the mechanisms underlying low-carbon development in tourism (LCDT). Unlike previous studies that mainly examined the direct impact of FDI or environmental regulation on low-carbon outcomes, this study explicitly investigates how FDI affects LCDT through the dual moderating channels of GTAX and GTI. By linking capital flow, fiscal policy, and technological innovation within a unified framework, the study expands the theoretical understanding of how FDI contributes to sustainable transformation in the service industry, particularly tourism.

Second, from a methodological perspective, this research applies both moderating effect models and threshold effect models to capture the nonlinear and region-specific mechanisms through which GTAX and GTI shape the

relationship between FDI and LCDT. This dual approach enhances the robustness and explanatory power of the empirical results. It also extends the methodological toolkit for analyzing complex policy–investment–environment interactions in the fields of green finance, tourism economics, and sustainable development.

Third, by revealing significant regional heterogeneities in the effects of FDI on LCDT across eastern, central, and western provinces, this study provides evidence-based insights for differentiated policy design. The findings suggest that the positive effects of FDI on LCDT are more pronounced in regions with stronger green innovation capacity and more effective green taxation implementation. These results offer valuable policy implications for the refinement of region-specific GTAX systems, the strengthening of innovation-driven green transformation, and the improvement of local environmental governance. Moreover, the study contributes to promoting interregional coordination, enhancing resource allocation efficiency, and narrowing the green development gap among provinces.

2. LITERATURE REVIEW AND HYPOTHESES

2.1 FDI and LCDT

China's commitment to its “dual carbon” goals has ushered the tourism industry into a pivotal stage of low-carbon transition. As an energy-intensive sector that encompasses transportation, accommodation, and scenic site operations, tourism is responsible for nearly 8% of global carbon emissions, presenting a substantial obstacle to the achievement of “dual carbon” targets (Peeters & Papp, 2024). Facilitating the LCDT not only improves energy efficiency and reduces environmental stress but also aligns with global sustainability trends and enhances the international competitiveness of China's tourism industry (Lu, 2024).

In the process of promoting LCDT, FDI plays a critical role as a mechanism for optimizing resource allocation and facilitating cross-border flows of technological and managerial inputs. On the one hand, FDI contributes directly to the LCDT by introducing advanced low-carbon technologies, improving management practices, and aligning domestic operations with international green standards—thereby enhancing firms' participation in global value chains and providing both technical support and institutional frameworks (Yan *et al.*, 2024a). On the other hand, FDI encourages firms to proactively internalize international environmental regulations, strengthen environmental responsibility, and foster green innovation capacity. These improvements, in turn, enhance international competitiveness and promote the LCDT (Liu *et al.*, 2024).

In addition, a growing body of research affirms the positive impact of FDI on the LCDT. Grossman and Krueger (1991) highlighted the complex relationship between FDI, economic growth, and environmental quality, providing a foundation for examining how FDI can influence LCDT. Sun and Hasi (2024) argued that FDI not only promotes technological upgrading in domestic firms but also indirectly improves their environmental performance. Shi *et al.*, (2023), based on empirical analysis, found that FDI significantly enhances firms' green innovation output, with even stronger effects observed in the service sector. Wang and Shao (2022) further pointed out that Chinese tourism enterprises have successfully absorbed advanced low-carbon management practices through investments in developed countries, which have subsequently been localized and promoted domestically. Moreover, Cheng and Qi (2021) emphasized that in sectors with urgent low-carbon transformation needs—such as tourism—FDI facilitates the transfer of green technologies and managerial experience more effectively, thereby offering strong support for sustainable development.

Collectively, these findings indicate that FDI contributes not only to green transformation at the micro level but also to the efficient allocation of low-carbon development resources at the macro level.

Drawing upon the preceding analysis, this study puts forward the following hypothesis:

H1: *FDI can promote LCDT.*

2.2 GTAX, FDI, and LCDT

While the preceding discussion emphasizes the role of FDI in facilitating LCDT, the effectiveness of this process largely depends on the availability of green financial instruments that can channel resources toward environmentally sustainable sectors. In recent years, green finance has emerged as a primary channel for mobilizing financial resources toward clean energy transitions and sustainable tourism projects (Gan *et al.*, 2025). Several quantitative studies have indicated that, when integrated with renewable energy and technological innovation, green finance can promote the sustainable transformation of the tourism sector by reducing carbon emission intensity and enhancing the energy efficiency of tourism infrastructure (Chen *et al.*, 2025; Fu *et al.*, 2024). However, the extent to which green finance effectively drives low-carbon outcomes also hinges on the design of fiscal and regulatory mechanisms—particularly GTAX—that influence firms' incentives and investment behaviors.

GTAX, as a policy tool that integrates economic disincentives with environmental guidance, has increasingly emerged as a key instrument for advancing sustainable development (Su & Li, 2025; Ming-Jun&Jian-Ya, 2025). Its

effectiveness is reflected in several key dimensions. First, by sending clear price signals, GTAX raises the cost of high-emission activities, thereby promoting more efficient resource allocation (Ming-Jun&Jian-Ya, 2025). Second, it provides economic incentives for firms to pursue green innovation, thereby driving technological progress and industrial upgrading (Wang *et al.*, 2025). Third, GTAX encourages a shift toward sustainable industrial development models, ultimately enhancing the environmental performance of the economy (Munonye, 2025). Finally, by channeling tax revenues into green infrastructure and environmental protection projects, it fosters a positive feedback loop that reinforces long-term sustainability goals (Arimura *et al.*, 2024).

In the process of promoting LCDT, GTAX has become an essential policy instrument by internalizing environmental costs and encouraging enterprises to accelerate their low-carbon transformation. Porter hypothesis well-designed environmental regulations, such as GTAX, can stimulate technological innovation, which may enhance the positive effects of FDI on LCDT (Porter, 1991). Given that tourism encompasses several high-emission components-such as transportation, accommodation, and scenic area operations-fiscal incentives can effectively motivate firms to adopt energy-saving technologies, optimize their energy structures, and enhance overall carbon efficiency (Jin *et al.*, 2024). In particular, under mechanisms such as environmental taxes and carbon taxes, GTAX can indirectly promote alignment with environmental certification systems and green consumption standards, thereby accelerating low-carbon governance and the development of green branding in the tourism sector (Liu, 2024).

Extensive empirical evidence highlights the efficacy of GTAX in simultaneously advancing economic development and environmental protection. Wang *et al.*, (2023) found that China's implementation of carbon and energy taxes has significantly improved energy efficiency in hotel and scenic spot operations. Using provincial-level panel data, Qamruzzaman (2025) provided empirical evidence that environmental taxes not only curb carbon emissions but promote green innovation. Kim and Hyun (2020) emphasized that, by enhancing tourists' environmental awareness, GTAX can effectively guide sustainable tourism consumption. Moreover, Jabeen *et al.*, (2024), drawing on data from G7 countries from 1994 to 2020, demonstrated that environmental taxes positively contribute to low-carbon development by reducing greenhouse gas emissions and improving environmental quality.

Drawing upon the preceding analysis, this study puts forward the following hypothesis:

H2: *GTAX can promote LCDT.*

In recent years, China has gradually improved its GTAX system through the environmental “fee-to-tax” reform, effectively guiding FDI into green industries (Huang & Li, 2023). Studies have shown that GTAX, along with green finance and GTI, can significantly reduce carbon emissions (Zhang *et al.*, 2024).

Beyond its cost-constraining function, GTAX also exerts screening and incentive effects. A stable tax regime sends clear signals regarding environmental governance to foreign investors, attracting investment entities that possess green technologies and strong environmental responsibility (Tang *et al.*, 2024), thereby increasing the likelihood of FDI being allocated to green tourism projects. Additionally, by raising the operational costs of high-carbon activities and combining tax credits with green subsidies, GTAX enhances the economic attractiveness of green investment (Shang *et al.*, 2023). Empirical evidence further confirms that environmental tax reforms have promoted FDI inflows and strengthened foreign investors' willingness to engage in low-carbon projects (Huang & Li, 2023). Therefore, GTAX is likely to play a significant moderating role in the relationship between FDI and LCDT.

Drawing upon the preceding analysis, this study puts forward the following hypothesis:

H3: *GTAX can positively moderate the impact of FDI on LCDT.*

Moreover, a growing body of literature indicates that the moderating effect is not linear, but instead exhibits threshold and asymmetrical characteristics (Okombi & Babouama, 2024). While moderate levels of GTAX may incentivize green investment, excessive tax burdens can discourage foreign capital inflows-especially in sectors such as tourism, where long payback periods and high policy sensitivity make investors more risk-averse (Ianc, 2025). For example, Li and Liu (2025), in their study on green innovation in the manufacturing sector, found that the positive impact of FDI on green performance is the strongest when the level of urbanization is within a moderate range, suggesting the presence of an “optimal bandwidth” for environmental conditions. Similarly, Pang (2022) found through a threshold model that environmental taxes only have a significant incentive effect on GTI when they are below a certain critical value. Further, Zhang *et al.*, (2021) and Deng *et al.*, (2022) demonstrated nonlinear and inverted U-shaped relationships between FDI and green development from the perspectives of knowledge accumulation and spatial heterogeneity, respectively.

Given the capital-intensive, high risk, and long investment return cycle nature of the tourism industry, its sensitivity to GTAX is particularly pronounced. If tax policies are poorly designed, they may exacerbate foreign investors'

concerns about policy uncertainty and reduce their willingness to invest (Kholil *et al.*, 2025). Therefore, the design of GTAX systems must carefully account for the potential nonlinear moderating effects on FDI.

Drawing upon the preceding analysis, this study puts forward the following hypothesis:

H4: *The moderating effect of GTAX on the relationship between FDI and LCDT may exhibit a nonlinear threshold characteristic; as GTAX moves from a lower to a higher threshold, the moderating effect of FDI on LCDT gradually weakens.*

2.3 GTI, FDI, and LCDT

In addition to fiscal mechanisms such as GTAX, the capacity for GTI plays a critical moderating role in shaping how FDI contributes to LCDT. GTI, in the context of ecological modernization, refers to the upgrading and transformation of conventional technologies to promote resource efficiency and mitigate environmental degradation (Nie & Zhang, 2025). Rather than solely enhancing productivity, it prioritizes environmental compatibility, eco-efficiency, and sustainable resource use (Sun *et al.*, 2024a). These innovations are particularly vital for tourism industry, which is both energy-intensive and highly sensitive to environmental impacts. As global concerns over climate change and resource scarcity intensify, GTI is increasingly seen as a critical enabler of LCDT, offering new pathways toward sustainability and long-term resilience (Tiwari *et al.*, 2025).

In the tourism sector, GTI has played a pivotal role in improving environmental quality in tourism-intensive destinations by reducing energy consumption and transport-related emissions (Yang *et al.*, 2024). Drawing on panel data from 15 of the world's most popular tourist destinations, Avcı *et al.*, (2024) found a significant negative correlation between GTI and tourism-related carbon emissions, with evidence supporting a bidirectional causal relationship. Regions with higher levels of GTI are able to leverage green finance more effectively for sustainable tourism and urban low-carbon initiatives (Hailiang *et al.*, 2023). Furthermore, the application of GTI in tourism encompasses the adoption of renewable energy sources, the integration of intelligent energy management systems, and the use of sustainable construction materials, thereby contributing to advancing the LCDT (Avcı *et al.*, 2024).

Although GTI has demonstrated notable effectiveness in reducing carbon emissions within the tourism sector, its implementation trajectory is neither strictly linear nor unidirectional, but rather characterized by inherent complexities (Jiang & Lv, 2024). On the one hand, the adoption of GTI facilitates emission reductions and improves resource efficiency, thereby contributing to environmental sustainability. On the other hand, such GTI may give rise to the so-called “green rebound effect,” wherein lower operational costs induced by technological advancements many lead to an increase in tourism activities, potentially offsetting some of the environmental gains (Sun *et al.*, 2024b). Despite these concerns, a substantial body of empirical evidence underscores the positive influence of GTI on LCDT. Kayani *et al.*, (2024), in their analysis of BRICS countries, identified technological advancement and the deployment of renewable energy as key drivers of emissions reduction in tourism-related sectors. Moreover, the synergistic relationship between FDI and GTI merits attention. In addition to capital infusion, FDI facilitates the transnational transfer of green technologies and plays a crucial role in promoting environmentally sustainable upgrades of tourism infrastructure, particularly in developing economies (Caetano *et al.*, 2022). As such, the strategic relevance of GTI in advancing LCDT continues to grow.

Drawing upon the preceding analysis, this study puts forward the following hypothesis:

H5: *GTI can promote the LCDT.*

Building on the above analysis, FDI can positively influence LCDT through multiple channels, such as the introduction of advanced technologies and the optimization of resource allocation (Deng *et al.*, 2024; Wang *et al.*, 2024). FDI can promote low-carbon development more effectively in contexts where green technological innovation is present, as it both mitigates environmental impacts and enhances efficiency (Grossman and Krueger 1991; Porter, 1991). However, empirical findings on the sustainability outcomes of FDI remain inconclusive. On the one hand, FDI has the potential to accelerate the green transition of tourism. On the other hand, in certain regions, its environmental impact has been less favorable. These discrepancies are largely attributed to variations in institutional enforcement, technological absorptive capacity, and the stringency of environmental regulations (Hu *et al.*, 2018). Therefore, GTI effects of FDI are highly context-dependent and must be examined in conjunction with other key moderating factors (Hu *et al.*, 2019).

Among various moderating factors, GTI, as an endogenous capability at the firm or regional level, has increasingly been recognized as a key mechanism in moderating the environmental effects of FDI. Existing research suggests that GTI not only mitigates the potential negative environmental externalities associated with FDI but also amplifies its ecological benefits (Deng *et al.*, 2024). The relationship between FDI and GTI is often nonlinear: only when the level of urbanization reaches a certain threshold do the adverse effects of FDI begin to diminish and synergistic green effects emerge (Li & Liu, 2025). Furthermore, a sound institutional environment and a higher degree of marketization can significantly enhance the positive impact of FDI on GTI, indicating that GTI plays a critical role in mediating the relationship between FDI and low-carbon development (Deng *et al.*, 2024).

Accordingly, this study puts forward the following hypothesis:

H6: GTI can positively moderate the relationship between FDI and LCDT.

H7: The moderating effect is nonlinear, as GTI advances from lower to higher threshold levels, the moderating impact of FDI on LCDT progressively strengthens.

The conceptual framework underlying this study is depicted in Figure 1. In the diagram, dashed arrows represent potential moderating and threshold effects, while dashed boxes indicate the corresponding moderating and threshold variables.

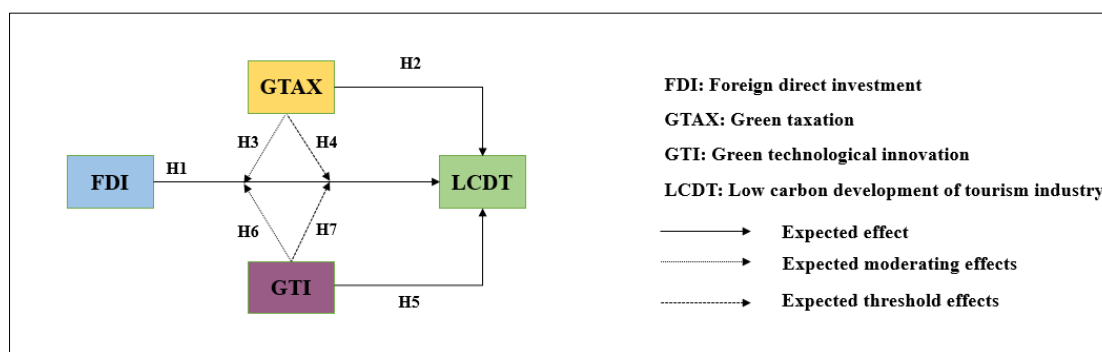


Figure 1: Conceptual framework of the impact mechanism.

3. Econometric Model and Data

3.1 Econometric Model

To investigate the influence of FDI, GTAX, and GTI on LCDT, this study adopts a panel threshold regression model with two-way fixed effects. The model also tests the moderating roles of GTAX and GTI within this relationship. Given regional heterogeneity in economic development and institutional contexts, sub-sample regressions are conducted to further explore spatial differences.

To test Hypotheses H1, H2, and H5, the following models (1) - (3) are constructed:

$$LCDT_{it} = \alpha_0 + \alpha_1 FDI_{it} + \alpha_2 Control_{it} + \delta_i + \sigma_t + \varepsilon_{it} \quad (1)$$

$$LCDT_{it} = \beta_0 + \beta_1 GTAX_{it} + \beta_2 Control_{it} + \delta_i + \sigma_t + \varepsilon_{it} \quad (2)$$

$$LCDT_{it} = \gamma_0 + \gamma_1 GTI_{it} + \gamma_2 Control_{it} + \delta_i + \sigma_t + \varepsilon_{it} \quad (3)$$

Here $LCDT_{it}$ denotes the level of LCDT in province i at time t ; FDI_{it} represents FDI; $GTAX_{it}$ indicates GTAX; and GTI_{it} refers to GTI. $Control_{it}$ is a vector of control variables, including social consumption level, fiscal expenditure, environmental regulation, and the degree of openness. δ_i and σ_t denote individual (province-specific) and time fixed effects, and ε_{it} is the error term.

In order to examine Hypotheses H3 and H6, this study further constructs the following models (4) - (5).

$$LCDT_{it} = \mu_0 + \mu_1 FDI_{it} + \mu_2 GTAX_{it} + \mu_3 FDI_{it} * GTAX_{it} + \mu_4 Control_{it} + \delta_i + \sigma_t + \varepsilon_{it} \quad (4)$$

$$LCDT_{it} = \rho_0 + \rho_1 FDI_{it} + \rho_2 GTI_{it} + \rho_3 FDI_{it} * GTI_{it} + \rho_4 Control_{it} + \delta_i + \sigma_t + \varepsilon_{it} \quad (5)$$

Here μ_3 and ρ_3 indicate the direction of the moderating effects. δ_i is the individual fixed effect, σ_t is the time fixed effect, and ε_{it} is the random error term.

In order to test H4 and H7, according to Hansen's (1999), this study constructs the following single-threshold regression methods (6) - (7).

$$LCDT_{it} = \vartheta_0 + \vartheta_1 FDI_{it} * I(GTAX_{it} \leq \gamma) + \vartheta_2 FDI_{it} * I(GTAX_{it} > \gamma) + \vartheta_3 Control_{it} + \delta_i + \sigma_t + \varepsilon_{it} \quad (6)$$

$$LCDT_{it} = \varphi_0 + \varphi_1 FDI_{it} * I(GTI_{it} \leq \gamma) + \varphi_2 FDI_{it} * I(GTI_{it} > \gamma) + \varphi_3 Control_{it} + \delta_i + \sigma_t + \varepsilon_{it} \quad (7)$$

Here $GTAX_{it}$ and GTI_{it} serve as threshold variables, γ denotes the threshold value, and FDI_{it} is the explanatory variable. I represents the indicator function. Extensions to multiple thresholds are possible but not examined here.

3.2 Variable

3.2.1 Explained Variable

The explained variable is LCDT. According to (Li *et al.*, 2025b), this study measures LCDT using the tourism carbon intensity index, calculated as the ratio of total tourism revenue to tourism-related carbon emissions, i.e.,

Tourism carbon intensity = Total tourism revenue / Tourism carbon emissions.

This indicator provides a straightforward reflection of the environmental cost associated with the economic benefits generated by the tourism industry.

3.2.2 Explanatory Variable

The explanatory variable is FDI. FDI data are sourced from the China Statistical Yearbook and provincial yearbooks. To ensure consistency, values are converted to RMB using annual average USD-RMB exchange rates (Guo *et al.*, 2025a; Xiao *et al.*, 2023).

3.2.3 Moderating and Threshold Variables

GTAX. Following Gerni *et al.*, (2025), GTAX is defined as the ratio of environment-related tax revenue to GDP. Environment-related tax revenue includes energy taxes, vehicle taxes, pollution emission taxes, and resource use taxes (Lu & Zhou, 2023).

GTI. GTI is measured by the combined number of green invention patents and green utility model patents, following Zeng *et al.*, (2023). A logarithmic transformation is applied in the model:

$$GTI = \ln(\text{Green invention patents} + \text{Green utility model patents} + 1)$$

3.2.4 Controls Variables

Social Consumption Level (SC). SC represents the aggregate ability of residents to consume goods and services, reflecting the significance of consumption in regional economic performance (Claudio-Quiroga *et al.*, 2025). Following Liu *et al.*, (2021), it is measured as the ratio of total retail sales of consumer goods to regional GDP.

Fiscal Expenditure (FE). FE reflects the government's capacity in macroeconomic regulation and environmental protection. Adequate fiscal resources enable governments to support GTI, thereby promoting low-carbon development (Wei *et al.*, 2022). Following Zhou *et al.*, (2024), it is measured as the ratio of local fiscal expenditure to regional GDP.

Environmental Regulation (ER). ER reflects the extent of regulatory oversight on environmentally harmful activities. Following Yan *et al.*, (2024b), it is measured using the Environmental Performance Index (EPI).

Trade Openness (OPEN). OPEN is considered a key factor influencing the inflow of FDI, and its impact is closely related to the stage of economic development (Jiang & Liu, 2023). Following Bleaney and Tian (2022), it is measured as the ratio of total imports and exports to regional GDP.

3.3 Data

Due to data availability, this study constructs a panel dataset covering 30 provinces in mainland China (excluding Tibet, Hong Kong, Macau, and Taiwan) over the period 2007–2022. Detailed variable definitions and data sources are provided in Table A1 of the Online Appendix.

All variables are initially subjected to unit root tests. Non-stationary series are transformed using first-order differencing. Post-transformation results confirm that all variables meet stationarity requirements. Multicollinearity is further assessed via VIF analysis, with results indicating no significant collinearity issues. The relevant results are shown in Tables A2-A3 in the Online Appendix. All variables were winsorized at the 1% level to reduce the influence of outliers. The analysis was performed using Stata 18.

4. EMPIRICAL RESULTS AND DISCUSSION

4.1 Fixed Effects Model

This study uses a two-way fixed effects panel model to estimate Models (1) - (5) and to test Hypotheses H1, H2, H3, H5, and H6. Table 1 shows the regression results.

Table 1: The regression results

LCDT	(1)	(2)	(3)	(4)	(5)
FDI	0.3320*** (0.0580)			0.5576*** (0.0531)	- 0.2326* (0.1398)
GTAX		0.4829*** (0.0403)		2.1742*** (0.1394)	
GTI			0.7050*** (0.0332)		0.5686*** (0.0510)
FDI*GTAX				- 0.3604***	

LCDT	(1)	(2)	(3)	(4)	(5)
				(0.0281)	
FDI*GTI					0.0429*** (0.0148)
SC	0.4498*** (0.0953)	0.2325*** (0.0884)	0.0526 (0.0723)	0.0289 (0.0762)	0.0102 (0.0721)
FE	0.0389 (0.0999)	0.1439 (0.0890)	-0.2849*** (0.0747)	0.0237 (0.0765)	-0.2721*** (0.0748)
ER	0.5468*** (0.0441)	0.3670*** (0.0391)	0.0928*** (0.0357)	0.2800*** (0.0366)	0.1373*** (0.0373)
OPEN	-0.3704 (0.3239)	2.3065*** (0.3749)	1.186149*** (0.2494)	1.4790*** (0.3218)	1.4874*** (0.2644)
Cons	-5.7364*** (0.5232)	-4.41417 *** (0.4447)	-5.2422*** (0.3610)	-4.4366*** (0.4039)	-4.8066*** (0.4829)
Year-fixed effect	√	√	√	√	√
Province-fixed effect	√	√	√	√	√
N	480	480	480	480	480
R square	0.3531	0.4744	0.6541	0.6284	0.6700

Note: *p<0.1; **p<0.05; ***p<0.01

The estimation results of models (1), (2), and (3) in Table 1 demonstrate that FDI, GTAX, and GTI each have a statistically significant and positive effect on LCDT. As shown in model (1), the coefficient of FDI is positive and significant at the 1% level, indicating that FDI effectively promotes LCDT. This finding supports hypothesis H1, which posits that FDI contributes to LCDT. As shown in model (2), the interaction term between FDI and GTAX is positive and significant, suggesting that higher levels of GTAX strengthen the positive effect of FDI on LCDT. This result supports hypothesis H2, which proposes that GTAX positively moderates the relationship between FDI and LCDT. The finding implies that effective implementation of GTAX can encourage enterprises to adopt cleaner technologies and enhance the environmental benefits derived from FDI. As shown in Model (3), the interaction term between FDI and GTI is positive and significant, indicating that GTI enhances the contribution of FDI to LCDT. This finding supports Hypothesis H5, confirming that GTI strengthens the positive environmental effects of FDI by improving technological absorption and diffusion capacity within the tourism industry. The corresponding coefficients are 0.3320, 0.4829, and 0.7050, all significant at the 1% level. These findings not only offer strong empirical support for the influence of these factors on LCDT but also echo the conclusions drawn by Trstenjak et al. (2025) and Jo et al. (2025). Accordingly, Hypotheses 1, 2, and 5 are empirically validated.

The estimation results of Model (4) suggest a significant interaction effect between FDI and GTAX. The coefficient of the interaction term *FDI*GTAX* is -0.3604 and is statistically significant at the 1% level, indicating that GTAX negatively moderates the impact of FDI on LCDT. This finding is inconsistent with the theoretical expectation outlined in Hypothesis 3, suggesting that, under certain conditions, GTAX may dampen the positive effect of FDI on LCDT. Several possible explanations may account for this result:

Firstly, GTAX may elevate firms' regulatory compliance and operational expenditures, thereby attenuating the environmental spillover effects associated with FDI. In regions with high GTAX intensity, enterprises are subject to substantial environmental levies-such as eco-taxes and carbon emission charges-which significantly increase their cost structures (Xu & Li, 2024). This effect is particularly pronounced in the tourism industry, where many FDI projects entail capital-intensive infrastructure development and high resource consumption. Under stringent GTAX regimes, financial constraints may crowd out investment in green technologies, thereby undermining the potential positive externalities of FDI (Kholil *et al.*, 2025).

Secondly, variations in GTAX intensity across provinces may incentivize foreign-invested enterprises to engage in spatial tax optimization by relocating to regions with relatively lower environmental tax burdens, thereby contributing to regional disparities in the low-carbon effects of FDI (Li *et al.*, 2025a). Given the heterogeneity in GTAX enforcement at the local level, some foreign firms may adopt a "race-to-the-bottom" strategy to minimize compliance costs by investing in jurisdictions with weaker environmental fiscal regimes (Pham *et al.*, 2025).

Thirdly, in the absence of complementary incentives, GTAX may inadvertently dampen the willingness of FDI to engage in green investment. Current policy frameworks tend to emphasize punitive environmental measures, while positive incentives-such as fiscal subsidies or green credit facilities-remain underdeveloped. This is particularly problematic in the

tourism sector, where investment *horizons* are long and returns are uncertain. Under high tax pressure and weak incentive structures, firms may adopt more conservative investment strategies, thereby limiting their contributions to low-carbon transformation (Buccella *et al.*, 2024; Tchorzewska, 2024).

The estimation results of Model (5) demonstrate a significant interaction between FDI and GTI. The interaction term $FDI*GTI$ carries a coefficient of 0.0429, which is statistically significant at the 1% level. This indicates that GTI positively moderates the effect of FDI on LCDT. The result aligns with the findings of Wang *et al.* (2024), thereby validating hypothesis 6.

4.2 Threshold Regression

To explore potential nonlinear moderating effects, this study applies bootstrap threshold estimation and the Wald test to model (6) and (7). Results are presented in Figure 2 and Table 2. Figures 2a-2b show distinct coefficient shifts across low (L), medium (M), and high (H) levels of the moderators, suggesting significant nonlinear effects. Table 2 further confirms a single-threshold structure in model (6) and a double-threshold in model (7). Accordingly, threshold regressions are conducted, with estimation results reported in Table 3.

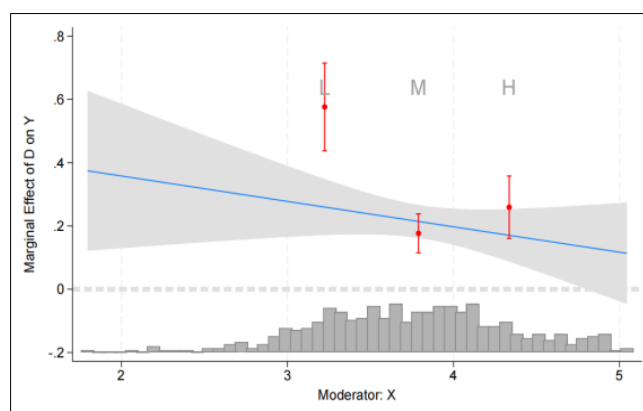


Figure 2a: Nonlinear impacts revealed in model 6

Figure 2a illustrates the estimated marginal effects of FDI (X) on LCDT (Y) across different levels of GTAX (moderator, D). The horizontal axis (X-axis) represents the moderator GTAX, ranging from low (L) to high (H) levels. The vertical axis (Y-axis) shows the marginal effect of FDI (X) on LCDT (Y), which reflects how changes in FDI influence LCDT at different levels of GTAX. The shaded area indicates the 95% confidence interval, while the histogram at the bottom shows the distribution of GTAX. Results confirm a single-threshold nonlinear effect, where the marginal effect of FDI on LCDT decreases as GTAX increases, suggesting that higher green tax levels weaken the positive impact of FDI on LCDT.

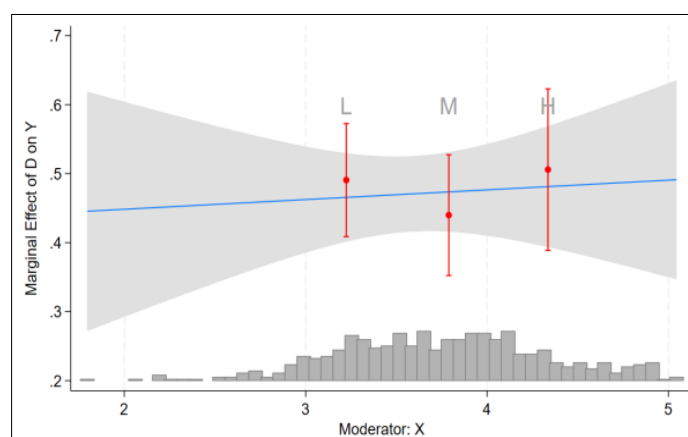


Figure 2b: Nonlinear impacts revealed in model 7

Figure 2b presents the estimated marginal effects of FDI (X) on LCDT (Y) across different levels of GTI (moderator, D). The X-axis represents GTI, ranging from low (L) to high (H) levels. The Y-axis represents the marginal effect of FDI (X) on LCDT (Y). The shaded region denotes the 95% confidence interval, and the histogram shows the distribution of GTI. The results identify a double-threshold nonlinear pattern, indicating that the moderating role of GTI

changes at two threshold points. When GTI is low, FDI's effect on LCDT is weak and when beyond higher GTI levels, FDI exerts a stronger positive influence on low-carbon transition.

Table 2: Threshold effects results

Model	Variables	Type	Values	p-values	95% Conf. Interval
(6)	GTAX	Single	1.3341	0.0000	[1.2632,1.3739]
		Double	/	/	/
(7)	GTI	Single	7.1944	0.0000	[7.0757,7.2729]
		Double	8.7562	0.0133	[8.6808,8.7915]

Note: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 3: Threshold effects regression results for each variables

Model	(6)	(7)		
FDI*LCDT(GTAX $\leq$ 1.3341)	0.1047*	0.059		
FDI*LCDT(GTAX $>$ 1.3341)	0.3864***	0.000		
FDI*LCDT(GTI $\leq$ 7.1944)			-0.1505**	0.02
FDI*LCDT(7.1944 $<$ GTI $\leq$ 8.7562)			0.1480***	0.004
FDI*LCDT(GTI $>$ 8.7562)			0.3845***	0.000
SC	0.2637***	0.002	0.1933**	0.019
FE	0.0371	0.674	-0.0903	0.291
ER	0.4232***	0.000	0.3593***	0.000
OPEN	-0.2456	0.392	-0.0921	0.739
Year-fixed effect	√	√	√	√
Province-fixed effect	√	√	√	√

Note: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

4.2.1 Threshold Effects of GTAX

The estimation results from model (6) provide strong evidence of a significant single-threshold effect in the moderating role of GTAX on the FDI and LCDT relationship. The estimated threshold for GTAX is 1.3341, with a narrow confidence interval and statistical significance at the 1% level, indicating the robustness of the threshold structure. A comparison of coefficient estimates across regimes reveals substantial heterogeneity. When GTAX falls below the threshold (i.e., < 1.3341), the marginal effect of FDI on LCDT is relatively weak (coefficient = 0.1047). In contrast, when GTAX exceeds the threshold (> 1.3341), the coefficient rises markedly to 0.3864. These findings imply that higher levels of GTAX significantly amplify the positive spillover effects of FDI on LCDT, potentially by strengthening environmental incentives and enhancing institutional credibility.

When GTAX remains below the identified threshold (1.3341), the positive effect of FDI on LCDT is relatively weak and only marginally significant. This may be attributed to several factors. First, insufficient environmental regulatory pressure under low GTAX regimes reduces firms' incentives to invest in emission reduction, prompting foreign firms to retain carbon-intensive technologies. Second, the persistence of the "pollution haven" effect means that some FDI is driven by cost minimization rather than technological upgrading, thus offering limited contributions to decarbonization. Third, low levels of GTAX may discourage foreign firms from engaging in high-cost low-carbon innovations or collaborating with local partners, thereby constraining green technology spillovers.

In contrast, when GTAX exceeds the threshold (1.3341), the positive impact of FDI on LCDT is significantly amplified. This can be explained by several reinforcing mechanisms. First, higher environmental costs activate the innovation compensation effect, prompting FDI enterprises to adopt advanced technologies from their home countries to reduce compliance burdens (Xuan, 2025). Second, elevated GTAX levels act as credible market signals, attracting green-oriented FDI that views low-carbon capabilities as a competitive advantage, especially in emerging sectors such as eco-tourism and carbon-neutral travel (Kong *et al.*, 2024). Third, stricter environmental tax regimes facilitate local supply chain upgrading, compelling FDI to align with evolving sustainability standards and fostering a virtuous cycle of technological spillovers and industrial transformation. Thus H4 is validated.

4.2.2 Threshold Effects of GTI

The estimation results from model (7) provide strong evidence of a double-threshold effect in the moderating role of GTI on the FDI-LCDT relationship. When GTI is below the first threshold (7.1944), FDI has a negative effect on LCDT. This suggests that in contexts with underdeveloped GTI capacity, FDI may lead to environmentally harmful outcomes, such as the transfer of carbon-intensive production or pollution-intensive operations. As GTI rises above the first threshold but remains below the second (7.1944-8.7562), the effect of FDI becomes positive, indicating that moderate levels of GTI improve absorptive capacity and facilitate more effective use of green technologies introduced by foreign firms. When GTI

surpasses the second threshold (>8.7562), the positive impact of FDI is further amplified. This reflects enhanced synergy between advanced domestic green capabilities and foreign investment, enabling more effective diffusion of low-carbon technologies, sustainable management practices, and green supply chain integration within the tourism sector.

The findings indicate that at low levels of GTI, the limited technological capacity and weak environmental governance in host regions tend to attract FDI characterized by pollution-intensive and energy-consuming activities, thereby exerting a detrimental impact on LCDT (Li and Liu, 2025). As GTI reaches a moderate level, improvements in the host country's absorptive capacity and regulatory enforcement enable foreign firms to partially adopt cleaner technologies and adapt to environmental standards, thus shifting FDI toward a more supportive role in the green transition (Li, 2025). At high levels of GTI, a mature domestic green innovation system and stringent regulatory environment compel foreign-invested enterprises to comply with higher environmental benchmarks. Simultaneously, enhanced local capabilities in technology absorption, imitation, and re-innovation facilitate deeper FDI-technology integration, significantly amplifying the positive contribution of FDI to LCDT. These dynamics are consistent with the findings of Fang *et al.*, (2023) and Ngoc *et al.*, (2025). Thus H7 is validated.

4.3 Heterogeneity Analysis

4.3.1 Heterogeneity Analysis on Different Economic Development Levels

To explore the impact of economic development heterogeneity on the FDI-LCDT nexus, this study follows Guo and Cai (2023) and calculate the average real per capita GDP for each province from 2007 to 2022. Based on the median value, provinces are classified into high and low-development groups. Separate regressions are then performed for each subgroup. The results are reported in Table 4.

Table 4: Heterogeneity analysis across different economic development levels

Variables	High economic development		Low economic development	
FDI	0.8581*** (0.0958)	-0.0956 (0.3942)	0.3333*** (0.0767)	-0.5836*** (0.2179)
GTAX	2.3407*** (0.1847)		2.2889*** (0.2160)	
GTI		0.6605*** (0.1512)		0.5106*** (0.0647)
FDI*GTAX	-0.4103*** (0.0373)		-0.2854*** (0.0538)	
FDI*GTI		0.0144 (0.0409)		0.0907*** (0.0243)
controls	ok	ok	ok	ok
Year-fixed effect	√	√	√	√
Province-fixed effect	√	√	√	√

Note : * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

In high economic development regions, the moderating role of GTI in the relationship between FDI and LCDT is statistically insignificant. This heterogeneity reflects a possible attenuation of the FDI-GTI interaction mechanism. First, these regions often exhibit mature green innovation systems, robust technological foundations, and comprehensive policy support, which may result in diminishing marginal contributions of new FDI to technological upgrading—an “innovation saturation” effect (Ketchoua *et al.*, 2024). Second, FDI in such areas is predominantly market-seeking, driven by consumption and expansion motives rather than technological spillovers, thus limiting its capacity to catalyze green transitions (Barboza *et al.*, 2025). Third, local governments in these regions tend to adopt proactive, well-institutionalized strategies for promoting low-carbon development, where policy instruments and fiscal interventions may dominate or substitute the interactive pathways between FDI and GTI (Liu *et al.*, 2023).

4.3.2 Heterogeneity Analysis on Different Geographic Locations

Considering the significant heterogeneity in economic development across Chinese regions, industrial structure, and the enforcement of green development policies, notable differences exist in the distribution of GTAX burdens and levels of GTI across provinces (Fang *et al.*, 2023). To further examine whether these spatial variations affect the role of FDI in promoting LCDT, this study follow Gao *et al.*, (2024) and divide the sample into three major geographic regions: eastern, central, and western China. Panel threshold regressions are then conducted separately for each sub-region. The results are presented in Table 5.

Table 5: Heterogeneity analysis across eastern, central, and western China

Variables	Eastern		Central		Western	
FDI	0.5770*** (0.1357)	-0.9556*** (0.2933)	0.9459*** (0.1170)	3.0060*** (0.5876)	0.2568*** (0.0710)	-0.3375 (0.2414)
GTAX	1.9924*** (0.2661)		2.4775*** (0.1286)		2.1448*** (0.2000)	
GTI		0.3890*** (0.1308)		1.9088*** (0.2204)		0.4512*** (0.0680)
FDI*GTAX	-0.3399*** (0.0516)		-0.4555*** (0.1024)		-0.2945*** (0.0547)	
FDI*GTI		0.0911*** (0.0311)		-0.3226*** (0.0623)		0.0614** (0.0286)
controls	ok	ok	ok	ok	ok	ok
Year-fixed effect	√	√	√	√	√	√
Province-fixed effect	√	√	√	√	√	√

Note : * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

In the eastern region, the interaction $FDI*GTAX$ is significantly negative (-0.3399, $p < 0.01$), suggesting that more stringent GTAX attenuate the positive contribution of FDI to LCDT. Conversely, the interaction $FDI*GTI$ is significantly positive (0.0911, $p < 0.01$), indicating that advancements in GTI strengthen the environmental spillover effects of FDI in this region.

In the central region, both $FDI*GTAX$ (-0.4555) and $FDI*GTI$ (-0.3226) yield statistically significant negative coefficients at the 1% level. These findings imply that neither GTAX nor GTI currently acts as an effective facilitator of FDI-driven decarbonization in the tourism sector. Instead, they appear to exert a counteractive influence, potentially due to institutional constraints, limited absorptive capacity, or policy misalignments.

In the western region, the negative sign of the $FDI*GTAX$ coefficient (-0.2945) similarly suggests a suppressive effect of GTAX on FDI's environmental performance. However, the interaction $FDI*GTI$ is positive and statistically significant (0.0614, $p < 0.05$), indicating that GTI capabilities in this region may play a catalytic role in reinforcing the low-carbon benefits of foreign investment, albeit to a modest extent.

The heterogeneity analysis reveals distinct regional disparities in the synergistic effects of FDI and GTI on LCDT. In the central region, the interaction effect is negative, indicating a decoupling between GTI and FDI. This may be due to underdeveloped green technologies, limited commercialization, and weak integration with the tourism industry (Gavrilović & Maksimović, 2018). Additionally, FDI in this region is often directed toward traditional or resource-intensive sectors (Brühl, 2024), which may hinder green transformation and exacerbate environmental pressures. By contrast, the eastern region benefits from a mature innovation system and strong absorptive capacity, facilitating effective FDI-GTI integration and promoting LCDT. In the western region, although economic development is weaker, targeted policies have attracted FDI into ecological and sustainable tourism projects, enhancing the FDI-GTI synergy. Overall, the effectiveness of this interaction depends on institutional quality, innovation maturity, and the alignment between foreign capital and local green strategies.

4.4 Robustness Test

4.4.1 Dynamic Adjustment Test

The presence of reciprocal causality among GTAX, GTI, and LCDT raises endogeneity concerns, potentially undermining the reliability of the parameter estimates. To address this issue, this study follows Wang (2024) by incorporating one-period lagged values of the key explanatory variables. The outcomes in Table 6 remain broadly consistent with the baseline results, thereby reinforcing the robustness of the empirical findings.

Table 6: Threshold regression results using lagged explanatory variables

	(6)	(7)
FDI*LCDT($GTAX \leq \gamma_1$)	0.1456** (0.0576)	
FDI*LCDT($GTAX > \gamma_2$)	0.3897*** (0.0530)	
FDI*LCDT($GTI \leq \gamma_1$)		-0.0568 (0.0655)
FDI*LCDT($\gamma_1 < GTI \leq \gamma_2$)		0.2139***

	(6)	(7)
		(0.0541)
FDI*LCDDT(GTI> γ_2)		0.4115*** (0.0511)
Controls	ok	ok
Year-fixed effect	✓	✓
Province-fixed effect	✓	✓

Note: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

4.4.2 Extreme Value Trimming Test

To address potential biases arising from extreme observations, this study follows Li *et al.*, (2025b) excludes the top and bottom 1%, 5%, and 10% of values for GTAX and GTI. This yields sub-samples of 29, 28, and 27 provinces, respectively. Threshold regressions are then re-estimated using these trimmed samples. The empirical results in Table 7 closely align with the baseline findings, thereby confirming the robustness of the model.

Table 7: Extreme value trimming test results

	1%		5%		10%	
	(6)	(7)	(6)	(7)	(6)	(7)
FDI*LCDDT(GTAX $\leq \gamma_1$)	0.1394** (0.0655)		0.1257* (0.0686)		0.1302* (0.0734)	
FDI*LCDDT(GTAX $> \gamma_2$)	0.4190*** (0.0601)		0.4104*** (0.0630)		0.4143*** (0.0672)	
FDI*LCDDT(GTI $\leq \gamma_1$)		-0.1939** (0.0754)		-0.198** (0.0778)		-0.221*** (0.0818)
FDI*LCDDT($\gamma_1 < \text{GTI} \leq \gamma_2$)		0.1382** (0.0595)		0.1447** (0.0621)		0.1213* (0.0664)
FDI*LCDDT(GTI $> \gamma_2$)		0.3484*** (0.0560)		0.3643*** (0.0585)		0.3473*** (0.0619)
Controls	ok	ok	ok	ok	ok	ok
Year-fixed effect	✓	✓	✓	✓	✓	✓
Province-fixed effect	✓	✓	✓	✓	✓	✓

Note: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

4.4.3 Additional Control Variables

To further validate the robustness of the empirical findings, energy intensity (EI) was introduced as an additional control variable within the threshold regression framework. As presented in Table 8, the inclusion of EI yields consistent results with the baseline estimates, further validating the robustness of the empirical findings.

Table 8: Threshold effects with energy intensity as an additional control

	(6)	(7)
FDI*LCDDT(GTAX $\leq \gamma_1$)	0.1237** (0.0487)	
FDI*LCDDT(GTAX $> \gamma_2$)	0.2901*** (0.0461)	
FDI*LCDDT(GTI $\leq \gamma_1$)		-0.0484 (0.0588)
FDI*LCDDT($\gamma_1 < \text{GTI} \leq \gamma_2$)		0.1640*** (0.0456)
FDI*LCDDT(GTI $> \gamma_2$)		0.3083*** (0.0450)
Controls	ok	ok
Year-fixed effect	✓	✓
Province-fixed effect	✓	✓

Note: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

5. CONCLUSION

5.1 Key Findings

Drawing upon panel data from 30 Chinese provinces over the period 2007-2022, this study applies a panel threshold model with two-way fixed effects to empirically assess the impact of FDI on LCDDT, with particular emphasis on

the moderating roles of GTAX and GTI. The principal findings are summarized as follows: First FDI, GTAX, and GTI each significantly promote the LCDT; Secondly, GTI positively moderates the FDI and LCDT nexus, whereas GTAX exhibit a negative moderating effect; and thirdly, these moderating effects demonstrate regional heterogeneity. These results highlight the context-dependent nature of FDI's environmental outcomes and the critical importance of aligning fiscal and innovation policies with regional development strategies.

5.2 Discussion

While the empirical findings largely align with the proposed hypotheses, some results diverge from expectations. To elucidate the underlying causes and theoretical implications of these variations, further analysis is presented.

5.2.1 Main Effects Perspective

The empirical results of this study indicate that FDI, GTAX and GTI all significantly promote LCDT. Hypotheses 1, 2, and 5 are empirically validated and H6 doesn't validated. This finding is largely consistent with the conclusions of existing literature (Tchorzewska, 2024; Guo *et al.*, 2025a). Moreover, this study empirically reveals China's policy-oriented pathway toward promoting the market-oriented allocation of green factors, optimizing resource structures, and facilitating high-quality tourism development. Specifically, GTAX, as a form of environmental regulation, has played a pivotal role in guiding corporate environmental responsibility and has effectively contributed to the achievement of cleaner production and emission reduction goals (Gerni *et al.*, 2025). Meanwhile, GTI has significantly strengthened the endogenous momentum for LCDT by improving energy efficiency and accelerating the application and commercialization of green products and services (Kumail *et al.*, 2024).

5.2.2 Moderating Effects Perspective

The empirical findings indicate that GTAX negatively moderates the relationship between FDI and LCDT, while GTI exerts a significant positive moderating effect. Hypotheses 4, hypotheses 7 are validated. This outcome suggests that, amid increasing environmental tax pressures, the rising cost burden on enterprises may lead to resistance or passive responses toward GTAX, thereby discouraging green investment behavior. Conversely, GTI enhances energy efficiency and reduces the marginal cost of environmental management, which can partially offset cost constraints and thus amplify the positive effect of FDI on LCDT.

5.2.3 Heterogeneity Perspective

From the dual dimensions of economic development level and geographical location, the empirical results reveal significant heterogeneity in the impact of FDI on LCDT.

In terms of economic development level, the moderating effect of GTI on the relationship between FDI and LCDT is not statistically significant in regions with higher levels of economic development. This may be attributed to two factors. First, these regions may already possess well-established green technology infrastructures and mature low-carbon transition mechanisms, enabling foreign-invested enterprises to effectively integrate into and promote the tourism sector's green transformation regardless of the degree of local technological innovation. Consequently, the marginal moderating role of GTI in such regions is relatively diminished. Second, the lack of effective synergy between GTI and FDI in these areas may hinder the practical application of technological outcomes within the tourism sector, thereby weakening the moderating effect.

With regard to geographical location, the moderating effect of GTI on the relationship between FDI and LCDT is negative in central China, but positive in the eastern and western regions. This indicates regional disparities in green technology absorption capacity, FDI utilization efficiency, and institutional environments. In central regions, a weaker foundation for green industries and a potential "technological mismatch" between GTI and FDI-coupled with insufficient collaborative mechanisms-may undermine the conversion of their interaction into low-carbon momentum, even leading to adverse effects. In contrast, the eastern region, supported by a robust technological base and well-functioning market mechanisms, facilitates effective interaction between FDI and GTI. The western region, meanwhile, may benefit from policy support and preferential green investment, achieving a synergistic effect between GTI and FDI. Therefore, region-specific strategies are essential to advancing the low-carbon transformation of the tourism sector-particularly by strengthening the technological transformation capacity and institutional support in central regions, and enhancing cross-regional collaboration efficiency.

6. Theoretical Contributions and Policy Implications

6.1 Theoretical Contributions

This study makes several key theoretical contributions and offering new insights into how FDI promotes LCDT and thereby advancing the scientific understanding of the environmental effects of FDI under institutional and technological contexts.

First, this study breaks through the traditional limitations of FDI-related environmental effect theories, which have predominantly focused on the manufacturing sector, by introducing the “pollution halo” and “pollution haven” hypotheses into the context of the service sector-specifically tourism-for the first time. By constructing an integrated “FDI-GTAX-GTI” framework, the study reveals the complex mechanisms through which FDI drives LCDT via channels such as technology spillovers, managerial upgrading, and alignment with international environmental standards. This theoretical framework not only bridges the gap between industrial and service-sector perspectives on FDI’s environmental impacts but also reveals how fiscal and technological factors jointly shape the pathways through which FDI drives LCDT. In doing so, the study refines and contextualizes classical environmental theories by demonstrating that the environmental outcomes of FDI depend not merely on the scale of investment but on the synergy between capital inflow, tax-based incentives, and technological capabilities. This integration broadens the theoretical boundaries of the “pollution halo” hypothesis, positioning it within a multidimensional context that incorporates both institutional regulation and technological innovation.

Second, by introducing both moderating and threshold effect models, this study transcends the conventional linear assumptions of environmental economics and empirically reveals nonlinear and context-dependent mechanisms in the interaction between FDI, GTAX, and GTI. Using a panel threshold model, it empirically uncovers significant nonlinear effects-identifying a single threshold for GTAX (1.3341) and double thresholds for GTI (7.1944 and 8.7562). These findings demonstrate that the green effects of FDI are highly contingent upon local institutional and technological conditions. The results provide robust empirical evidence for the theory of “optimal environmental regulation intensity” and deepen the contextual understanding of the pollution haven hypothesis, highlighting its conditional applicability. Moreover, by empirically validating the conditional nature of the pollution haven and halo effects, the study enhances theoretical precision regarding when and where FDI yields green outcomes. This approach enriches the methodological and conceptual toolkit for studying FDI-environment dynamics, offering a replicable analytical framework for future research in other sectors or countries.

Third, the study identifies substantial regional heterogeneity in the synergistic effects between FDI and GTI: an amplifying effect in eastern China, a negative effect in the central region, and a complementary effect in the western region. These differentiated outcomes challenge the prevailing assumption of a uniformly positive FDI-innovation synergy and instead highlight the importance of spatial and institutional contexts. By developing a tripartite explanatory framework encompassing institutional quality, innovation maturity, and FDI structure, this research advances theoretical understanding of the spatial asymmetry and context dependency of LCDT. It demonstrates that the environmental effectiveness of FDI is not universal but contingent on the local governance environment, innovation ecosystem, and absorptive capacity. This insight contributes to a more comprehensive and adaptive theoretical paradigm that integrates regional development disparities into the broader narrative of green transformation and sustainable tourism.

Collectively, these contributions deepen the academic understanding of how FDI with GTAX and GTI to LCDT. The study thus enriches the theoretical discourse on FDI, moving it beyond the manufacturing bias toward a more inclusive and multidimensional framework applicable to emerging service-based economies.

6.2 Policy implications

6.2.1 From the Perspective of FDI Promoting LCDT

To enhance the role of FDI in advancing LCDT, policymakers should not only focus on the scale of investment inflows but also on their environmental and technological quality. Local governments should prioritize the attraction of high-quality, environmentally sustainable FDI projects that introduce advanced green technologies, energy-efficient management practices, and eco-friendly infrastructure. By shifting from quantity-driven to quality-oriented FDI strategies, governments can ensure that foreign capital contributes effectively to both economic growth and carbon reduction.

Moreover, regional policy differentiation is crucial for maximizing FDI’s green spillover effects. In the eastern provinces, where innovation capacity and institutional maturity are relatively strong, policy emphasis should be placed on enhancing the technological synergy between foreign and domestic firms to consolidate innovation-driven LCDT. In contrast, central regions should focus on strengthening environmental regulation and improving monitoring mechanisms to prevent potential “pollution haven” effects associated with FDI inflows. Meanwhile, western provinces should adopt more proactive and flexible strategies, such as providing green subsidies, tax exemptions, and land-use incentives, to attract sustainable and clean-energy FDI projects that can serve as catalysts for regional transformation.

In addition, policy frameworks should aim to refine the design and implementation of GTAX by introducing differentiated and performance-based tax incentives that reward low-carbon production and penalize excessive emissions. Such mechanisms not only encourage foreign investors to adopt cleaner technologies but also align local fiscal policies with global sustainability goals.

At the same time, governments should promote regional innovation cooperation and technology diffusion through platforms that connect FDI enterprises, research institutions, and local firms. Leveraging FDI as a key channel for importing and localizing advanced low-carbon technologies can create positive spillover effects that strengthen local innovation ecosystems and accelerate the transition to a low-carbon tourism economy. Finally, establishing a transparent and stable policy environment that integrates green finance, taxation, and innovation support will further reinforce the long-term sustainability of FDI's contribution to LCDT.

6.2.2 From the Perspective of the Moderating Role of GTAX

Given the persistently negative interaction effects between GTAX and FDI on LCDT, the current GTAX regime in China appears to function more as a cost burden than as a green incentive. This suggests a lack of regionally differentiated guidance mechanisms. Accordingly, the study puts forward the following policy recommendations:

- 1) Establish cost-buffering and dynamic compensation mechanisms. Temporary tax exemptions should be provided for key green tourism investments (e.g., low-carbon transportation, zero-carbon hotels) to alleviate compliance cost pressures. Additionally, a “green tax-to-subsidy” channel could be implemented, allowing a portion of the environmental taxes paid by firms to be redirected toward their own green technology upgrades or carbon offset programs. This approach not only buffers short-term compliance costs but also reinforces long-term green innovation incentives, transforming GTAX from a pure cost into a strategic reinvestment tool.
- 2) Formulate a national baseline for GTAX. China's current GTAX structure lacks a unified baseline, resulting in uneven implementation and potential interregional tax competition. Establishing a national GTAX benchmark rate while granting provinces limited flexibility to adjust rates based on local ecological capacity and industrial composition would ensure both fairness and adaptability. In ecologically fragile or underdeveloped regions, introducing “green investment tax credits” could further encourage FDI participation in low-carbon projects. For example, foreign firms could be allowed to deduct a percentage of their verifiable low-carbon investment expenditures from payable environmental taxes. This policy would help redirect capital flows toward regions with higher environmental value, while also balancing economic and ecological objectives.
- 3) Strengthen green incentive policy mixes. Measures such as interest subsidies for green credit lines supporting FDI-linked low-carbon tourism projects could help reduce financing costs. Tax credits for the adoption of green technologies-such as income tax deductions for purchasing low-carbon equipment-should also be considered. Furthermore, corporate income tax deductions for the purchase or application of certified low-carbon technologies should be introduced to stimulate technological upgrading. In addition, establishing a pilot green transformation insurance fund for the tourism sector-jointly financed by local governments, policy banks, and commercial institutions, it could help share the risks associated with adopting new technologies and reinforce investor confidence in sustainable development initiatives.

Overall, these policies would transform GTAX from a static fiscal instrument into a dynamic governance mechanism that aligns environmental taxation with technological innovation and regional sustainability goals. By doing so, GTAX can evolve from a short-term constraint into a long-term driver of green competitiveness and low-carbon transition in China's tourism sector.

6.2.3 From the Perspective of Heterogeneities

In terms of economic development levels, it is recommended to adopt a gradual “technology-first, tax-later” policy approach to enhance the positive impact of FDI on LCDT. First, efforts should be made to strengthen support for GTI, such as establishing industry-academia-research collaboration platforms and providing incentives for the transfer of green patents, thereby improving their effectiveness in localized application. Second, drawing on the experience of Guo *et al.*, (2025b) in the logistics sector, phased and regionally differentiated green incentive policies should be promoted to ensure synergy between environmental regulation and the supply of technological capabilities. Finally, in conjunction with global research on carbon pricing and referencing the conclusion of Ahmad *et al.*, (2024), that a moderate increase in carbon tax can significantly reduce carbon emissions-a gradual increase in GTAX burden should be implemented to facilitate LCDT driven by FDI, GTI, and GTAX.

In terms of regional heterogeneity, it is recommended that the central region advance along two dimensions simultaneously. First, efforts should be made to strengthen the capacity for green technology collaboration and transformation. Drawing on the coordinated industry-university-research mechanisms proposed by Ketchoua *et al.*, (2024), FDI enterprises should be encouraged to jointly establish green pilot projects with local universities and innovation institutions to facilitate technology demonstration and conversion. At the same time, building on the successful experience of Sun *et al.*, (2024a) in constructing a synergistic network of green innovation knowledge, policy, and personnel within the renewable energy sector, policy incentives should be designed to foster a regional “super-network” of green innovation. Second, the GTAX framework should be adjusted to better facilitate the inflow of green FDI. For instance, FDI projects that introduce and localize green technologies may qualify for tax deductions or phased tax reductions. Furthermore, part

of the GTAX revenue could be earmarked to establish a “Green Technology Development Fund for the Central Region” which would provide subsidies to offset the initial costs associated with enterprises’ green transition.

7. Limitations and Directions for Future Research

The relationship between FDI and LCDT may be shaped by various contextual factors, suggesting a promising avenue for future research. Specifically, the current analysis focuses solely on GTAX and GTI. Future research could incorporate additional influencing factors.

In addition, this study only used a panel bidirectional fixed effects model to analyze variable relationships. Future research can use other models (such as coupling coordination model or game theory) for more attempts.

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