

DIGITAL TRANSFORMATION OF DUNHUANG'S CULTURAL TOURISM FLOW ECONOMY: OPERATIONAL MECHANISMS AND LONG-TERM GOVERNANCE

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Abstract. Against the backdrop of deep integration of all-media and digital technologies, heritage tourism destinations face the triple governance challenge of “how to trigger, how to monetize, and how to sustain” the flow economy. Taking the Dunhuang Mogao Grottoes, a World Cultural Heritage site, as a case Beijing City University study and based on the analytical framework of “flow triggering – flow monetization – flow sustainability”, this paper systematically examines the operational mechanisms and long-term governance paths of Dunhuang’s cultural tourism flow economy under digital transformation. The findings show that Dunhuang has built a digitally driven, three-dimensional flow-triggering system through game collaborations, algorithmic recommendations, and user-generated content; developed a diversified and efficient digital monetization system through cultural and creative e-commerce, immersive performances, digital study tours, and virtual resource libraries; and established a long-term governance system that equally emphasizes prevention and regulation, relying on IoT-based intelligent monitoring, 8K spherical-screen digital diversion, a big data governance platform, unified management institutions, and special legislation. Dunhuang’s practice demonstrates that digital transformation can effectively resolve the apparent contradiction between heritage conservation and tourism development, achieving a flow economy that is both “prosperous in revenue” and “long-lasting in popularity”. This paper further discusses the governance implications for Samarkand, a Silk Road World Heritage city, providing theoretical and practical references for the digital transformation of heritage tourism destinations in the all-media era.

Keywords: *digital transformation; cultural tourism flow economy; operational mechanism; long-term governance; Dunhuang; Samarkand*

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1. Introduction

All-media and digital technologies are reshaping the logic of tourism flow generation and conversion. New business forms such as short videos and social media check-ins can trigger a city’s tourism boom in a very short time, yet “more visitors but less revenue” and “popular for no more than three months” have become a common destiny for many destinations. For heritage destinations whose core attraction is non-renewable cultural heritage, flow governance must achieve simultaneous improvement in economic returns and community well-being under the premise of conservation priority.

The Dunhuang Mogao Grottoes, a World Cultural Heritage site, has been at the forefront of digital transformation in recent years. In 2025, Dunhuang received 24.393 million tourists, generating 22.9 billion yuan in tourism expenditure, maintaining a high-quality development trend of “revenue growth higher than visitor growth” for eight consecutive years. From the “Digital Dunhuang” resource library to the immersive performance Joy of Dunhuang, from the “Ten-thousand-star Concert” to the “Dunhuang Cultural Tourism Digital Model”, Dunhuang has transcended the short-lived explosion model of traditional internet-famous cities and formed a sustainable “ever-lasting popularity” paradigm. Meanwhile, Samarkand, a World Heritage city in Uzbekistan, has seen its tourist numbers surge from about 180,000 in 2015 to

2.6 million in 2024, but faces challenges such as fragmented management, lagging digitalization, and community conflicts. Based on the three-stage framework of “flow triggering – flow monetization – flow sustainability”, this paper systematically analyzes the operational mechanisms and long-term governance paths of Dunhuang’s cultural tourism flow economy, and extends the discussion to implications for Samarkand.

2. Literature Review and Research Methodology

2.1 Literature Review

Existing research has focused on the role of short-video algorithm recommendations in triggering tourism flows (Li et al., 2021), as well as the application of VR/AR and the Internet of Things in heritage conservation and tourism marketing (Ch’ng et al., 2019; Buhalis & Sinarta, 2019). Traditional governance of heritage tourism relies on planning and carrying capacity control (Garrod & Fyall, 2000). In recent years, the concept of digital governance has been introduced, emphasizing dynamic regulation through real-time data and intelligent algorithms (Gretzel et al., 2015). However, most studies focus on single technologies or communication effects, lacking a systematic deconstruction of the operational mechanism of “how flows are converted into sustainable economic returns”. In particular, an integrated analysis of the whole chain of “triggering – monetization – sustainability” for heritage destinations is missing. This paper fills this gap by taking Dunhuang as a case.

2.2 Research Methodology

A single-case in-depth study method is adopted, with Dunhuang selected as a typical case (eight consecutive years of double growth in visitor numbers and revenue, complete digital governance system). Data sources include government statistics, annual reports of the Dunhuang Academy, media reports, and academic literature. The analytical strategy is “pattern matching”, comparing Dunhuang’s practice with the three-stage model and deriving implications for Samarkand.

3. Results and Discussion

3.1 Flow Triggering Mechanism under Digital Transformation

Dunhuang has built a three-dimensional flow-triggering system of “game collaboration + algorithm recommendation + user-generated content”.

Game collaboration. Cooperating with top-tier games such as Minecraft and Game for Peace, Dunhuang recreated cultural heritage in game scenarios. Related topics gained hundreds of millions of exposures on Douyin, accurately reaching Generation Z.

Influencer co-creation. Inviting top travel bloggers from the Greater Bay Area to form a “flow group”, relying on collaborative filtering algorithms for precise amplification. One video of a blogger reciting “a solitary smoke straight in the vast desert, the setting sun round over the long river” in Cantonese gained 500,000 likes within 12 hours.

Public participation. The “Ten-thousand-star Concert” was turned into a “Douyin Sunset Chorus Party”. Tourists spontaneously recorded and uploaded short videos, generating a fission effect with 10 billion views across platforms.

This mechanism transforms cultural heritage into interactive digital content, achieving a shift from “waiting for flows” to “creating flows”.

3.2 Flow Monetization Mechanism under Digital Transformation

Dunhuang has broken away from ticket dependence and built a multi-level digital monetization matrix.

Cultural and creative e-commerce. By 2025, there were 116 cultural and creative enterprises, developing more than 9,000 products, with revenue of 558 million yuan in 2024. Blind box sales increased by 20% year-on-year.

Immersive performances. Joy of Dunhuang, the world's first cave-style immersive experience show, uses holographic projection, 3D wire suspension, and real-time motion capture. Over the past five years, it has performed 7,943 times and received 3.7596 million viewers.

Digital study tours and virtual resource library. The "Digital Dunhuang" resource library covers 344,000 square meters of murals, with over 23 million global visits. It has developed VR immersive exhibitions and online courses, realizing "seeing cultural relics outside the caves".

This mechanism keeps the growth rate of tourism expenditure higher than that of visitor numbers, solving the problem of "more visitors but less revenue".

3.3 Long-Term Governance Mechanism under Digital Transformation

The key to Dunhuang breaking the "popular for no more than three months" fate lies in building a four-in-one long-term governance system of "prevention – regulation – institution – community".

IoT intelligent monitoring. Sensors for temperature, humidity, CO₂, and vibration are deployed inside the caves, collecting real-time micro-environment data. When thresholds are exceeded, automatic warnings and flow-limiting measures are triggered, achieving dynamic coupling between flow and conservation thresholds.

Digital diversion. The digital exhibition center serves 6,000 tourists daily with 8K spherical-screen films, reducing the pressure on physical caves by 30%. "Digital Dunhuang" provides virtual alternative experiences.

Big data governance platform. The "Dunhuang Cultural Tourism Digital Model" integrates multi-source data from ticketing, sensors, social media, and transportation, enabling pre-event prediction, in-event regulation, and post-event evaluation.

Institutional guarantee and community sharing. The Dunhuang Academy, as a direct agency of the provincial government, has special legal authorization under the Gansu Dunhuang Mogao Grottoes Protection Regulations, exercising unified functions of protection, research, display, and management. Through industrial policies, local residents are guided to participate as guides, homestay operators, and artisans, sharing the benefits of the flow economy.

3.4 Implications for Long-Term Governance of Samarkand

Samarkand faces challenges such as surging tourist numbers, increasing pressure on heritage, and emerging community conflicts (UNESCO received heritage protection alerts in 2025). Based on Dunhuang's experience, five implications are proposed:

Build a unified digital governance platform. integrating multi-source data to enable flow prediction and dynamic regulation.

Deploy IoT intelligent monitoring. by installing environmental sensors at core heritage sites (e.g., Registan Square, Gur-e-Amir Mausoleum) and linking them with the reservation system.

Construct a digital exhibition and virtual experience center. providing 8K/VR virtual tours to reduce pressure on physical heritage, and develop a multi-lingual "Digital Samarkand" resource library.

Promote digital licensing and e-commerce of cultural creative products. by digitizing Islamic geometric patterns and Timurid emblems, developing IP licensing and online sales.

Improve institutional guarantee and community participation. by enacting special legislation, establishing a unified management authority (e.g., “Samarkand Heritage Administration”), and building a community benefit-sharing mechanism.

4. Conclusion

Based on the three-stage framework of “triggering – monetization – sustainability”, this paper systematically analyzed the operational mechanisms and long-term governance paths of Dunhuang’s cultural tourism flow economy under digital transformation, drawing the following conclusions:

First, the digital flow-triggering mechanism – through game collaborations, algorithm recommendations, and UGC fission – realizes the digital translation of cultural heritage and precise outreach to younger generations, shifting from “waiting for flows” to “creating flows”.

Second, the digital monetization mechanism – through cultural and creative e-commerce, immersive performances, digital study tours, and virtual resource libraries – builds a high-value-added digital economy ecosystem, solving the problem of “more visitors but less revenue”.

Third, the long-term governance mechanism is centered on IoT intelligent monitoring, a big data governance platform, digital diversion systems, unified institutional guarantees, and community benefit-sharing, forming a “technology + institution + society” triple-pillar governance model that turns the opposition between heritage conservation and economic development into synergy.

Fourth, Dunhuang’s experience has direct reference value for Samarkand and other Silk Road heritage cities. Through a unified digital platform, intelligent monitoring, virtual experiences, digital licensing of cultural creative products, and institutional improvement with community participation, Samarkand is expected to achieve the transition from “explosive but short-lived popularity” to “rational and long-lasting prosperity”.

This study provides a theoretical framework and practical path for the governance of flow economy in heritage tourism destinations in the all-media and digital transformation era. Future research can further quantify the input-output efficiency of digital technologies, explore the application of AI-generated content in flow governance, and test the governance model proposed in this paper over a longer time span and through broader international comparisons.

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