Digital Pathways to Sustainability: Empirical Evidence of Tourism Industry Transformation in the Industry 5.0 Era

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ABSTRACT

This research examined the interrelationships between digital transformation, innovative change, and sustainable growth within the Industry 5.0 paradigm in the tourism industry. As the tourism sector transitioned from digitalization to more human-centric, sustainable approaches following the COVID-19 pandemic, this study addressed a critical research gap by empirically validating these relationships. A quantitative approach was employed, with data collected from 122 managers across various tourism subsectors using validated measurement scales for digital transformation, innovative change, and sustainable growth. Structural equation modeling revealed that digital transformation had a strong positive impact on innovative change and a moderate direct effect on sustainable growth, while innovative change significantly influenced sustainable growth. The model explained substantial variance in both innovative change and sustainable growth. Additionally, innovative change partially mediated the relationship between digital transformation and sustainable growth. These findings validated theoretical frameworks proposing that digital technologies drive sustainability outcomes through enabling innovation. The research contributed valuable insights for tourism managers and policymakers regarding strategic approaches to digital transformation and innovation in pursuit of sustainable growth in the Industry 5.0 era.

Keywords: Digital transformation; Sustainable tourism; Industry 5.0; Innovation management; Tourism resilience.

1 Introduction

The global tourism industry is undergoing an unprecedented transformation as it transitions from the era of Industry 4.0, characterized by digitalization and automation, to Industry 5.0, which emphasizes human-centric approaches, sustainability, and resilience alongside technological advancement (De Giovanni, 2023). This evolution represents a paradigm shift from technology-driven systems to more value-oriented and purpose-driven frameworks integrating human intelligence with cognitive computing (Zizic et al., 2022). This transition is particularly significant for the hospitality and tourism (H&T) sectors, which are inherently human-centric service industries, as they seek to balance technological innovation with authentic, sustainable experiences.

The COVID-19 pandemic has served as a powerful catalyst for this transformation, accelerating the adoption of digital technologies across the tourism ecosystem (Pai et al., 2025). This unprecedented disruption has compelled tourism organizations to reimagine their operations, customer interactions, and business models through innovative technological solutions that simultaneously address immediate challenges while positioning for long-term sustainable growth (Twaissi et al., 2024).

The foundation for tourism's transition to Industry 5.0 lies in the widespread adoption of various digital technologies. Zizic et al. (2022) categorize these into four groups: physical-digital interface technologies (such as IoT, RFID, robotics, and virtual/augmented reality), network technologies (including blockchain,

interoperability systems, cybersecurity solutions, and social media), data-processing technologies (encompassing AI, machine learning, big data analytics, and cloud computing), and physical-digital process technologies (such as intelligent automation, novel materials, and energy management solutions). Integrating these technologies with human-centric values and sustainable practices marks the emergence of what can be termed "sustainable smart tourism" within the Industry 5.0 paradigm.

Sustainable innovation has emerged as a critical component of this transformation. Regarding the tourist industry, sustainable innovation is key to opening up new international markets, assisting businesses in lowering their negative social and environmental consequences, and boosting their bottom line. The convergence of digital transformation and sustainable innovation is particularly relevant for tourism, an industry that faces the dual challenge of recovering from the pandemic while addressing long-standing sustainability concerns. Sustainable innovation is important for the H&T industries to benefit the local economy, maintain cultural heritage, and reduce ecological impacts (Fan et al., 2022). In the Industry 5.0 context, this integration of technology, innovation, and sustainability represents a fundamental reimagining of tourism that aligns technological advancement with broader societal and environmental goals.

Despite the growing body of literature on digital transformation, innovation, and sustainability in tourism, a significant research gap exists in empirically validating the interrelationships between these concepts, particularly within the emerging Industry 5.0 paradigm (Tran & Khoa, 2025). However, this exploration was largely conceptual, synthesizing findings from existing studies rather than providing empirical validation of the proposed relationships. Furthermore, while existing literature has suggested that digital technologies enable innovation and contribute to sustainability, few studies have empirically examined the direct and indirect pathways through which digital transformation influences sustainable tourism growth (Bui Thanh Khoa, 2024a). This empirical gap limits our understanding of how tourism businesses can leverage digital technologies to achieve sustainable outcomes in the Industry 5.0 era.

Given the identified research gap, the primary objective of this study is to empirically investigate the relationships between digital transformation, innovative change, and sustainable growth in the tourism industry within the context of Industry 5.0. By examining these relationships empirically, this study seeks to validate the conceptual framework by providing quantitative evidence of how digital technologies drive innovation and sustainability in tourism. Moreover, this research aims to advance understanding of both direct and indirect pathways through which digital transformation influences sustainable tourism growth, thereby providing a more nuanced framework for conceptualizing these relationships. By situating these relationships within the Industry 5.0 paradigm, which emphasizes human-centric approaches, sustainability, and resilience alongside technological advancement, this study contributes to the emerging discourse on how tourism can evolve beyond digitalization toward more purposeful and value-driven development models.

2 Literature Review

2.1 Tourism and Industry 5.0 era

The concept of Industry 5.0 represents the next evolutionary stage beyond Industry 4.0, emphasizing human-centric approaches, sustainability, and resilience alongside technological advancement. While Industry 4.0 focuses primarily on digitalization and automation, Industry 5.0 integrates human intelligence with cognitive computing to create more value-driven and purpose-oriented systems (Huang & Jia, 2022). This paradigm shift is particularly relevant for the H&T sectors, which are fundamentally human-centric service industries now embracing digital transformation.

The tourism industry's journey toward Industry 5.0 was accelerated unexpectedly by the COVID-19 pandemic, which catalyzed rapid digitalization (Hussain et al., 2023). This global crisis compelled H&T enterprises to reimagine their operations, customer interactions, and business models through innovative technological solutions.

This evolution is characterized by a shift from merely digitalized tourism experiences to what can be termed "sustainable smart tourism" – where technological advancements serve human needs, promote environmental stewardship, and foster social equity (Hamid et al., 2021; Hung & Khoa, 2023). Industry 5.0 in tourism represents a convergence of technological sophistication and purposeful innovation to create more resilient, sustainable, and human-centered tourism ecosystems that can withstand future disruptions while meeting increasingly complex stakeholder expectations.

2.2 Hypotheses development

Digital transformation fundamentally reshapes how tourism businesses conceptualize, develop, and deliver their products and services, serving as a powerful catalyst for innovative change across the industry. This relationship is multifaceted and manifests through several distinct innovation pathways in the tourism sector.

Integrating digital technologies enables product and service innovations previously unimaginable in traditional tourism contexts. Mai et al. (2024) highlight that H&T firms can introduce new digital and sustainable products or services or integrate digital technologies into existing ones through digital technologies. A compelling example is the emergence of virtual tourism experiences powered by VR technologies, which "brings a new immersive experience to people without being physically at the destination (Khoa & Huynh, 2025; Samaddar & Mondal, 2023; Wakhyuni et al., 2024). Similarly, drone technology has revolutionized destination showcasing, as drones might provide live virtual tours of open-space tourist locations, which would be an eco-friendly innovation and solution to the over-tourism problem.

Most importantly, digital transformation allows for innovation in business models, which is associated with reevaluating how H&T organizations generate, distribute, and sustainably protect value. As an example of how digital technological advancements coupled with long-term sustainability can generate new economic paradigms, consider Ecobnb, a network-based tourist organization that uses digital platforms to advocate for sustainable tourism practices. Hence, this study proposed the hypothesis:

H1: Digital Transformation has a positive impact on Innovative Change in the tourism industry

Digital transformation serves as a powerful enabler of sustainable growth in tourism through its capacity to simultaneously address economic, social, and environmental dimensions of sustainability. The evidence for this relationship is substantial and encompasses multiple pathways through which digital technologies foster sustainable development in the sector.

Economically speaking, digital technologies provide new avenues for expansion for tourist businesses and boost company performance. In their study, Lee and Kim (2022) found that digital technologies can promote sustainable innovation, which helps the performance of H&T firms and their long-term sustainable competitive advantage. By differentiating tourism product/service quality and design and enhancing the firms' opportunity awareness during the crisis, digital technologies contribute specifically to economic sustainability (Zhang et al., 2023). To thrive in today's uncertain business climate, companies in the tourist industry must be able to assess customer needs quickly, spot emerging trends, and adjust their products and services appropriately.

Because it can tackle sustainability's economic, social, and environmental aspects all at once, digital transformation is a potent tool for achieving sustainable growth in the tourism industry. Substantial data supports this link, which includes many channels via which digital technologies promote sustainable development in the field. Digital technologies provide new avenues for expansion for tourist businesses and boost company performance overall. In their study, Hang et al. (2023); B. T. Khoa (2024) found that digital technologies can promote sustainable innovation, which helps the performance of H&T firms and their long-term sustainable competitive advantage. These skills are fundamental in uncertain business

climates because they allow tourist companies to spot emerging trends in the market and adjust their products and services appropriately. Hence, this study proposed the hypothesis:

H2: Digital Transformation positively impacts Sustainable Growth in the tourism industry.

Fundamentally, sustainable innovation is a way of thinking about business that helps the economy and the environment at the same time. Sustainable innovation is the lynchpin of company growth, according to Dat et al. (2025), which stresses its importance for businesses and society. Tourism, which has enormous economic potential and social and environmental implications, can benefit most from this double advantage.

New techniques from a social perspective foster more inclusive and culturally aware tourist activities. According to Bui Thanh Khoa (2024b), ethnographic-led tourism is a novel humanistic approach that uses VR and AR to facilitate socio-cultural exchange between tourists and local inhabitants. These innovations contribute to preserving cultural heritage while also providing tourists with more genuine and significant experiences. Furthermore, accessible technology advancements promote social fairness by ensuring that people of all ages, including those with impairments, may enjoy tourism. Hence, this study proposed the hypothesis:

H3: Innovative Change has a positive impact on Sustainable Growth in the tourism industry.

3 Method

This study employed a quantitative research approach utilizing validated measurement scales to investigate the relationships between Digital Transformation (DT), Innovative Change (IC), and Sustainable Growth (SG) in the tourism industry within the context of Industry 5.0. The selection of measurement instruments identified key dimensions of sustainable innovation in hospitality and tourism. All constructs were measured using a 5-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree), consistent with previous methodological approaches in tourism innovation research.

The Digital Transformation (DT) construct was measured using a four-item scale adapted from previous literature and informed by the categorization of digital technologies identified by Zhang et al. (2023). This scale encompasses four key dimensions of digital transformation in tourism: physical-digital interface technologies, network technologies, data-processing technologies, and physical-digital process technologies. Sample items include: "Our organization has substantially implemented physical-digital interface technologies (e.g., IoT, VR/AR, robotics)" and "Our organization effectively utilizes data-processing technologies (e.g., AI, ML, big data analytics)."

The Innovative Change (IC) construct was assessed using a three-item scale derived from the typology of innovations identified by Mai et al. (2024). This scale captures the three primary dimensions of innovation in tourism: product/service innovation, marketing innovation, and organizational/business model innovation. Sample items include: "Our organization has successfully implemented new digital and sustainable products/services in recent years" and "Our organization has substantially innovated its business model to better align with sustainability principles."

Sustainable Growth (SG) was measured using a four-item scale that reflects the multidimensional nature of sustainability in tourism, encompassing economic, social, environmental, and resilience dimensions. This approach is consistent with Dar et al. (2024) finding that consequences of sustainable innovation can be congregated according to the three main dimensions related to sustainability in economic, social, and environmental outcomes, with the addition of resilience as a critical fourth dimension in the post-pandemic context. Sample items include: "Our organization has achieved substantial economic growth while minimizing negative environmental impacts" and "Our organization has strengthened its resilience to external shocks through sustainable practices."

A total of 187 managers received the survey invitation, of whom 139 completed the questionnaire, yielding an initial response rate of 74.3%. After removing incomplete responses and conducting data-cleaning procedures to identify outliers and inconsistent responses, the final sample consisted of 122 valid responses, representing an effective response rate of 65.2%. This sample size exceeds the minimum requirement for conducting structural equation modeling (SEM) with three constructs, following the recommendation of at least 10 observations per measured variable (Hair et al., 2019). The demographic profile of respondents is presented in Table 1.

Table 1: Demographic Profile of Respondents

Characteristic	Category	Frequency	Percentage (%)
Gender	Male	66	54.1
	Female	56	45.9
Experience	Less than 5 years	11	9
	5-9 years	23	18.9
	10-15 years	38	31.1
	Over 15 years	50	41
Tourism Subsector	Accommodation services	51	41.8
	Travel services	29	23.8
	Attractions	24	19.7
	Food services	18	14.8
Organizational Size	Micro (fewer than 10 employees)	20	16.4
	Small (10-49 employees)	38	31.1
	Medium (50-249 employees)	40	32.8
	Large (over 250 employees)	24	19.7

4 Results and Discussion

4.1 Results

The measurement model assessment is a critical preliminary step in structural equation modeling to establish the reliability and validity of the constructs before examining structural relationships. This study employed a comprehensive evaluation of the measurement model by assessing both convergent and discriminant validity through rigorous statistical tests using SmartPLS software.

Convergent validity assesses the extent to which indicators of a specific construct converge or share a high proportion of variance. Table 2 presents the convergent validity results for the three constructs: Digital Transformation (DT), Innovative Change (IC), and Sustainable Growth (SG). Convergent validity analysis showed robust outer loadings (0.775-0.893) across all indicators, exceeding the recommended threshold of 0.708. Internal consistency was excellent, with Cronbach's alpha values ranging from 0.831 to 0.870 and composite reliability values between 0.898 and 0.911. All constructs' Average Variance Extracted (AVE) values were well above the critical threshold of 0.5 (Digital Transformation: 0.719, Innovative Change: 0.748, Sustainable Growth: 0.688), confirming adequate convergent validity.

Table 2: Convergent Validity and Reliability Results

Construct	Outer Loadings	Cronbach's Alpha	Composite Reliability	Average Variance Extracted
DT	0.782 - 0.890	0.870	0.911	0.719
IC	0.815 - 0.893	0.831	0.899	0.748
SG	0.775 - 0.878	0.850	0.898	0.688

Discriminant validity assesses the extent to which a construct is genuinely distinct from other constructs in the model. This study employed the Fornell-Larcker criterion, which compares the square root of each construct's AVE with its correlations with other constructs. The Fornell-Larcker criterion for discriminant

validity is satisfied when the square root of a construct's AVE (diagonal values in Table 3) exceeds its correlation with any other construct in the model (off-diagonal values). As shown in Table 3, this condition is met for all constructs in our model. The square root of AVE for Digital Transformation (0.848) exceeds its correlations with Innovative Change (0.723) and Sustainable Growth (0.698). Similarly, the square root of AVE for Innovative Change (0.865) is more significant than its correlation with Sustainable Growth (0.745). These results prove that each construct captures phenomena that other constructs do not, confirming discriminant validity.

Table 3: Discriminant Validity - Fornell-Larcker Criterion Results

Construct	DT	IC	SG
DT	**0.848**		
IC	0.723	**0.865**	
SG	0.698	0.745	**0.829**

Note: The diagonal elements (in bold) represent the square root of AVE for each construct

The measurement model assessment demonstrates strong evidence of convergent and discriminant validity, providing a solid foundation for examining the structural relationships between the constructs. Our measurement instruments' high reliability and validity ensure that the conclusions drawn from the structural model analysis are based on accurate representations of the underlying theoretical constructs. These results align with the conceptualization of digital transformation, innovation, and sustainability in the tourism context.

After establishing the reliability and validity of the measurement model, we proceeded to evaluate the structural model to examine the hypothesized relationships between Digital Transformation (DT), Innovative Change (IC), and Sustainable Growth (SG). The structural model assessment involves examining collinearity issues, the significance and relevance of path coefficients, the coefficient of determination (R^2), effect sizes (f^2), and predictive relevance (Q^2).

Before evaluating the path coefficients, we assessed potential collinearity issues among the predictor constructs by examining the Variance Inflation Factor (VIF) values. Table 4 presents the VIF values along with path coefficients and effect sizes. All VIF values are below the conservative threshold of 3.0, with Digital Transformation as a predictor of Innovative Change showing a VIF of 1.000 and both Digital Transformation and Innovative Change as predictors of Sustainable Growth showing a VIF of 2.095. These values are well below the critical threshold of 5.0, indicating that collinearity is not a concern in the structural model. The absence of collinearity issues strengthens the reliability of our path coefficient estimates and allows for a more accurate assessment of the relationships between construct

Table 4: Path Coefficients, VIF, and f^2 Effect Sizes

Relationship	Path Coefficient	t-value	p-value	VIF	f^2	R^2	R^2 Adjusted	Q^2
DT → IC	0.723	12.568	<0.001	1.000	1.092	0.523	0.518	0.365
DT → SG	0.378	4.857	<0.001	2.095	0.226	0.642	0.635	0.419
IC → SG	0.472	5.631	<0.001	2.095	0.352			

The path coefficients represent the hypothesized relationships between the constructs in our model. As presented in Table 4, all path coefficients are positive and statistically significant ($p < 0.001$), supporting all three hypotheses. The relationship between Digital Transformation and Innovative Change (H1) shows a strong positive path coefficient of 0.723 ($t = 12.568$, $p < 0.001$), indicating that Digital Transformation has a substantial positive impact on Innovative Change in the tourism industry. The relationship between Digital Transformation and Sustainable Growth (H2) exhibits a moderate positive path coefficient of 0.378 ($t = 4.857$, $p < 0.001$), supporting the hypothesis that Digital Transformation positively impacts Sustainable Growth in the tourism industry. The relationship between Innovative Change and Sustainable Growth (H3)

demonstrates a strong positive path coefficient of 0.472 ($t = 5.631$, $p < 0.001$), confirming that Innovative Change positively impacts Sustainable Growth in the tourism industry.

The effect of Digital Transformation on Innovative Change shows a considerable effect size ($f^2 = 1.092$), indicating that Digital Transformation substantially impacts Innovative Change. The effect of Digital Transformation on Sustainable Growth demonstrates a medium effect size ($f^2 = 0.226$), suggesting that Digital Transformation makes a meaningful direct contribution to Sustainable Growth beyond its indirect effect through Innovative Change. The effect of Innovative Change on Sustainable Growth exhibits a large effect size ($f^2 = 0.352$), highlighting the critical role of innovation in driving sustainable growth outcomes.

The coefficient of determination (R^2) represents the variance in endogenous constructs explained by all exogenous constructs linked to it. Table 4 presents the R^2 and Q^2 values for the endogenous constructs in our model. Together, Digital Transformation and Innovative Change explained 64.2% of the variance in Sustainable Growth ($R^2 = 0.642$). The model demonstrated strong predictive relevance with Q^2 values above zero for Innovative Change (0.365) and Sustainable Growth (0.419).

5 Conclusion

5.1 Research Contribution

This research makes significant theoretical contributions by empirically validating and extending the conceptual framework of digital transformation in tourism. Our multidimensional conceptualization of Digital Transformation—encompassing physical-digital interface technologies, network technologies, data-processing technologies, and physical-digital process technologies—provides a more nuanced understanding of how different technological components contribute to tourism outcomes. The empirical validation of the relationships between Digital Transformation, Innovative Change, and Sustainable Growth establishes a solid theoretical foundation for future research examining technology's role in tourism's evolution toward more sustainable and human-centric models within the Industry 5.0 paradigm.

Our study advances innovation theory by empirically demonstrating the distinctive yet interrelated nature of digital transformation and innovation in tourism. The strong mediation effect of Innovative Change (47.4% of the total effect) in the relationship between Digital Transformation and Sustainable Growth illuminates the mechanisms through which digital technologies influence sustainability outcomes. Furthermore, our research extends sustainability theory by empirically validating the multidimensional nature of Sustainable Growth, incorporating economic, social, environmental, and resilience dimensions. This more comprehensive framework reflects the evolving understanding of sustainable tourism in the post-pandemic context, where the adaptive capacity to withstand external shocks has become increasingly important alongside traditional triple-bottom-line considerations.

From a practical perspective, our findings provide tourism managers with empirical evidence that investments in digital technologies yield substantial returns in innovative capabilities ($R^2 = 0.523$) and sustainable growth outcomes (total effect = 0.719). This evidence can help justify and prioritize digital transformation initiatives, particularly in resource-constrained environments. Our multidimensional conceptualization offers practical guidance on which technological domains to prioritize, suggesting that a comprehensive approach encompassing all four dimensions is most effective for driving innovation and sustainability outcomes. Moreover, the strong relationship between Digital Transformation and Innovative Change ($\beta = 0.723$) indicates that managers should strategically deploy digital technologies to enable product/service innovations, marketing innovations, and organizational/business model innovations, with particular attention to technologies enabling business model innovation.

This research offers actionable insights for sustainable growth strategies, demonstrating that a dual focus on digital transformation and innovation yields significant sustainability benefits across multiple dimensions. The substantial explanatory power of our model ($R^2 = 0.642$) suggests that integrated strategies

simultaneously addressing technological advancement, innovation capabilities, and sustainability goals can be highly effective. For policymakers, our findings support initiatives promoting digital transformation and innovation as pathways to sustainable tourism development, particularly for small and medium-sized enterprises. The results suggest that policy initiatives should focus on building ecosystem capabilities through digital infrastructure investment, promoting collaboration between tourism businesses and technology providers, developing supportive regulatory frameworks, and implementing educational policies that enhance digital capabilities and innovation skills in the tourism workforce.

5.2 Limitation and Further Research

While this study provides valuable insights into the relationships between Digital Transformation, Innovative Change, and Sustainable Growth in tourism, several limitations should be acknowledged, pointing to promising avenues for future research. Methodologically, our cross-sectional design limits causal inferences, suggesting that longitudinal studies could better capture the dynamic nature of digital transformation and it is evolving impact on innovation and sustainability over time; additionally, our reliance on self-reported measures from managers, introduces potential standard method bias, despite our statistical tests suggesting this was not a significant concern—future research could triangulate data sources by incorporating objective measures of digital technology adoption, innovation outputs, and sustainability performance. Sample-wise, while our study included 122 managers across various tourism subsectors, larger samples would enable a more granular analysis of subsector differences and organizational characteristics that might moderate the observed relationships; furthermore, our geographic focus may limit generalizability to tourism contexts with different technological infrastructure, regulatory environments, and cultural attitudes toward innovation and sustainability—comparative studies across diverse geographic contexts would enrich understanding of how these relationships manifest globally. Conceptually, future research could expand our framework to include additional antecedents of digital transformation (e.g., organizational readiness, competitive pressure), mediators beyond innovation (e.g., organizational learning, dynamic capabilities), and more fine-grained outcomes that distinguish between different aspects of sustainability; moreover, as Industry 5.0 continues to evolve, research examining how the human-centric aspects of this paradigm complement technological advancement in tourism would be particularly valuable. Methodologically, future studies could employ mixed-methods approaches that complement quantitative findings with qualitative insights into how tourism organizations navigate the complexities of digital transformation, innovation, and sustainability in practice; experimental or quasi-experimental designs could also provide more substantial evidence for causal relationships between digital technology interventions and sustainable tourism outcomes. As the tourism industry continues transforming in the post-pandemic era, research addressing these limitations will be essential for developing a more nuanced understanding of how digital technologies and innovation can contribute to a more sustainable and resilient tourism ecosystem.

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