

*Original Research*

# Green Technology Innovation, Tourism Industrial Structure, and Tourism Economy: Empirical Evidence from Cities in the Yangtze River Delta

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## Abstract

An investigation into the symbiosis of ecological technological advancement, augmentation of the tourism sector's framework, and the progressive metamorphosis of the economic vitality of tourism suggests potent methodologies for the attainment of elevated, eco-consciously refined development within the tourism domain. This study, grounded upon panel data between 2000 and 2019 from a quartet of provinces and municipalities within the Yangtze River Delta and harnessing the technique of OLS regression, initially dissects the interconnection between ecological technological ingenuity and the fiscal escalation of tourism. Subsequently, this study delves into the intermediary function of the tourism sector's cadre by utilizing a model to ascertain the mediation impact. The exposition uncovers several findings: (1) Ecological technological innovation not merely engenders affirmative repercussions during its contemporary term but is also poised to endow future tourism with fiscal augmentation; (2) The innovation within the Yangtze River Delta milieu fosters the refinement of the tourism industry's scaffold, though with a brief time of latency; (3) Within the odyssey of ecological technological innovation and the economic propulsion of tourism, the refinement of the tourism industry's structure assumes a compartmentalized mediating influence; (4) Differential analysis reveals that, in comparison to their counterparts in Zhejiang and Anhui, the initiatives in ecological technological innovation in Shanghai and Jiangsu provinces show a more emphatic impetus towards the economic proliferation of tourism.

**Keywords:** tourism economy, ecological technological innovation, tourism industry structure, mediation impact, Yangtze River Delta region

## Introduction

Green technological innovation stands as a pivotal conduit for mitigating climatic challenges and diminishing carbon emissions. As delineated by the data from the “China Green Technology Innovation Index Report,” there has been a momentous escalation in national green patent filings, ballooning from over 43,000 in 2008 to more than 150,000 in 2021, with the sum of green patents granted surging from over 19,000 to 184,000, reflecting an annual growth rate of 17.5%. The “14<sup>th</sup> Five-Year Plan” of the nation underscores the mandate to “support green technological innovation and foster clean production.” In this context, green technological innovation has once again ascended to the forefront of societal scrutiny. The “Green Technology Promotion Catalogue” posits that green innovation thrives in spheres like energy-saving and environmental protection, clean production, clean energy, ecological environment industries, and infrastructural green enhancements, all of which interweave intimately with the tourism sector. Technologies such as the Internet of Things, big data, and cloud platforms have invigorated the intelligence and digitization of tourism enterprises; vegetation restoration techniques have mitigated environmental degradation within scenic areas; and tourism provides a vast tableau for the deployment of green technology. Ergo, probing into the logical mechanisms, transmission channels, and materialization avenues of green technological innovation in relation to the tourism economy is of paramount practical significance and scholarly merit.

Within the economic realm, scholars have embarked on profound inquiries into green technological innovation. The extant literature principally orbits around two facets: first, the driving forces behind green technological innovation, including foreign direct investment [1], information technology [2], environmental regulation [3], digital transformation, digital finance [4], monetary policy [5], and various other technological, institutional, and policy factors; and second, the economic repercussions of green technological innovation, spanning connections with corporate performance [6, 7], economic development of superlative quality [8-12], green production efficiency [13-15], employment [16], and carbon emissions [17, 18]. However, as the tourism industry emerges as a dominant service sector and an economic pillar underpinning high-quality economic development, the investigation of green technological innovation has scarcely touched upon its economic aftermath on the tourism industry, with mere snippets of scholars delving into the impact of technological innovation on tourism development [19, 20].

The Yangtze River Delta region stands as one of the most open and technologically innovative areas in China [21], replete with abundant tourism resources that have catalyzed the swift development of its tourism economy. This sector has witnessed a substantial surge in tourism

revenue, escalating from 0.4 trillion RMB in 2005 to 8.18 trillion RMB in 2019. The presence of a multiplier effect ensures that more developed regions reap significantly greater benefits during the advancement of the tourism economy. Therefore, within such affluent economic territories as the Yangtze River Delta, the yield from tourism is notably higher compared to other areas [22]. While examining this region, one discerns a degree of internal imbalance in its tourism economic progression [23], which exhibits a fluctuating upward trajectory [24]. Metropolises like Shanghai, Suzhou, and Nanjing have tourism economies that are conspicuously superior to their counterparts [25]. Conventionally, tourism has been perceived as a “smokeless industry.” Nevertheless, this is not entirely accurate; studies by the World Tourism Organization posit that tourism’s carbon emissions could constitute 5%-14% of human-induced carbon emissions. Given the dual constraints of resources and the environment, it is imperative that the tourism industry shifts its developmental approach, optimizes its industrial structure, and reconfigures its growth impetus, placing innovation at the forefront as the primary driver of progress, thereby invigorating the sector with renewed vitality.

In light of these considerations, this paper contributes to two principal dimensions. Firstly, it broadens the scope of research on green technological innovation, which has historically concentrated on its impact on manufacturing and macroeconomics. By exploring the economic consequences of green technological innovation within the tourism industry, this study not only enriches the discourse on the economic aftermath of such innovation but also provides references for the pursuit of green, high-quality development within the tourism sector under new developmental paradigms. Secondly, it delves deeper into the correlation between green technological innovation and the tourism economy. The paper examines the mediating role that the optimization of the tourism industry structure plays within this relationship, unveiling the pivotal importance of industrial structure optimization in bolstering the growth of the tourism economy and offering insights into the internal adjustments and enhancements necessary for the industry.

## Theoretical Analysis and Research Hypotheses

### Green Technology Innovation and Tourism Economic Development

Dating back to 1776, Adam Smith, in his *Wealth of Nations*, underscored the pivotal role of technological progress in fostering economic growth. This was echoed by Joseph Schumpeter, who, in 1912, systematically discussed the fundamental concept of innovation, which was subsequently internalized within the domain of technology [26]. Since then, technological innovation has emerged as a subject of interest

and been recognized – as a continuous endogenous driving force for economic growth. Principally, technological innovation spurs economic development through the effects of creative destruction and profitability, with the potential to induce spatial spillover effects through knowledge diffusion, thereby influencing the economic development of the surrounding regions. The Solow growth model identifies increased factor inputs, optimized factor structures, enhanced efficiency of resource combinations and allocation, and improved industrial quality as significant elements contributing to economic growth.

Firstly, the effects of creative destruction, facilitated by green technological innovation, optimize factor structure and improve the quality of industries. Green technological innovation places greater emphasis on big data, the internet, cloud computing technologies, and digital platforms, which drive new forms and their value chains in the tourism industry toward integrated and continual advancement. This mode of industrial development has shifted to new business models such as “Internet Plus,” “+Internet,” and “Smart Culture & Tourism.” Simultaneously, green technological innovation accelerates iterative innovation in tourism products, enabling precise supply-demand connections for new products and services and embedding green principles and practices throughout the tourist experience. This integration of green principles throughout the tourist experience elevates visitor engagement and satisfaction. Illustratively, AR technology has created additional commercial value for small cultural heritage sites [27]. The application of live streaming in tourism has opened new channels for co-creating value [28], and autonomous driving technology provides tourists with more diverse options for sightseeing and travel [29].

Secondly, the income effects of green technological innovation have enhanced the efficiency of resource combination and allocation. On one hand, green technological innovation can increase resource utilization efficiency, reduce pollution and waste, and, through the adoption of eco-friendly equipment and production processes, decrease emissions and waste management costs. For this reason, green technological innovation heightens the rate of resource recycling and overall efficiency. Studies have found that technological innovation can enhance green economic efficiency [13]. Moreover, the coupling of technological innovation with industrial structural upgrading directly impacts regional green economic efficiency along with spatial spillover effects [14]. On the other hand, new technologies represented by the digital economy achieve precision connections of factors, products, and services, as well as co-creation and sharing of knowledge, information, and value through data resources and digital platforms, therefore facilitating resource combination and allocation efficiency.

Based on the foregoing analysis, this study hypothesizes:

Hypothesis 1: Green technological innovation can drive the growth of the tourism economy.

### Green Technology Innovation and Optimization of the Tourism Industry Structure

Green technology innovation and the optimization of the industrial structure of tourism are inherently interwoven. The evolution of industrial structures is propelled by advancements in total factor productivity, an indicator that measures the output level achieved through technical progress given a set input of production factors such as labor and capital. As technical advancements elevate total factor productivity, industries experience enhanced efficiency and production capabilities, which ultimately exert influences upon their structural composition. Specifically, green technological innovations can ameliorate production processes within certain sectors of the tourism industry and augment production efficiency, making them more competitive in relation to their counterparts. This competitive edge can trigger a reallocation of resources, moving from traditional to emergent or high-value-added tourism sectors. For instance, as information technology and the digital economy burgeon, we witness the rapid ascendancy of the internet and software industries, leading to a scenario where traditional tourism enterprises are supplanted by internet-based tourism companies like Fliggy and Ctrip, and content-sharing platforms such as Xiaohongshu, TikTok, and Zhihu carve out niches in tourism, collaborating with various enterprises in the sector. During this transitional phase in the industry’s structure, technological advancements may also foster the industry’s elevation and transformation. The introduction and assimilation of new technologies can spur companies to revamp their modes of production and innovate products and services, thereby enhancing their competitiveness in the market. Such technology-driven transformations may result in the adjustment and realignment of industrial structures.

Technological innovation can also affect the shift in industry structures through differences in factor intensity and the elasticity of factor substitution. These modes of influence can be interpreted as variations in productivity and production costs spurred by technological progress. The influence of factor intensity differences, wherein certain sectors of tourism might rely more heavily on labor-intensive factors compared to others that depend more on capital or other factors, will be expounded first. The advent of new technology capable of either elevating the productivity of certain factors or reducing the demand for them sways the demands and distributions of factors within the tourism industry. For example, the adoption of robotic services in some tourism and hospitality sectors substitutes a portion of highly labor-intensive tasks, provoking a structural shift from labor-intensive industries toward more capital-dependent modes of production. We then

consider the impacts of factor substitution elasticity, which is the idea that some production factors are interchangeable, allowing for the adjustments of productivity changes brought by technological progress to be accommodated by altering the substitution of factors. The application of new technologies that generate novel production methods, products, or services can alter the demands and utilization patterns for various production factors, thereby changing the productivity dynamics among different industries, such as the emergence of “cloud tourism” and “online museums”, which transform traditional patterns of visitor engagement at physical sites.

Hence, the paper posits the following hypothesis:

H2: Green technological innovation will propel the optimization of the tourism industry’s structure.

### Green Technology Innovation, Optimization of the Tourism Industry’s Structural Composition, and the Expansion of the Tourism Economy.

In theory, economic growth is stimulated when resources are transferred from sectors with lower production efficiency to those with increasing rates of productivity. Chenery and others point out that the impact of structural change on economic development varies with the productivity levels and growth rates of different sectors at various stages of development. Studies have found that structural changes initially manifest as labor moving from the less efficient agricultural sector to the more efficient manufacturing sector, and subsequently to the less efficient service sector. This pattern reflects a “reverse U-shape” effect of structural changes on economic growth, characterized by initial stimulation followed by later suppression [30]. Structural changes result from the dual forces of creating old products and developing new products. Industrial structural changes inherently embody a process of rationalization and sophistication. However, the impacts of industrial structure rationalization and sophistication on the economy remain unclear. On the one hand, enhanced rationalization and sophistication of industrial structures signify substantial progress in the economic development model on one hand, and they potentially cause extensive spatial redistribution of natural resources and labor on the other, leading to increased material consumption and reduced operational efficiency [31]. This shift in economic development models is accompanied by the ongoing optimization of industry structures. In China, the advanced level of the tourism industry structure has marginally increased, while the rationalization level of the industry structure has declined [32].

Based on this, the present study hypothesizes:

Hypothesis 3: The optimization of the tourism industry structure mediates the relationship between green technology innovation and tourism economic growth.

## Research and Design

### Data Source and Processing

This study analyzes the Yangtze River Delta’s tourism industry. Given the repercussions of the COVID-19 pandemic, tourism data between 2000 and 2019 was collected and curated to conduct an empirical examination of the intrinsic correlations and transmission mechanisms among urban tourism economies, tourism industrial structures, and green technological innovation. The data utilized here originates from the “China Tourism Statistics Yearbook,” the “China Culture and Tourism Statistics Yearbook,” and various provincial and municipal statistical yearbooks. The count of green patents was ascertained using the International Patent Classification (IPC) green patent list, and gaps in the data were reconciled via linear interpolation.

### Model Construction

Based on the aforementioned premises, the study formulates the following model:

$$\text{Intgdp}_{it} = \gamma_1 + \alpha_1 \text{Intinno}_{it} + \alpha_2 \text{lnhum}_{it} + \alpha_3 \text{lnopen}_{it} + \alpha_4 \text{lnmar}_{it} + \alpha_5 \text{lnfix}_{it} + \varepsilon_1 \quad (1)$$

$$\text{Intind}_{it} = \gamma_2 + \beta_1 \text{Intinno}_{it} + \beta_2 \text{lnhum}_{it} + \beta_2 \text{lngov}_{it} + \varepsilon_2 \quad (2)$$

$$\text{Intgdp}_{it} = \gamma_3 + \delta_1 \text{Intind}_{it} + \delta_2 \text{Intinno}_{it} + \delta_3 \text{lnhum}_{it} + \delta_4 \text{lnopen}_{it} + \delta_5 \text{lnmar}_{it} + \delta_6 \text{lnfix}_{it} + \varepsilon_3 \quad (3)$$

Herein, ‘i’ denotes the province, ‘t’ the temporal dimension, while the constants  $\gamma_1$ ,  $\gamma_2$  and  $\gamma_3$  the coefficients  $\alpha$ ,  $\beta$  and  $\delta$  represent the relational parameters of the equation, with  $\varepsilon$  serving as the stochastic perturbation term. Model 1 assesses the impact of green technological innovation on the economic growth of the tourism sector; Model 2 examines the influence of green technological innovation on the structural composition of the tourism industry; and Model 3 evaluates whether the tourism industry structure mediates the relationship between green technological innovation and tourism economic growth.

### Constituents of the Indices

(1) The Dependent Variable: Tourism economic growth is measured based on the methodology of Tarik Dogru [33], whereby the revenue of tourism enterprises, encompassing income from tourist attractions, hotels, and travel agencies, serves as a proxy for the ascendancy in the tourism economy.

Table 1. Variable Definition and Descriptive Statistics.

Variable	Name	Symbol	Formula	N	Mean value	Standard deviation	Minimum value	Maximum value	p50
Explained variable	Tourism economic growth	Intgdp	Logarithm of tourism revenue	80	14.800	0.973	11.960	16.210	14.960
Explanatory variable	Green technology innovation	Intinno	Logarithm of green patent authorization	80	8.026	1.730	4.277	10.940	8.325
Mediating variable	Tourism industry structure	Intind	Equation (3) Logarithm of tourism industry structure	80	3.794	0.872	1.871	5.324	3.719
Control variate	Open level	Inopen	Logarithm of total import and export volume and entropy right of foreign investment	80	-0.745	0.882	-2.451	0.538	-0.580
	Degree of marketization	Inmar	Logarithm of Fan Gang Index	80	2.168	0.217	1.543	2.442	2.236
	Government regulation	Ingov	Logarithm of local fiscal expenditure/ regional GDP	80	-1.974	0.319	-2.660	-1.461	-2.035
	Fixed assets	Infix	Logarithm of fixed assets	80	14.970	0.721	13.050	16.110	15.260

Table 2. Stationarity Tests.

	LLC	HT	Breitung	IPS	Hadri LM
Intgdp	0.0031***	0.0000***	0.0188**	0.0001***	0.0440**
Intind	0.0042***	0.0000***	0.0077***	0.0001***	0.1104
Intinno	0.0005***	0.8927	0.3331	0.0233**	0.0000***
Inhum	0.0062***	0.8021	0.9967	0.5819	0.0000***
Ingov	0.0189**	0.3632	0.2572	0.6229	0.0000***
Infix	0.0000***	0.0000***	0.0001***	0.0000***	0.7785
Inopen	0.0352	0.9404	0.5900	0.0365**	0.0000***

Note: The symbols \*, \*\*, and \*\*\* respectively denote significance at the 1%, 5%, and 10% levels, as consistently applied hereinafter.

(2) The Independent Variable: Green technological innovation. Following the approach of Xiping Liu [34], the study quantifies the level of green technological innovation in the Yangtze River Delta region through the volume of green patent grants. While the usage of patent data as an indicator bears inherent limitations, the close correlation of patents with technological innovation, the accessibility of patent data, and the objective and slow-changing nature of patent standards render this metric a relatively dependable indicator of technological innovation.

(3) The Mediating Variable: Tourism industry structure. To gauge the optimization of the industry structure, three methodologies prevail: The first employs the Theil index; the second, the industrial

structure similarity coefficient to measure the rationalization of the industrial structure [35]; and the third, the modified structural dispersion index, which can gauge the rationalization level of the industry structure, albeit being overly intricate. In alignment with the essence of optimizing the tourism industry structure, the crux should be the enhancement of the efficiency of the tourism sector. Consequently, this study measures the optimization of the tourism industry structure through the cumulative addition of the output efficiency of each tourism sector and its proportional significance, comprising tourist attractions, hotels, and travel agencies. The specific calculation method is as follows:

Table 3. Correlation analysis.

	Intgdp	Intinno	Intind	Infix	Ingov	Inhum	Inmar
Intgdp	1						
Intinno	0.853***	1					
Intind	0.884***	0.756***	1				
Infix	-0.483***	-0.591***	-0.480***	1			
Ingov	0.364***	0.428***	0.593***	-0.373***	1		
Inhum	0.803***	0.815***	0.754***	-0.388***	0.574***	1	
Inmar	0.440***	0.528***	0.519***	-0.359***	0.754***	0.535***	1

$$tind = \sum \frac{y_i}{y} * \frac{y_i}{l_i} = \frac{y_1}{y} * \frac{y_1}{l_1} + \frac{y_2}{y} * \frac{y_2}{l_2} + \frac{y_3}{y} * \frac{y_3}{l_3} \tag{4}$$

In this model, *y* represents the total revenue of the tourism industry, while *y<sub>i</sub>* denotes the revenues generated specifically by hotels, tourist attractions, and travel agencies within the tourism sector. Additionally, *l<sub>i</sub>* signifies the employment figures corresponding to hotels, tourist attractions, and travel agencies, respectively.

(3) Control variables. Building upon the foundation of existing literature, this paper has introduced the following control variables: the level of openness (open), represented by the total value of imports and exports along with foreign investment measured by the entropy weighting method; the degree of marketization (mar), depicted by the Fan Gang Index; fixed assets (fix), described as the total societal investment in fixed assets; and government regulation (gov), expressed by the ratio of local fiscal expenditures to the regional gross domestic product.

### The Empirical Results

#### Stationarity Test

To preclude the occurrence of spurious regression phenomena in the processing of panel data, it is imperative to conduct stationarity tests on the various variables. To ensure the reliability and precision of the results, this study has used five different methods to ascertain the stationarity of all variables. Given the complexity of unit root test theories and their specific applicability, the tests are delineated in Table 2. Notably, some variables do not pass the stationarity test; following the precedent set by Zhao Lei and Zhang Chen [36], if more than half of the variables are confirmed stationary by the unit root tests, this indicates the panel data is indeed stable.

#### Correlation Analysis

A detailed descriptive analysis is presented in Table 1. The correlation analysis of various variables presented in Table 3 reveals that green technological innovation is positively associated with tourism economic growth, suggesting that green technological innovation exerts a beneficial impact on the expansion of the tourism economy and thus preliminarily corroborates Hypothesis 1. Furthermore, the significant correlational relationships between the control variables and the dependent variable validate the appropriateness of the control variables selected. Considering that the correlation coefficients among some control variables exceed 0.5, a multicollinearity test has been conducted during the regression analysis, and the variance inflation factor (VIF) values of all models are below 10, thereby adequately mitigating the potential impact of multicollinearity on the models.

#### Analysis of Regression Results

Utilizing the foundational regression model and conducting a Hausman test, a random effects model was elected for regression analysis. Table 4 shows the regression coefficients of Intinno on Intgdp for the current period, along with one, two, three, and four periods lagged. The findings reveal that for the contemporaneous regression, the coefficients of Intinno and Intgdp stands at 0.391, suggesting they are statistically significant at the 1% level. With a one-period lag, the coefficient holds at 0.394, again significant at the 1% level. A two-period lag yields a coefficient of 0.368 for Intinno and Intgdp, remaining significant at the 1% level. The three-period lag displays a coefficient of 0.357, and the four-period lag shows 0.347, both of which retain significance at the 1% level. This resonates with the assertions made by J. Navío-Marco and others who have emphasized that “technological innovation has progressed in tandem with tourism development over the years” [37]. It also aligns closely with the findings of Chang Gan and colleagues [19], where it is argued that not only technological innovation but specifically

Table 4. Intgdp and Intinno.

	Intgdp				
	(1)	(2)	(3)	(4)	(5)
Intinno	0.391***				
	(9.30)				
Inhum	-0.0843	-0.208	-0.113	-0.0257	0.541
	(-0.30)	(-0.57)	(-0.30)	(-0.07)	(0.79)
Inopen	0.492***	0.491***	0.465***	0.440***	0.300**
	(13.13)	(10.62)	(11.92)	(15.74)	(2.47)
Inmar	0.540***	0.646***	0.556***	0.655***	1.419**
	(4.18)	(2.96)	(2.88)	(3.40)	(2.15)
Infix	-0.0445	-0.0587	-0.0661	-0.0482	-0.0582
	(-0.57)	(-1.05)	(-1.07)	(-0.75)	(-0.86)
Intinno_11		0.394***			
		(6.97)			
Intinno_12			0.368***		
			(6.94)		
Intinno_13				0.357***	
				(6.19)	
Intinno_14					0.347***
					(8.95)
Constant term	11.95***	12.63***	12.75***	11.97***	12.72***
	(5.95)	(6.96)	(6.32)	(5.84)	(8.69)
N	80	76	72	68	64
R-sq	0.8908	0.8925	0.8742	0.8593	0.8467

green technological innovation plays a critical role in the advancement of the tourism sector. Furthermore, building upon the foregoing, this study conducts a lagged analysis, which underscores green technological innovation as a pivotal driving force for the long-term growth of the tourism economy.

Table 5 suggests the immediate regression, as well as one, two, and three-period lags between Intinno and Intind. In the case of the immediate regression, the coefficient of the relationship between Intinno and Intind is a positive 0.197, which is significant at a 5% level. For the one-period lag, the coefficient remains positive at 0.212 and is significant at the 10% level, though the degree of significance and the coefficient are reduced compared to the immediate term. As the number of lag periods increases, the coefficients for both two and three-period lags between Intinno and Intind are not statistically significant. These findings indicate that green technology innovation precipitates a reallocation of the internal production factors within the tourism industry, such as labor and capital, leading to a more rational resource distribution. Consequently, the output

efficiency of various sectors within the tourism industry and the overall industrial structure are enhanced. Also, the lagged analysis indicates that the bolstering impact of green technologies on the optimization of the tourism industry's structure may not be enduring.

Table 6, Column 1, presents the examination of the direct effect of Intinno on Intgdp. The regression results reveal that the coefficient of Intinno on Intgdp is a positive 0.391 and is significantly so at the 1% level, indicating that green technological innovation fosters growth in the tourism economy. Column 2 examines the impact of Intinno on the mediating variable, Intind. The coefficient between Intinno and Intind is 0.197 and is significant at the 5% level, suggesting that green technological innovation advances the optimization of the tourism industry's structure. Column 3 tests for the presence of a mediating effect of Intind on the relationship between Intinno and Intgdp. When Intinno, Intind, and Intgdp are included within a single model, the coefficient for Intinno and Intgdp is a positive 0.311 and is significant at the 1% level. Through the analysis of the mediating effect testing procedure, the coefficient

Table 5. Intinno and Intind.

	Intind			
	(1)	(2)	(3)	(4)
Intinno	0.197**			
	(2.24)			
Inhum	0.209	0.233	0.370	0.541
	(0.51)	(0.39)	(0.58)	(0.79)
Inopen	0.334**	0.324**	0.309**	0.300**
	(2.32)	(2.14)	(2.17)	(2.47)
Inmar	0.974**	1.285*	1.195*	1.419**
	(2.40)	(1.80)	(1.74)	(2.15)
Infix	-0.128	-0.0826	-0.0811	-0.0582
	(-1.54)	(-1.28)	(-1.30)	(-0.86)
L.Intinno		0.212*		
		(1.71)		
L2.Intinno			0.197	
			(1.55)	
L3.Intinno				0.180
				(1.36)
Constant term	1.202	-0.386	-0.754	-2.308
	(0.83)	(-0.26)	(-0.41)	(-1.23)
N	80	76	72	68
R-sq	0.7153	0.7431	0.7102	0.6896

Table 6. Mediation effect test.

	(1)	(2)	(3)
	Intgdp	Intind	Intgdp
Intinno	0.391***	0.197**	0.311***
	(9.30)	(2.24)	(5.71)
Inhum	-0.0843	0.209	-0.169
	(-0.30)	(0.51)	(-0.74)
Inopen	0.492***	0.334**	0.358***
	(13.13)	(2.32)	(4.45)
Inmar	0.540***	0.974**	0.147
	(4.18)	(2.40)	(0.50)
Infix	-0.0445	-0.128	0.00721
	(-0.57)	(-1.54)	(0.11)
Intind			0.404***
			(3.96)
Constant term	11.95***	1.202	11.46***
	(5.95)	(0.83)	(7.59)
N	80	80	80
R-sq	0.8908	0.7153	0.9280

between Intind and Intgdp is found to be a positive 0.404, with significance at the 1% level. This indicates that the tourism industry's structure plays a partial mediating role in the process through which green technological innovation is driving economic growth in tourism, thus confirming Hypothesis 2. The results above demonstrate that green technological innovation promotes the economic development of tourism by optimizing the industry's structure, namely by adjusting the allocation of factors among sectors within the tourism industry and enhancing the efficiency of resource allocation.

### Heterogeneity Analysis

As shown, green technological innovation and the development of the tourism industry demonstrate an imbalance across the Yangtze River Delta region. This paper categorizes samples based on administrative affiliation to investigate the regional heterogeneity of the impact of green technological innovation on the tourism economy. Shanghai stands out as, an internationally well-known destination with rich tourism resources and boasting convenient transportation infrastructure. Jiangsu and Zhejiang provinces contribute to this dynamic landscape, as they share developed economy



Table 7. Heterogeneity analysis.

	Intgdp			
	(1) Shanghai	(2) Jiangsu Province	(3) Zhejiang Province	(4) Anhui Province
Intinno	0.633***	0.329*	0.0993	-0.0626
	(5.30)	(1.99)	(0.71)	(-0.29)
Inhum	-3.737***	0.355	0.824*	2.339**
	(-3.11)	(0.79)	(2.04)	(2.44)
Inopen	1.286**	0.254	-0.743	-0.875
	(2.26)	(0.70)	(-1.38)	(-0.95)
Inmar	0.776	-0.177	1.191	-2.992
	(0.83)	(-0.25)	(1.04)	(-1.15)
Infix	-0.0979*	-0.143**	-0.00581	0.0805
	(-2.06)	(-2.55)	(-0.06)	(0.38)
Constant term	29.67***	12.93***	7.126***	6.616
	(5.35)	(9.90)	(3.78)	(1.08)
N	20	20	20	20
R-sq	0.940	0.974	0.948	0.842

and prosperous tourism industries. However, Anhui province lags behind compared to other regions of the Yangtze River Delta. A mixed OLS model was employed to examine the influence of green technological innovation on the progress of the tourism economy. The heterogeneity analysis, referring to Table 7, reveals that in column 1, Shanghai's coefficients for Intinno and Intgdp are positively marked at 0.633 and significant at a 1% level; column 2 shows that Jiangsu's coefficients are positively marked at 0.329 and significant at a 10% level. These data indicate that green technological innovation has spurred economic growth in the tourism sectors of Shanghai and Jiangsu, with the impact being markedly more pronounced in Shanghai. In contrast, columns 3 and 4 exhibit that Zhejiang and Anhui's relationships between green technological innovation and tourism's economic growth are not significant. This result demonstrates that green technology innovation has not promoted their tourism economies; however, the link between human capital and tourism economic growth is significant, suggesting a greater reliance on human capital investment in these provinces compared to green technological innovation. The results of this heterogeneity analysis diverge somewhat from Gan C's research concerning technological innovation and the tourism economy [19]; these disparities may be attributed to differing provincial endowments, infrastructure, and the implementation of policies.

## Examination of Robustness

To ascertain the credibility of the mediating model and the research findings, the following robustness checks were conducted: The Sobel test was utilized to further scrutinize the stepwise regression's mediating model, and the outcomes indicated that the tourism industry structure plays a partial mediating role in the process of green technological innovation affecting tourism economic growth, accounting for 20.36% of the overall effect, which is largely consistent with the results of the stepwise regression's mediating model.

## Conclusions and Countermeasures

This study pioneers the examination of the development of the tourism economy through the lens of green technological innovation, focusing on the Yangtze River Delta region from 2000 to 2019. Employing a mediation effect model, it scrutinizes the relationship between the optimization of the tourism industry structure and the interplay between green technological innovation and tourism economic development. The research uncovers that green technological innovation imparts a sustained positive impact on the development of the tourism economy. Moreover, green technological innovation spurs the optimization of the tourism industry structure, enhancing the efficiency of the allocation and utilization of production factors within the tourism sector. Another revelation is that green technological innovation shapes the development of the tourism economy by optimizing the industry structure. Lastly, a heterogeneity analysis reveals that the impact of green technological innovation on the development of the tourism economy is more pronounced in Shanghai Municipality and Jiangsu Province. Delving into the role of green technological innovation as a driver of the tourism economy, the study explores the underlying mechanisms of this dynamic. Set against the pursuit of high-quality development of the tourism sector, this study benefits the long-term progression of the tourism industry and offers insights for its sustainable advancement.

The following three implications for policy-makers are proposed, drawing upon the aforementioned conclusions:

The first is to foster multi-channel green technological innovation. Considering the risky and accumulative nature of green technological innovation, the government should actively guide the process while recognizing the regulatory role of the market. Incentives for public participation in technological innovation can be cultivated through tax deductions and a variety of reward measures, gradually shifting from an enterprise-led initiative to a comprehensive system of green technological innovation that encompasses government guidance, enterprise leadership, and broad public involvement.

The second is to prioritize the dissemination and application of green technological innovations, particularly the propagation and utility of intelligent, digital, and low-carbon technologies across cities. The economic benefits of new technologies necessitate time and large-scale implementation to reduce costs. Both the government and enterprises can propagate green philosophies, steering consumers towards eco-friendly consumption and opting for environmentally sustainable, energy-efficient products. In this sense, they can create a market demand for green technology applications.

The third is to fully augment the leading role of Jiangsu Province and Shanghai Municipality. Shanghai can capitalize on its robust green technological innovation capabilities to provide invaluable experience for the tourism development of Anhui Province and Zhejiang Province. Relevant departments and tourism enterprises across these regions should enhance communication and exchange in tourism technology, managerial expertise, and tourism talent, benefiting from mutual learning and collaborative growth.

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### Conflict of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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