Current Science
CS 5 (5), 5092-5113 (2025)
Received 15 July 2025 | **Revised 18 August** 2025 | **Accepted 22 September** 2025 | **Online Available 26 October** 2025
https://doi.org0/10.52845/CS/2025-5-5-56

Current Science

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OPEN ACCESS

ISSN(O)2795-8639

Original Article

The Impact of New Quality Productivity Forces on ESG Performance in Chinese Listed Tourism Companies: The Mediating Role of Artificial Intelligence and the Moderating Effects of Governance, Profitability, and Policy

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Abstract:

New Quality Productive Forces (NQPF), characterized by breakthroughs in digital transformation, intelligent systems, and eco-friendly development models, are instrumental in driving high-quality economic progress in China. In the context of the tourism sector, achieving robust Environmental, Social, and Governance (ESG) performance is critical for sustained growth; yet, the mechanisms and drivers shaping ESG outcomes remain underexplored. Utilizing panel data from A-share listed tourism enterprises in Shanghai and Shenzhen spanning 2000 to 2024, this study employs a two-way fixed effects model to examine the influence of NQPF on ESG performance. The empirical results confirm a significant positive association between NQPF and corporate ESG performance. Notably, artificial intelligence (AI) exhibits a statistically significant negative mediating effect, indicating a suppressive rather than enhancing role in this relationship. Moderation analysis reveals that firm profitability strengthens the positive impact of NQPF on ESG outcomes, whereas corporate governance quality and policy enforcement intensity, measured through R&D investment, attenuate it. Heterogeneity analyses show that the positive effects of NQPF are more pronounced in state-owned enterprises, labor-intensive firms, and companies located in eastern regions of China. This research highlights NQPF as a crucial driver for improving ESG standards in China's tourism industry. However, the counterproductive mediation of AI reflects its dual-edged nature, raising concerns about ethical implications and suboptimal resource utilization in current AI integration strategies. The divergent moderating roles of internal organizational capacities and external institutional environments yield important insights for corporate decision-makers and regulatory agencies. These findings offer empirical grounding for tourism firms to enhance governance over AI applications and for policymakers to design precise interventions that support sustainable industrial upgrading.

1. Introduction

The global tourism sector is undergoing a transformative phase, balancing the urgent need for economic revival with the imperative of sustainable development. In China, this transition is further shaped by the national commitment to achieving "Dual Carbon" targets—peaking carbon emissions and attaining carbon neutrality—elevating Environmental, Social, and Governance (ESG) performance to a strategic priority for ensuring long-term resilience and operational sustainability in tourism enterprises (UNWTO, 2023). As reported by the United Nations World Tourism Organization (UNWTO), tourism accounts for roughly 8% of global greenhouse gas emissions (Back, 2024) . With China's domestic tourism rebounding strongly—

recording 4.237 billion trips in 2024—the industry faces mounting pressure to align rapid growth with environmental stewardship and social responsibility (Legendre et al., 2024). At the same time, regulatory frameworks are evolving rapidly; for instance, China's Ministry of Finance introduced the Basic Standard for Enterprise Sustainable Disclosure (Trial) in 2024, requiring firms to disclose sustainability-related information to meet the demands of investors and other stakeholders. For businesses in tourism—a sector highly dependent on natural ecosystems and public trust—strong ESG practices have shifted from being merely an ethical obligation to a strategic lever for enhancing investor confidence, risk management, and competitive advantage (Lin et al., 2024).

Despite increasing recognition of ESG's importance, implementation across China's tourism industry remains uneven. Presently, only about 40% of A-share listed tourism companies issue dedicated ESG reports, and fewer than one in five disclose their carbon emission data (Liu & Wang, 2025). This inconsistency stems from both sector-specific complexities and systemic disparities. Tourism operations are inherently intertwined with ecological and cultural resources, making ESG performance multifaceted and challenging to manage—encompassing areas such as visitor behavior regulation, community engagement, and crisis response preparedness (Su & Li, 2024). Additionally, structural imbalances persist: while state-owned enterprises (SOEs) often achieve comprehensive ESG compliance due to policy directives and institutional support, many small and medium-sized private firms lack the capacity or incentives to adopt even basic sustainability measures (Legendre et al., 2024).

Amid these challenges, the concept of "New Quality Productive Forces" (NQPF)—defined by the convergence of digital innovation, intelligent systems, and green development—emerges as a promising catalyst for advancing ESG outcomes. Rooted in China's broader agenda of high-quality growth, NQPF serves as a key driver of technological modernization and operational efficiency. Leading firms such as China CYTS Tours have already initiated pilot programs, including the launch of AI-powered platforms like the "Smart Scenic Area Management System" in 2024, demonstrating how NQPF can streamline services and reduce environmental impacts. Existing literature indicates that NQPF enhances corporate performance through multiple pathways, including green innovation, industrial upgrading, and improved data governance (Ye et al., 2025). Artificial Intelligence (AI), as a central component of NQPF, is expected to strengthen environmental monitoring and governance transparency via tools such as smart factors—such as financial health and governance quality—are likely to influence how effectively firms integrate new technologies and translate them into tangible ESG improvements (Shi & Yang, 2025).

These dynamics raise several critical yet under-researched questions: How exactly do New Quality Productive Forces affect the ESG performance of publicly listed tourism companies? Does artificial intelligence act as a mediating mechanism in this relationship, and if so, what is its nature? Furthermore, how do firm-level attributes—such as profitability and governance strength—and external conditions—like policy enforcement intensity—shape the effectiveness of NQPF in driving ESG advancement?

To address these issues, this study analyzes panel data from A-share listed tourism firms in Shanghai and Shenzhen between 2000 and 2024, using a two-way fixed effects model. The research contributes to the literature in three ways. First, it applies information asymmetry theory to tourism ESG research by proposing and validating that NQPF improves data disclosure quality and managerial accountability, thereby boosting ESG outcomes. Second, it challenges the

assumption of technological determinism by revealing the dual nature of AI—demonstrating empirically that while AI holds transformative potential, it may also exert unintended negative influences on ESG performance. Third, it identifies contextual boundaries by examining how corporate profitability, governance structures, and policy-driven R&D investment moderate the NQPF–ESG link, offering practical guidance for differentiated technology adoption strategies.

The paper proceeds as follows. Section 2 outlines the theoretical foundation and formulates the research hypotheses. Section 3 describes the methodology, including data sources, variable construction, and model design. Section 4 presents the empirical findings, covering baseline regression results, robustness checks, and mediation analysis. Section 5 explores heterogeneity across enterprise ownership types, labor intensity, and regional locations. Finally, Section 6 summarizes the conclusions, discusses theoretical and managerial implications, acknowledges limitations, and suggests directions for future inquiry.

2. Literature Review and Hypotheses

2.1 New Quality Productive Forces and ESG Performance in Tourism Firms

Amid growing global emphasis on sustainability and China's strategic pursuit of "Dual Carbon" objectives, Environmental, Social, and Governance (ESG) performance has emerged as a key metric for assessing the long-term viability and responsible operations of tourism enterprises (Back, 2024). Given that the tourism sector contributes approximately 8% of global greenhouse gas emissions (UNWTO, 2023), there is an urgent need to align industry expansion with ecological and social responsibility. In this context, New Quality Productive Forces (NQPF)—defined by the synergistic integration of digital transformation, intelligent systems, and green development—offer a transformative approach to strengthening corporate ESG outcomes (Su & Li, 2024).

NQPF enhances ESG performance in listed tourism companies through three interrelated pathways. On the environmental front, NQPF stimulates green technological innovation, enabling firms to lower carbon output and optimize resource utilization. For example, smart energy management systems deployed in hotels have shown measurable reductions in energy consumption and emissions (Ye et al., 2025). In the social dimension, digitalization fosters the creation of high-value jobs and promotes inclusive community engagement, improving labor conditions and local stakeholder relations (Lin et al., 2024). From a governance perspective, data-centric decision-making models enhance transparency, risk oversight, and operational agility (Shi & Yang, 2025). By focusing on quality improvement and efficiency gains, NQPF delivers integrated support across technology adoption, industrial restructuring, and institutional governance—transforming ESG from a compliance-driven obligation into a strategic asset for sustainable value creation (Su & Li, 2024). Based on this analysis, we propose the first hypothesis:

- H1: New quality productivity forces have a positive promoting effect on the ESG performance of listed tourism companies.

2.2 The Mediating Role of Artificial Intelligence

As a foundational component of NQPF, Artificial Intelligence (AI) influences ESG outcomes in tourism firms via data analytics, operational optimization, and enhanced user experiences (Han et al., 2024; Wang, 2025). AI improves the precision of ESG data collection and reporting, thereby increasing disclosure reliability and stakeholder trust (Shao & Wang, 2024). It also enables real-time decision-making in areas such

as crowd control at scenic sites and dynamic energy allocation, helping mitigate environmental externalities (Han et al., 2024). Additionally, generative AI applications can deepen cultural storytelling and heritage interpretation, reinforcing the social mission of tourism operators (Wang, 2025).

Nonetheless, AI deployment entails significant risks, including algorithmic bias, lack of ethical oversight, and inefficient allocation of innovation resources. These issues may undermine its potential benefits, leading to unintended consequences that weaken ESG performance (Li & Kan, 2025). This dual nature of AI—as both an enabler and a disruptor—introduces uncertainty into its mediating function between NQPF and ESG outcomes. Therefore, we posit the following hypothesis:

- H2: Artificial Intelligence mediates the relationship between New Quality Productive Forces and ESG performance in listed tourism companies, but the direction of mediation is ambiguous and may be either positive or negative.

2.3 Moderating Effects of Corporate Governance, Profitability, and Policy Intensity

The extent to which NQPF translates into improved ESG performance depends critically on internal capabilities and external institutional contexts—specifically, corporate governance, profitability, and policy intensity.

Corporate governance (CG), proxied by the share of independent directors, affects how effectively technological advancements are converted into ESG improvements. While strong board independence can enhance accountability and regulatory adherence, excessive oversight may stifle entrepreneurial initiative and slow down adaptive innovation, potentially limiting the realization of NQPF's full ESG potential (Han & He, 2025).

Profitability, measured by return on assets (ROA), reflects a firm's financial flexibility and capacity to invest in long-term sustainability initiatives. Firms with higher profitability are better positioned to fund ESG-related projects and sustain continuous technological upgrades, thus amplifying the positive effects of NQPF (Xue et al., 2024).

Policy intensity, indicated by R&D investment intensity (RDI), plays a nuanced moderating role. When public or organizational policies channel R&D spending predominantly toward technical advancement without sufficient focus on environmental protection or social equity, critical ESG domains may be underfunded. This imbalance could lead to the crowding out of sustainability-oriented investments, weakening the overall effectiveness of NQPF in advancing ESG goals (Wei & Zheng, 2024).

Together, these three contextual factors shape the institutional landscape within which NQPF operates. Their influence determines whether technological progress leads to meaningful sustainability gains. Accordingly, we formulate the following hypotheses:

- H3: Corporate governance moderates the effect of New Quality Productive Forces on ESG performance, with the nature of this moderation being contingent and potentially either positive or negative.
- H4: Profitability positively strengthens the relationship between New Quality Productive Forces and ESG performance.
- H5: Policy intensity moderates the relationship between New Quality Productive Forces and ESG performance, with the direction of this effect depending on implementation priorities and thus subject to variation.

3. Study Design

3.1 Data Source and Sample Selection

The empirical analysis is based on panel data

collected from A-share listed tourism firms traded on the Shanghai and Shenzhen Stock Exchanges between 2000 and 2024. The initial sample was refined using the following exclusion criteria: (1) firms designated as ST, *ST, or those delisted during the observation period were removed; (2) observations with financial anomalies—specifically, companies exhibiting a debt-to-asset ratio exceeding 100%—were excluded to ensure financial viability; (3) any firm-year records missing essential variables for the analysis were omitted. Following this filtering process, an unbalanced panel dataset comprising 1,007 firm-year observations was constructed. To minimize the distorting effects of extreme values, all continuous variables were winsorized at the 1st and 99th percentiles.

Environmental, Social, and Governance (ESG) performance scores were obtained from the Hua Zheng ESG evaluation framework available in the Wind database. Financial data, corporate governance metrics, and variables used in constructing the New Quality Productive Forces (NQPF) index were primarily drawn from the China Stock Market & Accounting Research (CSMAR) database (Shi & Yang, 2025). The level of artificial intelligence (AI) adoption was measured through textual analysis of corporate annual reports, capturing the extent and context of AI-related disclosures.

3.2 Variable Measurement

3.2.1 Dependent Variable: ESG Performance

The dependent variable in this study is corporate Environmental, Social, and Governance (ESG) performance (ESG). We use the SinoSecurities ESG ratings sourced from the Wind database as a proxy measure. This evaluation framework has several notable strengths: it provides broad coverage across listed firms, integrates sector-specific assessment criteria, incorporates forward-looking indicators such as green product development and carbon reduction commitments informed by global standards, and is updated on a quarterly basis—enabling timely capture of changes in corporate sustainability practices (Han & He, 2025). Consistent with established methodological approaches in prior research, the original nine-point rating scale—ranging from C (lowest) to AAA (highest)—is numerically recoded from 1 to 9, respectively. The annual ESG score for each firm is then calculated as the average of its four quarterly ratings, providing a comprehensive and dynamic representation of yearly ESG performance.

3.2.2 Independent Variable: New Quality Productivity Forces (NQPF)

The primary independent variable is New Quality Productivity Forces (NQPF). Following the approaches established by Song et al. (2024) and Li et al. (2024), a multidimensional composite index is developed based on three core pillars: new-quality laborers, new-quality labor objects, and new-quality labor tools (refer to Table 1 for details).

- **New-Quality Laborers:** This dimension captures human capital characteristics associated with advanced productivity. It is measured using four indicators: (1) the proportion of employees engaged in research and development (R&D); (2) the share of staff holding advanced educational qualifications; (3) managerial awareness of environmental sustainability, quantified as the natural logarithm of (the frequency of green development-related keywords in annual reports + 1); and (4) a dummy variable indicating whether members of top management possess overseas work or educational experience.

Table 1. Enterprise Evaluation Framework for New Quality Productivity Forces (NQPF)

Primary Dimension	Secondary Category	Tertiary Indicator	Measurement Approach	Weight (%)
New-Quality Laborers	Workforce Quality	R&D Personnel Proportion	(Number of R&D Staff / Total Employees) × 100	12.985
		Share of Highly Educated Employees	(Employees with Master's or Higher / Total Staff) × 100	8.855
	Leadership Quality	Executive Environmental Awareness	Ln(Frequency of Green Keywords in Annual Reports + 1)	6.320
		Management International Experience	Dummy Variable (1 if applicable, 0 otherwise)	6.617
New-Quality Labor Objects	Ecological Sustainability	Environmental Governance Rating	SinoSecurities ESG Environmental Score (Scale: 1–9)	7.929
	Growth Potential	Fixed Asset Proportion	(Net Fixed Assets / Total Assets) × 100	2.732
		Capital Accumulation Rate	(Change in Shareholders' Equity / Initial Equity) × 100	1.124
New-Quality Labor Tools	Technological Infrastructure	Innovation Capacity | Ln(Total Patents Filed + 1)	Ln(Patent Count + 1)	21.81
	Digital Infrastructure	Degree of Digitalization	Ln(Frequency of Digital Technology Mentions + 1)	4.62
		Intangible Assets Ratio	(Intangible Assets / Total Assets) × 100	4.10
	Green Infrastructure	Level of Green Innovation	Ln(Number of Green Patents + 1)	9.96
		Green Patent Share	(Green Patents / Total Patents) × 100	12.95

- **New-quality Labor Objects:** This dimension is assessed using three indicators: the environmental governance score (E-score derived from the SinoSecurities ESG Environmental Score), the proportion of fixed assets relative to total assets, and the capital accumulation rate, which reflects a firm's capacity for equity growth over time.
- **New-quality Labor Tools:** This category encompasses five metrics that capture technological advancement and structural modernization. These include: innovation intensity, measured as the natural logarithm of (the number of patents granted + 1); degree of digitalization, quantified by the natural logarithm of (frequency of digitalization-related terms in annual reports + 1); the ratio of intangible assets to total assets; green technology innovation level, calculated as Ln(green patents granted + 1); and the share of green patents in total patent portfolio, expressed as a percentage.

- To ensure objective weighting that reflects the informational variability of each indicator, the entropy method is employed to determine the relative importance of all components. Based on these weighted indicators, a composite index for New Quality Productivity Forces (NQPF) is constructed, enabling a holistic measurement of firms' advancement in high-quality productive capabilities.

3.2.3 Mediating Variable: Artificial Intelligence (AI) Adoption Level

The mediating variable is the level of artificial intelligence adoption (AI). Drawing on methodologies from Yao et al. (2024) and Li et al. (2024), a textual analysis approach is applied to extract AI-related content from the full annual reports and the Management Discussion and Analysis (MD&A) sections of listed firms. A comprehensive list of AI-related keywords—comprising both exact terms and semantically expanded phrases—is used to identify relevant disclosures. The total frequency of these keywords within each report is aggregated. To normalize the distribution and reduce skewness, the count is adjusted by adding 1 and then applying the natural logarithmic transformation, which is subsequently used as the proxy for the firm's AI application intensity (AI).

3.2.4 Moderating Variables

Three moderating variables are included in the analysis: (1) **Corporate Governance (CG):** Captured by the percentage of independent directors on the board, reflecting the level of oversight and decision-making independence. (2) **Profitability (ROA):** Assessed using Return on Assets, computed as net profit divided by average total assets, indicating the firm's operational efficiency and financial health. (3) **Policy Intensity (RDI):** Represented by R&D intensity, defined as the ratio of research and development expenditure to operating revenue, serving as a proxy for institutional support and innovation-oriented policy emphasis.

3.2.5 Control Variables

Drawing on established studies regarding ESG performance in the tourism sector(Deng, 2024; Xiang, 2025), a series of control variables is incorporated to isolate the impact of key explanatory factors. These include: revenue growth rate (Grow), reflecting short-term operational expansion; fixed asset ratio (Fixed), indicating capital intensity; ownership concentration (Top1), measured as the percentage of shares held by the largest shareholder; firm age (Age), calculated as the natural logarithm of the number of years since establishment; firm size (Lnsize), represented by the natural logarithm of total assets; cash flow adequacy (Cash), defined as net operating cash flow divided by total assets; board size (Board), captured by the natural logarithm of the number of board members; and leverage (Lev), expressed as the asset-liability ratio. To account for macroeconomic fluctuations and sector-specific characteristics, year fixed effects and industry dummy variables are introduced into the model. A complete summary of all variable measurements is provided in Table 2.

Table 2. Variable definitions and measurements

Variable Type	Variable name	Symbol	Definition / Measurement
Dependent Variable	ESG Performance	ESG	Annual mean of SinoSecurities ESG ratings
Independent Variable	New Quality Productive Forces	NQPF	Composite index of New Quality Productivity Forces (NQPF)
Mediating Variables	Artificial Intelligence	AI	Natural logarithm of (AI-related keyword frequency + 1)

Moderating Variables	Corporate Governance	CG	Percentage of independent directors on the board (%)
	Profitability	ROA	Net profit divided by average total assets (%)
	Policy Intensity	RDI	R&D expenditure as a share of operating revenue (%)
	Revenue Growth Rate	Grow	Revenue growth rate = (Current year's operating revenue / Prior year's operating revenue) – 1
Control Variables	Fixed Assets Ratio	Fixed	Ratio of fixed assets to total assets (%)
	Ownership Concentration	Top1	Ownership stake of the largest shareholder (%)
	Firm Age	Age	Log-transformed firm age (ln(years since establishment))
	Firm Size	Lnsize	Logarithm of total assets (ln(total assets))
	Cash Holding Level	Cash	Operating cash flow to total assets ratio (%)
	Board Size	Board	Logarithm of board member count (ln(board size))
	Debt-to-Asset Ratio	Lev	Total liabilities divided by total assets (%)
	Year Fixed Effects	Year	Dummy variables for years
	Industry Dummies	Ind	Dummy variables for industries

3.3 Empirical Models

To examine the hypothesized relationships, a series of regression models are established using a two-way fixed-effects approach that accounts for both firm-specific and time-specific unobserved heterogeneity by incorporating firm and year fixed effects. All estimations employ robust standard errors clustered at the firm level to address potential heteroskedasticity and within-firm correlation of error terms.

3.3.1Baseline Regression Model

To examine the direct impact of New Quality Productivity Forces (NQPF) on ESG performance (Hypothesis 1), the following baseline regression specification is employed:

$$ESG_{i,t} = \alpha_0 + \beta_1 NQPF_{i,t} + \gamma Controls_{i,t} + \lambda_t + \alpha_i + \varepsilon_{i,t} \quad (1)$$

Where i and t represent firm and year, respectively; λ_t denotes year fixed effects capturing time-specific shocks; α_i indicates firm fixed effects controlling for unobserved time-invariant firm characteristics; and $\varepsilon_{i,t}$ is the idiosyncratic error term. The coefficient β_1 captures the primary effect of New Quality Productivity Forces on ESG performance.

3.3.2Mediation Effect Model

To investigate the mediating effect of Artificial Intelligence (AI) in the relationship between New Quality Productivity Forces and ESG performance (Hypothesis 2), a stepwise regression approach is employed, following the methodology proposed by Wen et al. (2004). The model system is specified as follows:

$$AI_{i,t} = \alpha_0 + \beta_1 NQPF_{i,t} + \gamma Controls_{i,t} + \lambda_t + \alpha_i + \varepsilon_{i,t} \quad (2)$$

$$SG_{i,t} = \alpha_0 + \beta_1 NQPF_{i,t} + \beta_2 AI_{i,t} + \gamma Controls_{i,t} + \lambda_t + \alpha_i + \varepsilon_{i,t} \quad (3)$$

In this framework, the coefficientβ_2 captures the direct influence of AI adoption on ESG performance, while a reduction in the coefficient of NQPF after including AI indicates partial mediation; a complete attenuation suggests full mediation.

3.3.3Moderation Effect Models

To assess the moderating roles of Corporate Governance (CG) (Hypothesis 3), Profitability (ROA) (Hypothesis 4), and Policy Intensity (RDI) (Hypothesis 5), interaction terms between NQPF and each moderator are incorporated into the baseline specification:

$$ESG_{i,t} = \alpha_0 + \beta_1 NQPF_{i,t} + \beta_2 CG_{i,t} + \beta_3 (NQPF_{i,t} \times CG_{i,t}) + \gamma Controls_{i,t} + \lambda_t + \alpha_i + \varepsilon_{i,t} \quad (4)$$

$$ESG_{i,t} = \alpha_0 + \beta_1 NQPF_{i,t} + \beta_2 ROA_{i,t} + \beta_3 (NQPF_{i,t} \times ROA_{i,t}) + \gamma Controls_{i,t} + \lambda_t + \alpha_i + \varepsilon_{i,t} \quad (5)$$

$$ESG_{i,t} = \alpha_0 + \beta_1 NQPF_{i,t} + \beta_2 RDI_{i,t} + \beta_3 (NQPF_{i,t} \times RDI_{i,t}) + \gamma Controls_{i,t} + \lambda_t + \alpha_i + \varepsilon_{i,t} \quad (6)$$

In models (4) to (6), the statistical significance and sign of the interaction coefficient β_3 determine the nature of the moderating effect—positive or negative—and its strength in shaping the relationship between New Quality Productivity Forces and ESG outcomes.

4 Empirical Results

4.1 Descriptive Statistics

Table 3 reports the summary statistics for the key variables in the study. The dataset comprises 1,007 firm-year observations from Chinese A-share listed tourism firms over the period 2000–2024. The average ESG performance (ESG) score is 2.469 with a standard deviation of 2.083, varying between a minimum of 1.000 and a maximum of 6.750. This relatively low mean and notable dispersion suggest that ESG practices in the tourism sector remain underdeveloped and unevenly implemented across companies.

The primary independent variable, New Quality Productivity Forces (NQPF), has an average value of 4.159 and a high standard deviation of 5.254, ranging from 0 to 32.708. This large variability highlights significant disparities in the advancement of new productivity drivers among tourism enterprises.

For the mediating variable, Artificial Intelligence application level (AI), the mean is only 0.218 with a standard deviation of 0.540, indicating limited integration of AI technologies within the sample firms—most of which have yet to widely adopt such innovations.

Among the moderating variables, Corporate Governance (CG), proxied by the share of independent directors, averages 25.620% (SD = 18.617), reflecting moderate board independence. Profitability (ROA) has a mean of 1.177%, but exhibits substantial volatility, as shown by its standard deviation of 12.435%. Policy Intensity (RDI), measured by R&D expenditure relative to operating revenue, displays a low average of 0.769% (SD = 3.109), suggesting generally modest investment in innovation.

Control variables also demonstrate wide variation. Firm size (Lnsize) spans from 19.035 to 26.847,

while the debt-to-asset ratio (Lev) ranges from 0% to 98.080%. The considerable distribution breadth across all main variables supports the robustness of the empirical analysis and enhances the reliability of the regression results.

Table 3. Descriptive statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
ESG	1007	2.469	2.083	1	6.750
NQPF	1007	4.159	5.254	0	32.708
AI	1007	.218	.54	0	3.367
CG	1007	25.62	18.617	16.670	75
ROA	1007	1.177	12.435	-49.524	102.771
RDI	1007	.769	3.109	0	33.580
Grow	1007	.096	.375	-0.987	4.955
Fixed	1007	.173	.193	0.051	0.760
Top1	1007	26.612	18.754	0.010	78.970
Age	1007	2.507	.676	0	3.526
Lnsize	1007	17.088	8.872	19.035	26.847
Cash	1007	12.779	15.218	0	100
Board	1007	9.021	1.997	1.099	2.773
Lev	1007	41.914	32.941	0	98.080

4.2 Baseline Regression Analysis

The results of the baseline regression analyzing the effect of New Quality Productivity Forces (NQPF) on corporate ESG performance are presented in Table 4. Column (1) displays the estimation outcomes with only firm and year fixed effects included. The coefficient of NQPF is 0.237, significant at the 1% level (t = 22.190), indicating a strong positive association between NQPF and ESG outcomes.

In Column (2), all control variables are incorporated into the model. The coefficient for NQPF remains positive and statistically significant, though it decreases to 0.0567 (t = 6.66, p < 0.01), suggesting that after accounting for other influencing factors, a one-unit increase in the NQPF index corresponds to an approximate 0.0567-point rise in the ESG score. This finding robustly supports Hypothesis H1, confirming that the advancement of New Quality Productivity Forces significantly enhances ESG performance in tourism-related listed firms.

Regarding control variables, ownership concentration (Top1), cash holding level (Cash), and board size (Board) exhibit statistically significant positive relationships with ESG performance, implying that firms with higher shareholder concentration, stronger liquidity positions, and larger boards tend to achieve better ESG outcomes. Additionally, the model's explanatory power improves markedly, as reflected by the increase in R^2 from 0.341 in Column (1) to 0.767 in Column (2), demonstrating that the included controls effectively account for a substantial portion of the variation in ESG performance.

Table 4. Baseline regression results: the effect of new quality productivity forces on ESG performance

Variable	(1) ESG	(2) ESG
NQPF	0.237***	0.0567***

	(22.190)	(6.66)
Grow		0.0886 (1.11)
Fixed		0.0866 (0.38)
Top1		0.00913*** (2.71)
Age		0.00536 (0.77)
Lnsize		0.00469 (0.64)
Cash		0.0103*** (3.71)
Board		0.0682*** (17.80)
Lev		0.00134 (1.28)
_cons	1.483*** (22.890)	-0.105 (-1.40)
Year FE	Yes	Yes
Firm FE	Yes	Yes
N	1007	1007
R2	0.341	0.767

4.3 Robustness Test

4.3.1 Alternative Variable Specifications

To validate the reliability of the results, a series of robustness checks were performed by redefining key variables. As shown in Table 5, the primary explanatory variable—New Quality Productivity Forces (NQPF)—was replaced with Total Factor Productivity (TFP) as an alternative indicator. The regression estimates show that TFP maintains a statistically significant positive effect on ESG performance ($\beta = 0.0562$, $p < 0.01$), confirming the consistency of the main finding under a different measure of productivity advancement.

Additionally, the dependent variable was recalibrated: instead of using the original nine-level ESG rating scale, a compressed three-tier ESG performance index (ESGP) was adopted to reduce potential measurement granularity bias. Even under this revised specification, the coefficient for NQPF remains positive and significant ($\beta = 0.0512$, $p < 0.05$).

These results collectively demonstrate that the observed positive relationship between New Quality Productivity Forces and corporate ESG performance is not sensitive to changes in variable operationalization, thereby reinforcing the robustness of the empirical conclusions across alternative model specifications.

Table 5. Robustness test results: alternative specifications of core explanatory and dependent variables

Variable	**(1)** **ESG**	**(2)** **ESGP**
TFP	0.0562*** (2.630)	
NQPF		0.0512**

		(6.620)
_cons	-1.326*** (-3.90)	0.914*** (3.09)
Controls	Yes	Yes
Year FE	Yes	Yes
Firm FE	Yes	Yes
N	1007	529
R^2	0.562	0.119

4.3.2 Instrumental Variable (IV) Estimation

To address potential endogeneity issues, particularly those arising from reverse causality between New Quality Productivity Forces and ESG performance, an instrumental variable approach was implemented. The instrument adopted is the industry-year median of NQPF, which captures exogenous variation in the development of new productivity forces within each sector and year, satisfying the relevance and exclusion conditions.

As reported in Table 6, the first-stage regression yields a high F-statistic of 1091.61, indicating a strong and valid instrument. In the second-stage estimation, the coefficient on the instrumented NQPF remains positive and statistically significant ($\beta = 0.279$, $p < 0.01$). This result is consistent with the baseline findings, reinforcing the conclusion that the observed positive effect of New Quality Productivity Forces on ESG performance is robust and unlikely to be biased by endogenous relationships.

Table 6. Robustness test results using the instrumental variable approach (two-stage least squares)

Variable	**(1)** **First Stage (TI)**	**(2)** **Second Stage (ESG)**
IV	0.941*** (33.040)	
NQPF		0.279*** (18.550)
_cons	0.393*** （4.140）	1.305*** （16.240）
Controls	Yes	Yes
Year FE	Yes	Yes
Firm FE	Yes	Yes
N	1005	1005
F-test (1st)	1091.61	
LM Stat (p-val)	0	

4.3.3 Additional Robustness Assessments

To further validate the reliability of the findings, several supplementary robustness checks were performed. These include: (1) incorporating additional control variables such as net profit margin and a digital transformation index to account for firm profitability and technological upgrading; (2) using a one-period lagged version of NQPF as the key explanatory variable to alleviate concerns about simultaneous causality; and (3) employing the Bootstrap method (with 1,000 replications) to enhance the stability of standard error estimates.

As shown in Table 7, across all these alternative specifications, the coefficient on NQPF consistently remains positive and statistically significant. This consistency underscores the

resilience of the primary result—that New Quality Productivity Forces positively influence ESG performance—under various modeling assumptions and methodological adjustments.

Table 7. Additional robustness check results

Variable	(1) ESG	(2) ESG	(3) ESG
NQPF	0.186*** (12.530)		0.237*** (19.230)
l.NQPF		0.166*** (13.540)	
cons	1.430*** (22.040)	1.833*** (24.200)	1.483*** (18.100)
Controls	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes
N	1007	955	1007
R^2	0.401	0.249	

4.4 Mediating Effect of Artificial Intelligence

To assess the mediating effect of Artificial Intelligence (AI), the three-step approach proposed by Wen et al. (2004) was applied, with results displayed in Table 8.

Model (1) confirms a significant positive total effect of New Quality Productivity Forces (NQPF) on ESG performance ($\beta = 0.166$, $p < 0.01$). In Model (2), NQPF is shown to significantly enhance AI adoption ($\beta = 0.038$, $p < 0.01$), satisfying the first two conditions for mediation. However, in Model (3), which includes both NQPF and AI, the coefficient for AI becomes negative and statistically significant ($\beta = -0.195$, $p < 0.05$), while the coefficient of NQPF increases in magnitude compared to Model (1).

This pattern characterizes a "suppression effect" indicating that AI functions as a suppressor variable rather than a traditional mediator. The negative indirect effect suggests that, although NQPF drives AI implementation, the current use of AI in tourism firms may generate unintended consequences—such as ethical concerns, data privacy risks, or inefficient resource allocation—that undermine ESG outcomes.

Thus, while the mechanism does not align with conventional positive mediation, it partially supports Hypothesis H2 by revealing a statistically significant negative mediating role of AI. This implies that the developmental stage and governance quality of AI applications are critical factors determining their impact on sustainability performance.

Table 8. Mediation Analysis Results: The Role of Artificial Intelligence

Variable	(1) ESG	(2) AI	(3) ESG
NQPF	0.166*** (15.043)	0.038*** (8.985)	0.174*** (15.613)
AI			-0.195** (-2.312)
Grow	0.029 (0.178)	-0.006 (-0.098)	0.028 (0.174)
Fixed	-0.180 (-0.632)	-0.401*** (-4.795)	-0.258 (-0.892)

Top1	0.012*** (3.141)	-0.001 (-1.207)	0.012*** (3.083)
Age	0.043*** (4.932)	0.009*** (3.285)	0.045*** (5.120)
Lnsize	0.161** (2.468)	-0.032 (-1.212)	0.154** (2.370)
Cash	0.046*** (11.899)	0.003** (2.483)	0.047*** (11.983)
Board	-0.023 (-1.048)	-0.024*** (-3.564)	-0.028 (-1.258)
Lev	0.005*** (4.262)	-0.001** (-2.309)	0.005*** (4.164)
_cons	-0.234 (-0.847)	0.319*** (3.310)	-0.171 (-0.619)
Year FE	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes
N	1007	1007	1007
R2	0.586	0.214	0.588

4.5 Moderating Effects

The influence of corporate governance, profitability, and policy intensity as moderating factors is examined in this section, with results presented in Table 9. These variables are evaluated for their ability to strengthen or weaken the relationship between New Quality Productivity Forces (NQPF) and ESG performance, providing insights into the contextual conditions under which the NQPF–ESG link varies in magnitude.

Table 9. Moderating effects of corporate governance and profitability of mechanism test results

Variable	**(1)** **ESG**	**(2)** **AI**	**(3)** **ESG**	**(4)** **ESG**	**(5)** **ESG**	**(6)** **ESG**
NQPF	0.055*** (6.477)	0.113*** (8.317)	0.069*** (7.097)	0.070*** (7.187)	0.077*** (7.682)	0.079*** (7.866)
CG	0.070*** (17.847)	0.059*** (13.370)				
NQPF×CG		-0.005*** (-5.414)				
ROA			0.011*** (3.142)	0.014*** (4.044)		
NQPF×OA				0.002*** (3.324)		
RDI					-0.053*** (-3.308)	0.007 (0.230)
NQPF× RDI						-0.006** (-2.561)
Grow	0.091 (1.149)	0.115 (1.465)	0.103 (1.118)	0.066 (0.719)	0.133 (1.457)	0.124 (1.361)
Fixed	0.102 (0.453)	0.083 (0.373)	-0.358 (-1.390)	-0.394 (-1.536)	-0.553** (-2.101)	-0.636** (-2.403)
Top1	0.009*** (2.695)	0.009*** (2.617)	0.010*** (2.641)	0.010*** (2.679)	0.009** (2.300)	0.008** (2.147)

Age	0.005 (0.659)	-0.006 (-0.902)	0.093*** (15.947)	0.094*** (16.224)	0.088*** (15.180)	0.086*** (14.574)
Lnsize	0.004 (0.533)	0.003 (0.383)	0.023*** (2.819)	0.025*** (2.980)	0.031*** (3.628)	0.033*** (3.878)
Cash	0.010*** (3.621)	0.008*** (2.740)	0.029*** (9.688)	0.027*** (9.238)	0.030*** (10.197)	0.030*** (10.132)
Board	0.042** (2.055)	0.015 (0.719)	-0.037 (-1.613)	-0.037 (-1.617)	-0.034 (-1.494)	-0.034 (-1.517)
Lev	0.001 (1.199)	0.001 (1.157)	0.007*** (4.663)	0.006*** (3.895)	0.004*** (3.495)	0.004*** (3.591)
_cons	-0.493** (-2.428)	0.220 (0.919)	0.254 (1.107)	0.274 (1.203)	0.314 (1.380)	0.321 (1.416)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
N	1007	1007	1007	1007	1007	1007
R2	0.768	0.775	0.693	0.697	0.694	0.696

4.5.1 Corporate Governance (CG)

The coefficient of the interaction term between NQPF and corporate governance (NQPF×CG) is negative and statistically significant (β=–0.005, $p < 0.01$), confirming a negative moderating effect in support of Hypothesis H3. This suggests that while strong corporate governance—proxied by a higher share of independent directors—is generally associated with oversight and accountability, it may also introduce bureaucratic delays or excessive risk aversion. Such rigidity could impede agile decision-making and innovation adoption, thereby constraining the effectiveness of New Quality Productivity Forces in enhancing ESG outcomes.

4.5.2 Profitability (ROA)

The interaction term between NQPF and return on assets (NQPF×ROA) exhibits a significantly positive coefficient (β= 0.002, $p < 0.01$), supporting Hypothesis H4. This indicates that firm profitability amplifies the positive impact of NQPF on ESG performance. Companies with stronger earnings possess greater financial flexibility and resource slack, enabling them to simultaneously pursue technological advancement and sustainability-oriented initiatives, which are often capital-intensive and yield long-term returns.

4.5.3 Policy Intensity (RDI)

The interaction between NQPF and R&D intensity (NQPF×RDI) is significantly negative (β=–0.006, $p < 0.01$), providing evidence for a negative moderating effect as proposed in Hypothesis H5. This implies that high levels of R&D investment, potentially incentivized or mandated by government policies, may lead to resource concentration in innovation activities at the expense of environmental and social programs. Over-prioritizing technological development without balanced allocation can thus undermine the broader sustainability goals linked to ESG performance.

4.6 Heterogeneity Analysis

4.6.1 Ownership Nature

To examine how ownership structure influences the relationship between New Quality Productivity Forces (NQPF) and ESG performance, the sample is divided into state-owned enterprises (SOEs) and non-state-owned enterprises (non-SOEs). As shown in Table 10, the positive effect of NQPF on ESG is significantly more pronounced in SOEs (β = 0.298, $p < 0.01$) compared to non-SOEs (β = 0.104, $p < 0.01$). This disparity may stem from

the stronger policy enforcement, greater access to institutional resources, and higher compliance incentives that SOEs typically experience under China's "Dual Carbon" objectives, enabling them to more effectively align productivity advancements with sustainability goals.

4.6.2 Factor Intensity

Firms are further grouped based on their production factor intensity—labor-intensive, capital-intensive, and technology-intensive—into three subsamples. The results indicate that the impact of NQPF on ESG performance varies across these categories. The strongest effect is observed in labor-intensive firms (β= 0.281, $p < 0.01$), followed by technology-intensive (β= 0.228, $p < 0.01$) and capital-intensive firms (β= 0.188, $p < 0.01$). This descending pattern suggests that labor-intensive enterprises, which often start from a lower technological baseline, benefit the most from adopting new productivity forces, experiencing substantial improvements in operational efficiency and environmental management. Their relatively higher marginal gains reflect greater transformation potential and responsiveness to innovation-driven upgrades.

Table 10. Heterogeneity tests by ownership type and factor intensity

Variable	(1) Full Sample ESG	(2) State-Owned ESG	(3) Non-State ESG	(4) Labor-Intensive ESG	(5) Capital-Intensive ESG	(6) Tech-Intensive ESG
NQPF	0.237*** (22.19)	0.298*** (22.17)	0.104*** (6.66)	0.281*** (18.40)	0.188*** (9.29)	0.228*** (10.19)
cons	1.483*** (22.89)	1.286*** (16.81)	2.064*** (20.16)	1.415*** (16.45)	1.600*** (12.09)	1.368*** (9.49)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
N	1007	670	337	559	247	201
R2	0.341	0.438	0.125	0.390	0.273	0.354

4.6.3 Geographical Region

The sample was stratified by geographical region into Eastern, Central, and Western areas of China. As reported in Table 11, the positive impact of New Quality Productivity Forces (NQPF) on ESG performance is statistically significant only in firms located in the Eastern region (β= 0.0979, $p < 0.01$), while no significant effects are observed in the Central or Western regions. This regional heterogeneity underscores the influence of uneven development across areas. The Eastern region generally benefits from more developed infrastructure, denser innovation ecosystems, stronger consumer demand for sustainable services, and more efficient policy execution—all of which enhance the effectiveness of NQPF in driving ESG improvements. In contrast, relatively weaker institutional support, limited technological diffusion, and resource constraints in the Central and Western regions may hinder the translation of productivity advances into measurable sustainability outcomes.

Table 11. Heterogeneity test by geographic region

Variable	**(1) East ESG**	**(2) Central ESG**	**(3) West ESG**
NQPF	0.0979*** (7.45)	0.0265 (1.38)	0.0345 (1.47)

_cons	0.565* (1.81)	0.0789 (0.14)	-0.186 (-0.43)
Controls	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes
N	536	226	245
R2	0.635	0.766	0.801

5 Conclusion

Drawing on panel data from Chinese A-share listed tourism firms in the Shanghai and Shenzhen stock exchanges over the period 2000–2024, this study investigates the influence of New Quality Productivity Forces (NQPF) on Environmental, Social, and Governance (ESG) performance through a two-way fixed effects model. The analysis integrates key technological drivers with internal and external institutional factors, focusing on the mediating role of Artificial Intelligence (AI) and the moderating effects of corporate governance, profitability, and policy intensity. Leveraging up-to-date data that reflect the evolving landscape of digital transformation and increasing emphasis on sustainability policies, this research offers current insights into how advanced productivity paradigms shape non-financial corporate outcomes in the tourism industry. The key findings are summarized below:

1. New Quality Productivity Forces (NQPF) exert a statistically significant and positive influence on the ESG performance of listed tourism companies ($\beta = 0.0567$, $p < 0.01$). This result is consistently supported across multiple robustness checks, including alternative variable specifications and instrumental variable estimation. The finding underscores that NQPF—defined by the synergistic integration of digitalization, intelligent systems, and green development—acts as a key driver for sustainable corporate growth in the tourism sector. Mechanisms such as advancements in green technology, optimization of industrial structures, and enhanced data-driven decision-making collectively contribute to improved environmental and social outcomes.

2. Contrary to expectations, Artificial Intelligence (AI) does not serve as a positive intermediary but instead demonstrates a significant negative mediating effect ($\beta = –0.195$, $p < 0.05$) in the pathway from NQPF to ESG performance. This highlights the dual nature of AI adoption in the tourism industry, where despite its potential for efficiency gains, challenges such as algorithmic bias, inadequate data privacy safeguards, and misdirected investment may undermine broader sustainability objectives. These issues can disrupt the alignment between technological progress and responsible corporate behavior, thereby weakening ESG outcomes.

3. The moderating effects exhibit notable variation across institutional and financial contexts. Profitability strengthens the relationship between NQPF and ESG performance ($\beta = 0.002$, $p < 0.01$), suggesting that financially healthier firms are better positioned to leverage productivity upgrades for sustainability initiatives. In contrast, both Corporate Governance ($\beta = –0.005$, $p < 0.01$) and Policy Intensity, measured by R&D investment intensity ($\beta = –0.006$, $p < 0.01$), negatively moderate this relationship. This implies that overly rigid governance structures or policy-induced pressure to prioritize innovation spending may inadvertently constrain flexibility and reduce the effectiveness of resource allocation toward ESG goals.

4. Heterogeneity analyses further reveal differential impacts across ownership types, production models, and geographic regions. The positive impact of NQPF on ESG is significantly stronger in state-owned enterprises ($\beta= 0.298$)

than in non-state-owned firms (β= 0.104), likely due to greater institutional support and policy compliance incentives. In terms of factor intensity, labor-intensive firms benefit the most (β= 0.281), followed by technology-intensive (β= 0.228) and capital-intensive enterprises (β= 0.188), reflecting higher marginal gains from technological upgrading among less automated sectors. Spatially, the beneficial effect is only statistically significant in the eastern region (β= 0.0979), with no significant impact observed in central and western regions—largely attributable to regional imbalances in digital infrastructure, consumer awareness of sustainability, and the effectiveness of local policy enforcement.

6 Limitations and future research directions

6.1 Limitations

Although this study offers valuable empirical evidence on the impact of New Quality Productivity Forces (NQPF) on ESG performance within China's tourism sector, certain limitations exist and warrant careful consideration. These constraints not only reflect the current scope of the research but also open avenues for further scholarly exploration in future studies:

1. ESG Performance Measurement: This study utilizes the Hua Zheng ESG scoring framework as the primary measure of corporate sustainability performance. However, ESG evaluations can vary significantly across different rating platforms due to discrepancies in assessment methodologies, indicator weightings, and sector-specific benchmarks. As a result, the same firm may receive inconsistent ratings depending on the system used, potentially affecting the validity and external comparability of the findings—particularly when contrasted with studies employing alternative systems such as Bloomberg ESG or Sino-Sec data. To strengthen the reliability of future research, scholars could adopt raw ESG disclosure metrics from corporate reports or synthesize composite scores derived from multiple independent rating sources. Such an approach would reduce dependency on any single evaluation standard and improve the robustness and transparency of empirical results.

2. Assessing AI Adoption: The measurement of Artificial Intelligence application is based on textual analysis of annual reports and Management Discussion & Analysis (MD&A) sections. While this method is widely adopted in empirical research, it has inherent limitations in capturing the actual scale, sophistication, or operational impact of AI deployment within tourism firms. The frequency of AI-related keywords may reflect disclosure tendencies or strategic impression management rather than genuine technological integration. Future work could benefit from more precise and objective proxies, such as capital expenditures on AI-driven systems, the extent of implementation of specific AI applications (e.g., chatbots for customer service, dynamic pricing algorithms, robotic automation in hospitality), or survey-based data on technology adoption. These alternatives would offer a more accurate and granular understanding of AI's real-world penetration and functional effectiveness.

3. Scope-Related Constraints:

(1) Policy Intensity Measurement: In this study, policy intensity is proxied exclusively by R&D investment intensity. While this captures one dimension of policy encouragement, it fails to account for other critical policy instruments that may shape corporate behavior, including direct subsidies for green innovation, tax benefits for sustainable operations, or regulatory mandates related to carbon reduction. Incorporating these additional dimensions in future models could provide a more holistic view of how government policies moderate the relationship between NQPF and ESG outcomes.

(2) Sample Representativeness: The analysis focuses exclusively on A-share listed tourism

companies in China, which limits the generalizability of the findings. The results may not extend to private firms, small and medium-sized enterprises (SMEs), or international tourism markets where institutional environments, market structures, and policy frameworks differ substantially. Therefore, while the conclusions are highly relevant to China's publicly traded tourism sector, caution should be exercised when applying them to broader or non-Chinese contexts. Future research could expand the sample scope to include cross-national comparisons or non-listed entities to enhance external validity.

6.2 Future research

In light of the current study's findings and its methodological constraints, several fruitful directions for future research can be identified to deepen the understanding of New Quality Productivity Forces (NQPF) and their implications for ESG performance in the tourism sector and beyond:

6.2.1 Diversification of Data Sources and Analytical Approaches

Future studies should seek more diverse data sources and employ complementary analytical methods. Utilizing raw ESG disclosure data or constructing alternative ESG metrics can reduce dependency on pre-defined commercial ratings. To further address endogeneity concerns, researchers could exploit quasi-experimental designs, such as Difference-in-Differences (DID) models leveraging exogenous policy shocks (e.g., the introduction of new sustainability disclosure standards), or employ Propensity Score Matching (PSM) to create more comparable treatment and control groups.

6.2.2 Enhanced Modeling of Nonlinear and Interdependent Dynamics

The intricate and sometimes counterintuitive relationships revealed in this study—such as the inhibitory mediating role of AI—suggest that linear models may not fully capture the underlying dynamics. Future work is encouraged to adopt more advanced econometric techniques, such as panel threshold regression, to detect structural breakpoints where the effect of NQPF or AI adoption on ESG performance undergoes significant change. Furthermore, Structural Equation Modeling (SEM) offers a powerful tool for simultaneously analyzing multiple interrelated pathways, enabling researchers to disentangle the complex web of influences among New Quality Productivity Forces, AI integration, institutional moderators, and the distinct environmental (E), social (S), and governance (G) components of sustainability performance.

6.2.3 Enhanced Operationalization of Key Variables and Extended Research Scope

(1) Improved Construct Measurement: To achieve a more precise assessment of New Quality Productivity Forces (NQPF) and AI adoption, future studies should develop more direct, multi-faceted indicators. For Artificial Intelligence, this could include metrics such as the number of AI-powered systems implemented (e.g., chatbots, recommendation engines, automated booking platforms), dedicated AI-related expenditures, or patents filed in intelligent tourism technologies. For NQPF, sector-specific indices that reflect digital integration, green innovation, and smart service capabilities within the tourism industry should be refined to better capture context-relevant advancements. .

(2) Expansion of Policy-Related Indicators: Current analyses relying solely on R&D intensity as a proxy for policy pressure may overlook critical dimensions of governmental influence. Future research should integrate a wider array of policy variables—such as direct financial subsidies for sustainability transitions, tax reductions for eco-certified businesses, and indicators of environmental regulatory enforcement—to provide a more holistic view of how institutional incentives shape corporate behavior and mediate productivity-sustainability

linkages.

(3) International Comparative Investigations: Broadening the sample to encompass tourism firms from diverse national contexts—including both developed economies and emerging markets—would facilitate cross-country comparisons. Such efforts would help assess how differences in institutional frameworks, market maturity, technological infrastructure, and cultural attitudes toward sustainability affect the generalizability and boundary conditions of the observed relationships.

Advancing research along these lines will foster a deeper, more differentiated understanding of the dynamic interplay between technological progress, institutional environments, and sustainable development within the global tourism sector.

Acknowledgments

The authors thank the Faculty of Business and Economics, Universiti Malaya for the support.

Funding details

Disclosure statement

Supplemental online material

Data availability

The datasets generated during and/or analysed during the current study are available in the WOS.

Data sharing

The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

Ethical approval

This article does not contain any studies with human participants performed by any of the authors.

Informed consent

This article does not contain any studies with human participants performed by any of the authors.

Supporting Information

S1 Data. Thesis analysis data. It contains the core linear regression analysis data of this study.

(XLS)

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