

Article

How the Digital Economy Enhances the Innovation Capacity of Cultural and Tourism Integration: Empirical Evidence from Cities in the Middle and Lower Reaches of the Yellow River

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Abstract

The digital economy is profoundly reshaping the global economic landscape; however, its impact on the innovation capacity of cultural and tourism integration—particularly within developing regions—remains insufficiently empirically tested. Utilizing panel data from 43 cities in the middle and lower reaches of the Yellow River (2009–2023), this study constructs indices for the digital economy and the innovation capacity of cultural and tourism integration using the entropy weight method. Employing a two-way fixed effects model, instrumental variable approach (using lagged variables and historical interaction terms), and mediation effect models, we empirically examine the impact, transmission mechanisms, and heterogeneity across city scales. The findings reveal that: (1) The digital economy significantly enhances the innovation capacity of cultural and tourism integration, with a benchmark regression coefficient of 0.683 (significant at the 1% level). (2) Mediation analysis indicates two transmission pathways—enhancing development potential of culture and tourism and promoting digitalization of cultural and tourism enterprises—with mediating effects accounting for 15.95% and 2.62%, respectively. (3) Heterogeneity analysis shows a significant negative effect in megacities (coefficient = -1.3726 , significant at the 10% level), contrasting with positive effects observed in super-large and large cities. This study elucidates the differentiated pathways through which the digital economy empowers cultural–tourism integration innovation, providing empirical evidence for tailored digital–cultural–tourism policies across cities of varying sizes, with implications for other developing regions exhibiting similar urban hierarchies.



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1. Introduction

In recent years, digital technologies such as big data, cloud computing, and artificial intelligence have accelerated innovation, and are integrating into the entire process of economic and social development with unprecedented depth and breadth. They have also provided crucial momentum and disruptive paradigms for the integration, transformation,

and value reshaping of the cultural and tourism industries. Theoretically, the wide application of digital technologies in cultural and tourism integration has effectively promoted high-quality integration and transformation of the cultural and tourism industries in terms of content, channels, and business models (Z. Fan, 2019). It has also given rise globally to the digital humanities ecosystem that combines virtual and real elements, forming an innovative system for cultural and tourism integration through the interaction between virtual digital economy and the physical entities of the cultural and tourism industry (Z. Wu & Wu, 2024), and reshaping the new landscape of cultural and tourism integration (Dai, 2020). This process echoes the international agendas advocated by UNESCO, such as creative transformation of cultural heritage, and the attention of the World Economic Forum on future tourism, providing a universal theoretical framework for understanding cultural inheritance, tourism experiences, and industrial innovation in the digital era. In practice, a cross-border cultural and tourism integration innovation is gradually unfolding. On one hand, the digital preservation of cultural heritage and its appreciation in international tourism have become a consensus. For instance, UNESCO's Digital Heritage project and the Google's Art and Culture platform enable world heritage to transcend time and space limitations, emerging as vital resources for promoting sustainable tourism development. On the other hand, immersive experience demands and digital technologies are reshaping the global tourism landscape. From the Louvre Museum's Mona Lisa: Beyond the Glass immersive experience and the virtual reconstruction tours of Notre-Dame de Paris, to the AR-based restoration of ancient city ruins in Italy, digital and intelligent technologies are constantly breaking through physical boundaries and creating immersive tourism scenarios where the virtual and real seamlessly converge. In this global picture, Chinese practice offers a distinctive China's Approach: such as the interactive digital characters at the National Natural History Museum of China and the Flying Over the Scroll Painting Along the River During the Qingming Festival at Kaifeng's Millennium City Park, which deeply integrate historical cultural resources with cutting-edge digital and intelligent technologies, demonstrating the unique advantages of large-scale markets and integrated innovation, and providing ideas that can be borrowed by other regions in the world.

The innovation in cultural and tourism integration transcends the traditional scope of industrial convergence. and emphasizes how the new technologies in AI, new tourism scenarios, and innovative cultural narratives facilitate the creative transformation and innovative development of cultural resources and tourism experiences, thereby shaping a completely new ecosystem for culture and tourism. In recent years, phenomenon-level tourist destinations in China, such as Zibo, Harbin, and Altay, have transformed the traditional development path of culture and tourism, through new concepts and creative innovations of cultural and tourism integration, such as prioritizing visitors, full-scale immersion, cultural IPs, and light asset operation, verifying the practical power and wide influence of the process of cultural and tourism integration innovation. While existing studies have made considerable progress in exploring the convergence of the digital economy and culture-tourism industries, several critical research gaps remain. First, regarding the research perspective, the literature predominantly focuses on the impact of the digital economy on the cultural or tourism sector in isolation, or treats culture-tourism integration as a "black box" to examine its aggregate effects. There is a notable lack of dedicated investigation into the systemic process and internal mechanisms of "culture-tourism integration innovation." Second, concerning transmission mechanisms, most studies remain confined to testing total effects, lacking systematic theoretical analysis and empirical validation regarding the distinct mediating roles of key variables—specifically "development potential of culture and tourism" and "digitalization of cultural and tourism enterprises"—in the transmission process. Third, regarding urban heterogeneity, significant disparities exist

across cities of different sizes in terms of resource endowments, digital infrastructure, and industrial development stages. However, existing research inadequately addresses the heterogeneous impacts of the digital economy on culture-tourism integration innovation across city tiers. In particular, there is a paucity of theoretical explanation and empirical support for the counter-intuitive phenomenon of a “negative effect in megacities.” To address these gaps, this study seeks to answer three core questions: (1) Can the digital economy significantly enhance the innovation capacity of cultural and tourism integration? (2) Through which key pathways does the digital economy drive this innovation? How do culture-tourism development potential and enterprise digitalization act as mediators to transmit and amplify the enabling effects of the digital economy? (3) Does a significant disparity exist the impact of the digital economy on the innovation capacity of cultural and tourism integration across cities of different sizes? The scientific novelty of this research is manifested in three aspects. Theoretically, we construct a framework linking the “Digital Economy—Development Potential of Culture and Tourism/Digitalization of Cultural and Tourism Enterprises—Innovation in Cultural and Tourism Integration.” By treating “innovation capacity of cultural and tourism integration” as an independent research subject, we identify and empirically test the differential transmission effects of two mediating paths, thereby deepening the understanding of the underlying mechanisms through which the digital economy empowers culture-tourism integration. Methodologically, we employ the entropy weight method to build a comprehensive evaluation index system for innovation capacity of cultural and tourism integration. Utilizing a two-way fixed effects model, instrumental variable approach, and mediation effect models, we provide robust analytical tools for future research. At the practical level, this study unveils the heterogeneous impacts of the digital economy across cities of different sizes. Notably, it identifies a counter-intuitive finding: the digital economy exerts a significant negative effect in megacities. These insights not only enrich the theoretical understanding of the spatial effects of the digital economy but also offer empirical evidence for formulating differentiated digital culture-tourism policies. This research seeks to establish a theoretical model structured around the pathway: “Digital Economy—Development Potential of Culture and Tourism/Digitalization of Cultural and Tourism Enterprises—Innovation in Cultural and Tourism Integration.” Taking the Yellow River Basin—a cradle of ancient world civilizations—as the empirical context, this study utilizes rigorous econometric modeling to empirically validate the driving mechanisms and elucidate the endogenous laws shaping this process.

2. Literature Review

2.1. The Connotation of Innovation in Cultural and Tourism Integration

The development of innovation theory has gone through three stages: the origin driven by technological innovation, the development led by the innovation system, and the upgrading led by the innovation ecosystem (Li et al., 2014). The industrial innovation is the process of transferring knowledge creativity, technological research and development, and product manufacturing to the marketization and industrialization of commodities. In particular, the deep transformation and reform of industries, as well as technological innovation for enhancing economic efficiency, are inevitable pathways to promoting value chain upgrading, the industrial chain reconfiguration, and industrial iteration, thereby holistically enhancing national competitiveness (Y. Wang, 2023). Industrial innovation includes enterprise innovation and its diffusion within the industry (S. Xiao, 2023). And industrial integration, as an economic phenomenon, originated earliest from the cross-industry phenomenon caused by the emergence of digital technology. The technology commons is its prerequisite condition, and the core connotation lies in the interrelation and

interaction between different industries, as well as their mutual influence and promoting effect (Z. Liu, 2018).

The classic interpretations of innovation theory, industrial innovation, and industrial integration provide a solid theoretical foundation for this study regarding the concept of the innovation in cultural and tourism integration. According to the theoretical logic of the classic interpretations, this study holds that when digital technologies such as 5G, AI, and big data form clusters and serve as the technology commons for cultural and tourism integration, the physical boundaries of cultural display, tourism experience, and content dissemination are broken, and tourists pursue deeper cultural identification, driving the integrated innovation of cultural and tourism industries. This integrated innovation goes beyond the simple bundling of tourism and culture, follows the logic of creative destruction, reorganizes elements, redefines processes, and reconstructs the cultural and tourism value chain, enabling a multi-dimensional upgrade in technology, products, business models, and innovation ecosystems of cultural and tourism integration, and achieving diversified value co-creation and elevation of cultural and tourism integration. Thus, this study holds that the innovation in cultural and tourism integration is a process driven by digital technology, wherein the cultural industry and the tourism industry undergo systemic and transformative changes in product forms, experience models, industrial logic, and value generation mechanisms, ultimately leading to the formation of new formats within the cultural and tourism sectors. This process is based on the condition of a “technology commons” dominated by digital technology, and driven by the internal logic of “creative destruction”, the cultural and tourism industries intersect, permeate, and reorganize at their boundaries, thereby triggering a full-chain innovation from knowledge creativity to market value, ultimately achieving the ascension of the cultural tourism industry value chain, the reconfiguration of the industry chain, and the systematic upgrade, and evolving towards an open and symbiotic cultural and tourism innovation ecosystem. It has gone through the origin driven by technological innovation, exhibiting stage-specific characteristics dominated by the innovation system, and the initial development stage driven by the policy sub-system of the innovation ecosystem. Its characteristics and facts are reflected in the new cultural and tourism consumption scenarios created by technological innovation, the symbiotic culture-tourism community dominated by the innovation system, and the cross-border content production led by integration policies.

2.2. New Cultural and Tourism Consumption Scenarios Driven by Technological Innovation

To fully meet the increasing demand for comprehensive experiential consumption in culture, art, entertainment, leisure, vacation, and knowledge acquisition, cities have integrated cultural consumption venues and tourism experience scenarios to create urban cultural and tourism functional zones. Such functional zones constitute pivotal carriers for urban branding; their innovative cultural and tourism provision can significantly bolster a city's prestige and attractiveness (Burkšienė & Dvorak, 2025).

Particularly, the integration of AR/VR technology into tourism development has created cross-temporal historical and cultural experience projects for urban tourism, achieving urban renewal in many historical and cultural cities. For instance, Edinburgh Castle in the UK displays significant historical artifacts and is connected to Holyrood Palace via the Royal Mile, with St Giles' Cathedral along the way, forming a typical urban cultural and tourism functional zone (Gill, 2025). Meanwhile, the development of smart cities has given rise to various new cultural and tourism business forms, shaping cultural and tourism consumption demonstration bases. Cultural and creative business forms in museums and heritage sites, relying on cultural relics and their educational attributes, provide rich content support for tourism and have become representative cultural and tourism experience

scenarios (Wei, 2022). Museums present cultural relics through digitalization, informatization, and virtual reality exhibitions, creating immersive role-playing, digital human environments, and digital twin historical events for visitors, offering a fully immersive experience of the virtual regeneration of cultural relics, intangible cultural heritage, and cultural and creative products. For example, Google's Arts & Culture project has integrated digital resources from over 2500 museums and galleries worldwide to conduct online exhibitions; Chengdu's "hot pot + scene innovation" has expanded consumption scenarios through "food + live streaming" and "food + performance", attracting global tourists with the 2024 International Food Carnival; Italy's Bologna, with its "Slow Food Movement + traditional cuisine" featuring local specialties like ragù and Parma ham, has opened outdoor restaurants in historical districts, combining wine tasting and artisanal cheese workshops, attracting a large number of tourists. Thirdly, ancient traditional costumes have been brought into historical and cultural districts by NPCs (non-player characters), creating immersive cultural and tourism consumption scenarios. For instance, the Sui-Tang Ancient City in Luoyang, China. Especially in recent years, in China, Hanfu (traditional Han clothing) has been highly favored by teenagers, who wear Hanfu to visit historical and cultural districts and historical and cultural theme parks, not only recreating the behavioral rituals of historical eras but also highlighting modern entertainment content and roles. This is attributed to teenagers' imitation of historical and cultural-themed films and TV shows, which can be regarded as a product of the combination of film and television with tourism. For example, Xi'an's "Twelve Hours of Chang'an" themed block recreates the urban scenes of the Tang Dynasty, allowing visitors to enter a themed area in ancient costumes to experience a journey back to the glorious Tang Dynasty.

In the context of the digital era, cities showcase diverse cultural symbols through digital technologies, expressing the interplay between history and modernity. Tourists construct multiple digital identities via digital platforms and social networks, achieving embodied experiences of cultural and tourism consumption in the process of spatial production. To support innovative cultural and tourism consumption scenarios in the digital economy, cities, relying on their inherent recreational functional areas, utilize high-tech such as AR/VR, digital twins, and artificial intelligence to create virtual reality scenes, striving to create demonstration blocks for cultural and tourism consumption, new business forms, and immersive scenarios, thus achieving integrated innovation in cultural and tourism industries.

2.3. The Cultural–Tourism Symbiosis in Industrial Integration

Culture accumulates, spreads, settles and is passed down in people's daily life and production process, gradually becoming an important factor in achieving self-identity, self-worth, national identity and cultural confidence in tourism experiences. Tourism itself is a kind of cultural life, a cultural undertaking with strong economic characteristics, and an economic undertaking with strong cultural characteristics (G. Yu, 1986). The mutual complementarity and interdependence of "shaping tourism with culture and highlighting culture through tourism" originate from the natural laws of cultural and tourism development and are continuously deepened under the dual impetus of the government and the market. The consistency and correlation demonstrated in the development of cultural industry and tourism industry constantly prompt the mutual use of resources, market coupling and policy coordination between the two. In particular, the innovativeness, permeability and spillover effect of the cultural industry accelerate the blurring of industry boundaries (G. Yu, 1986), while the uncertainty of the tourism industry's boundaries weakens the barriers to integration (Mao & Zhou, 2008). This results in the gradual blurring of boundaries, continuous infiltration of elements, diverse business intersections and product integration

and reorganization in the interaction process between the two. They break through the original boundaries and fields, blend with each other, share production factors and form a new symbiotic body, namely the cultural–tourism Symbiosis.

In cultural–tourism symbiosis, cultural symbols, events, scenarios and tourism resources complement each other, achieving efficient resource allocation and utilization through mutual integration in production and market interconnection. The cultural and tourism symbiotic entities, such as cultural and tourism enterprises, institutions, cultural and tourism districts, and cultural and tourism cities, jointly create new value, enhance tourism appeal, and increase the added value of products through competition and co-operation. The cultural–tourism symbiosis has diverse practices, such as historical and cultural districts and urban leisure functional areas. Historical and cultural districts are significant achievements in the historical development of cities and the implementation of national strategies, aiming to create cultural and tourism space carriers with exemplary effects through standardized construction, resource integration and policy support. These districts are characterized by cultural scene immersion, innovative integration of business models, and social public attributes, representing a systematic synergy of “cultural resources–tourism industry–urban space–community life.” Urban leisure functional areas are essentially recreational experience spaces that gather local cultural genes and diverse public service facilities in cities. With the shift in urban tourism demands, cultural and tourism elements are increasingly interpenetrating and reorganizing, forming a systematic symbiosis, making urban leisure areas become innovative urban units that continuously create composite value, enhance urban charm and living quality, and form a multi-functional integration of cultural fields, tourism experience areas and social life circles.

2.4. Cross-Border Content Production Guided by Regional Industrial Policies

The cross-border content production in the field of culture and tourism is essentially a strategic intention of regional development policies in the cultural and tourism sector. The coordination of systems, the integration of management institutions, and the integration of regulations have promoted the reorganization of market micro-subjects and the innovation of models, enabling the formation of highly perceptible and consumable diverse content forms. It is the most cutting-edge and vivid manifestation for observing and evaluating the depth and breadth of the innovation in cultural and tourism integration. The innovation of cultural and tourism content production fundamentally represents a new accumulation method of cultural symbol capital in the digital era. It not only changes the content form but also reconstructs the logic of cultural and tourism value creation. Culture and tourism, through reconfiguring resource value and consumption scenarios, ultimately drive the upgrade of content production. For instance, traditional cultural resources such as intangible heritage, cultural relics, and folk customs collaborate with tourism experience spaces to break through physical boundaries, achieving value reconfiguration in the dimensions of digital twins and cultural IP development. The “Digital Flying Apsaras” project at the Mogao Caves in Dunhuang has regenerated cultural heritage through virtual reality technology, translated cultural symbols, and innovated the narrative mode of spatial content. “Shaping tourism with culture” integrates digital technology, promoting the transformation of content production from a single linear narrative to an immersive experience narrative, and constructing a new type paradigm chain of cultural and tourism content production: “cultural memory—emotional resonance—behavioral transformation.” Cultural experience and tourism consumption coexist, forming a quantum entanglement state of cultural content production, folding multiple consumption scenarios such as “performance—accommodation—study tours,” and creating a composite content production network of “translation institutions + user-generating + AI co-creation.” For

example, Douyin, the domestic Chinese version of ByteDance's TikTok, drives cultural and tourism content creators to frequently broadcast content, reconfiguring the cultural dissemination ecosystem.

Based on the above characteristic facts, during the process of cultural and tourism integration, the combined and organic combination of capital, labor, information technology, and new urban productive forces has enhanced the attractiveness and added value of cultural and tourism products, creating disruptive innovative achievements such as cultural–tourism symbiosis, new scenarios and content production for cultural and tourism consumption. These characteristic facts demonstrate the inner and outer connotations of the innovation in cultural and tourism integration, that is, with “factor integration—technology empowerment—value reconfiguration” as the core, manifested as systematic changes in business models, spaces, and governance models. These evolutions reflect the deep synergy of capital, technology, labor, and new urban productive forces, laying the foundation for the generation of the innovation ecosystem of cultural and tourism integration (Y. Liu & Wu, 2025).

3. Theoretical Analysis and Hypotheses Development

3.1. *The Impact Effect of the Digital Economy on the Innovation in Cultural and Tourism Integration*

The development of the digital economy has injected powerful momentum into enhancing the innovation capability of cultural and tourism integration. This is mainly manifested in the following ways: digital technology provides diverse innovation channels; industrial digitalization achieves deep integration and collaborative innovation in culture and tourism; and the digitalized market optimizes the business environment for integrated innovation. At the technological level, advanced technologies encompassed by the digital economy, such as big data, algorithms, artificial intelligence, and virtual reality, offer rich technical means and tools for the innovation in cultural and tourism integration (C. Tang et al., 2024). For example, big data can precisely identify tourists' needs and preferences, providing a basis for the innovative design of cultural and tourism products; virtual reality, on the other hand, can create immersive tourism experiences, such as the reconstruction of historical scenes and virtual tours of cultural heritage, enriching the forms and content of cultural and tourism products. From an industrial perspective, under the trend of networking and intelligence, the digital economy has accelerated the diffusion of digital technologies and strengthens inter-industry connections (Yang & He, 2023), broken down the barriers between the cultural and tourism industries, gradually blurring their boundaries and enabling deep integration and collaborative development. On the one hand, cultural enterprises can use digital technologies to transform cultural resources into more attractive and interactive tourism products, expanding the dissemination channels and consumer markets for cultural products. On the other hand, tourism enterprises can incorporate more cultural elements to enhance the cultural connotation and quality of tourism products, creating distinctive cultural tourism brands. This integration and interaction between industries stimulate the innovative vitality of cultural and tourism integration, driving the industries toward diversification and high-end development. Analyzing from a market perspective, the digital economy constructs new cultural and tourism consumption scenarios and business models, creating a favorable business environment for enhancing the innovation capability of cultural and tourism integration (Holzmann & Gregori, 2023). The rise of digital platforms such as online travel platforms and social media has made it easier for tourists to access cultural and tourism information, make bookings, and share their travel experiences. At the same time, it has also provided cultural and tourism enterprises with broader marketing channels and market space. Cultural and tourism en-

terprises can leverage these platforms to carry out targeted marketing and innovate service models, such as launching personalized travel route customization and online cultural experience activities, to meet tourists' increasingly diverse and individualized demands, further promoting the innovative development of cultural and tourism integration.

In addition, the digital economy helps optimize the allocation of resources for cultural and tourism integration and enhances innovation efficiency (Su & Guo, 2023). By utilizing digital platforms, cultural and tourism enterprises can achieve resource sharing and information exchange, reduce transaction costs and innovation risks, and attract more talent, capital, and other factors into the field of innovation in cultural and tourism integration. This accelerates the transformation and application of innovative achievements, thereby driving the sustained enhancement of the innovation capacity of cultural and tourism integration.

It must be prudently noted, however, that the effects of lowering transaction costs and mitigating innovation risks via digital platforms are neither automatic nor unconditional. Regarding transaction costs, while digital transformation helps reduce such expenses (Goldfarb & Tucker, 2019), platforms may also leverage mechanisms such as market control, traffic distribution, and competition management to compel onboarded enterprises to continuously pay for the transaction-cost savings realized by the platforms. This transforms transaction costs from a natural attribute into a new form characterized by organizational and market-oriented features (Chan & Bheekie, 2025). With respect to innovation risks, although digital transformation enhances efficiency, it also exposes enterprises to multifaceted challenges—including data security threats, technological lock-in, and regulatory compliance pressures (Y. Chen et al., 2026). Therefore, the cost- and risk-reduction benefits of digital platforms are contingent upon specific conditions; their actual efficacy hinges on an enterprise's technological absorptive capacity and the governance quality of the platform itself (Tiwana et al., 2010).

Hence, the following hypothesis is proposed:

H1. *The digital economy can directly enhance the innovation capability of cultural and tourism integration.*

3.2. The Theoretical Mechanism of Digital Economy-Driven Innovation in Cultural and Tourism Integration

3.2.1. Digital Economy Enhances the Innovation Capacity in Cultural and Tourism Integration by Improving the Development Potential of Culture and Tourism

The development of the digital economy has brought vast market space and development opportunities to cultural and tourism industries, effectively tapping into and enhancing its growth potential (R. Tang, 2024). On the one hand, big data algorithms can precisely segment the source markets for cultural and tourism, profile tourism demand, and thereby assist enterprises in developing cultural and tourism products and services that better align with market needs. These include customized travel itineraries, personalized cultural experience activities, and other offerings designed to meet tourists' new consumption demands, such as digitalized diversified consumption, differentiated customized consumption, immersive consumption, and derived extended consumption (H. Fan & Zhang, 2021). This fosters multi-layered and overlapping innovation in cultural and tourism projects, products, and content production. On the other hand, the innovative application of digital technologies has expanded the dissemination channels and presentation formats of cultural and tourism resources, while optimizing the efficiency and reach of information dissemination. Through digital formats such as short videos, mini-dramas, and live streaming, many rural cultural and tourism attractions, as well as intangible cultural heritage (ICH) projects, have overcome the geographical constraints of

traditional marketing. This has enabled them to build visibility and appeal among broader source markets (J. W. Bi et al., 2021; Lin, 2022), thereby unlocking new market potential and growth opportunities for the cultural and tourism industry. As a result, previously niche or remote cultural and tourism destinations can adapt to the new consumption demands of digital culture and tourism through digitalized operations by tourism enterprises, injecting potential for spatial innovation and organizational transformation into the development of the cultural and tourism industries (Trenerry et al., 2021). For example, through short videos, short web dramas, live streaming, and other formats, many rural cultural and tourism attractions and intangible cultural heritage projects have quickly gained popularity, attracting a large number of tourists to experience them and driving the development of the local cultural and tourism industry.

Based on this, the following hypothesis is proposed:

H2. *The digital economy can enhance the innovation capability of cultural and tourism integration by strengthening the development potential of culture and tourism.*

3.2.2. Digital Economy Strengthens the Innovation Capacity in Cultural and Tourism Integration by Enhancing the Digitalization of Cultural and Tourism Enterprises

As an important entity in the integration of culture and tourism, the digital transformation of enterprises is the crucial pathway for the digital economy to drive innovation in cultural and tourism integration. With the support of digital technologies, enterprises can achieve digital upgrades in production, management, and marketing. In the production process, the extensive use of digital technologies enables enterprises to deeply understand the core value demands of tourists, which not only significantly enhances the tourism experience but also improves the response speed of enterprises to new tourism demands, promoting the efficiency of cultural and tourism integration innovation (J. Bi & Dong, 2023). In content creation and product development, digital technologies offer enterprises new tools and possibilities—for instance, AI-assisted design can rapidly generate multiple creative concepts for screening, while virtual reality filming can enrich the presentation formats of cultural products. However, the mere availability of these technological tools does not automatically translate into “more innovative” or “more appealing” offerings. The effective deployment of digital technologies is highly contingent upon enterprises’ technological absorptive capacity, the cultivation and retention of creative talent, and the accurate identification of evolving tourist preferences. At the same time, when adopting digital tools such as AI-assisted design and VR filming, enterprises may encounter additional costs and challenges—including technical adaptation, staff training, quality control, and the risk of creative homogenization (Trenerry et al., 2021). Consequently, the enabling effect of digital technologies on cultural content creation and product R&D is conditional; its ultimate success hinges on the organic integration of technological tools with creative capabilities, rather than on the mere introduction of technology per se. Moreover, digital transformation can reduce the cost of cultural and tourism integration innovation. Data integration reduces the transaction costs generated by the application of digital technologies, further promoting the online integration of cultural and tourism business, and creating superior conditions for enterprises to obtain external resources (J. Xiao et al., 2020). Digital transformation brings management innovations to enterprise strategic management, business models, organizational structure, business processes, and production operations (L. Yu et al., 2024), which helps cultural enterprises optimize internal management processes, improve operational efficiency, reduce costs, and achieve rational allocation and collaborative utilization of resources. In the marketing process, digital channels such as social media and online travel platforms can more accurately promote and sell cultural and tourism products and services to target customer markets, expand brand influence and market share, and at

the same time, adjust marketing strategies in real time based on data analysis to improve marketing effectiveness.

Therefore, this study proposes the following hypothesis:

H3. *The digital economy enhances the innovation capabilities of cultural and tourism integration by fostering the digital transformation of cultural and tourism enterprises.*

By comprehensively analyzing the theoretical mechanism of the impact of the digital economy on the innovation of cultural and tourism integration, it is found that the digital economy can not only directly have a positive impact on the innovation of cultural and tourism integration, but also drive this integration through multiple paths such as the potential of cultural and tourism development and the digitalization of cultural and tourism enterprises. Therefore, this study has developed the theoretical research framework as shown in Figure 1, providing a theoretical basis for the empirical research.

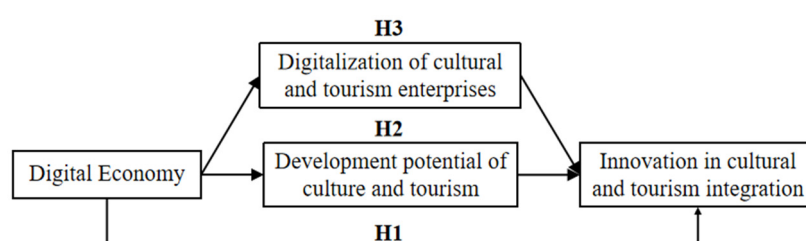


Figure 1. Research framework.

4. Methodology

4.1. Sample Selection and Data Collection

The Yellow River Basin is one of the only birthplaces of ancient civilizations in the world. It comprehensively documents the origin, formation and development of Chinese civilization, giving birth to agricultural civilization, urban civilization, Chinese characters and bronze ware, social differentiation and the construction of ritual systems, political systems, as well as Confucianism, Taoism, and commerce—all integral components of Yellow River civilization. It carries the only uninterrupted world civilization in human history. The philosophical ideas, humanistic spirit, values, and ethical norms embodied in the Yellow River basin, integrating diverse cultural elements such as Hehuang-ZangQiang, Guanzhong, Heluo—Sanjin, collectively highlight the rich connotations of Yellow River culture and demonstrate significant potential for building an internationally influential Yellow River cultural tourism belt. In the process of building the Yellow River National Cultural Park, China has designated cultural and tourism integration functional zone as one of its thematic functional areas. This initiative has fostered the elements of a cultural and tourism integration innovation ecosystem, thereby creating a policy environment conducive to such innovation. This study takes the middle and lower reaches of the Yellow River region as the case study area, based on four key considerations. First, cultural representativeness. The middle and lower reaches of the Yellow River constitute the region with the richest cultural deposits in the basin. Spanning from the Guanzhong Cultural Circle to the Heluo—Sanjin Cultural Circle, this area forms the core genealogy of Chinese civilization, thereby providing a substantial foundation of cultural resources for studying culture-tourism integration and innovation. Second, policy pioneering. Under China's strategic framework for constructing the Yellow River National Cultural Park, provinces in the middle and lower reaches—such as Shandong, Henan, and Shaanxi—have taken the lead in planning and developing culture-tourism integration functional zones. This has established a favorable policy environment for observing the innovative processes of

culture-tourism integration. Third, developmental gradient. The region exhibits a distinct urban hierarchy, encompassing megacities (e.g., Zhengzhou and Jinan), super-large cities (e.g., Xi'an), as well as large, and small-medium cities. This structure provides an ideal sample framework for examining the heterogeneous effects of the digital economy on culture-tourism integration and innovation across cities of varying scales. Fourth, data availability. Long-term panel data for all 43 cities in this region are relatively complete and maintain consistent statistical caliber. Consequently, this dataset satisfies the requirements of econometric models regarding both sample size and data quality. From the perspective of the theoretical components of the culture-tourism integration innovation ecosystem, the resource endowments and environmental conditions fostered by Shandong, Henan, and Shaanxi provinces in the middle and lower Yellow River region are comparatively exemplary. The middle and lower reaches of the Yellow River are located in the central and eastern part of China, between the North China Plain and the Jianghuai region. The terrain is predominantly characterized by plateaus, plains, and mountains, covering an area of 550,800 square kilometers. It primarily includes 43 cities across five provinces: Gansu, Shanxi, Shaanxi, Henan, and Shandong (Y. Wang et al., 2021), as shown in Figure 2.

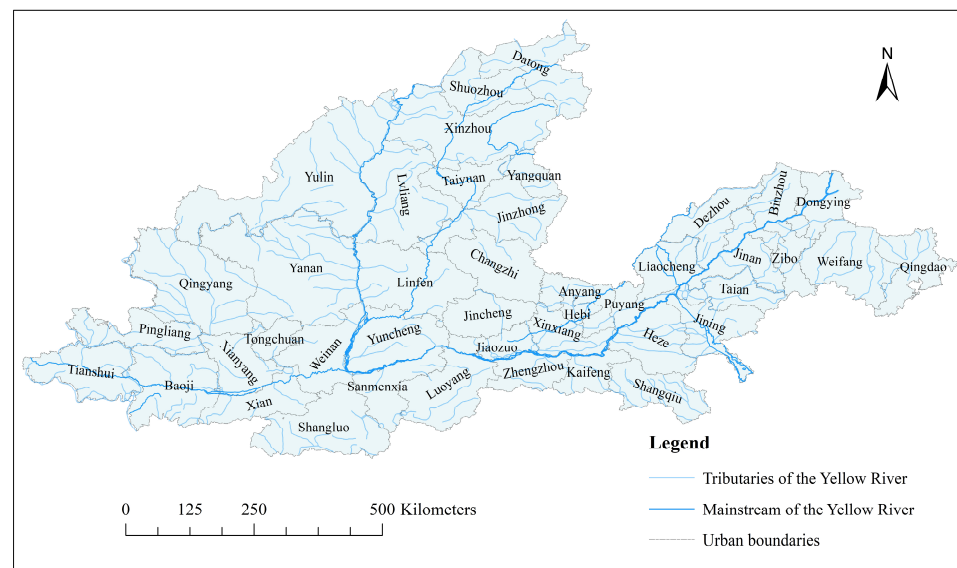


Figure 2. Forty-three cities in the middle and lower reaches of the Yellow River.

This study collected panel data for 43 sample cities from 2009 to 2023, uniformly using the data issued by the national and local statistical bureaus. The data sources include the China City Statistical Yearbook, China Tourism Statistical Yearbook, China Statistical Yearbook on Science and Technology, China Statistical Yearbook for Regional Economy, the official statistical data from tourism bureaus of relevant cities, as well as statistical yearbooks of some individual cities. Additionally, the assignment of values for digital industries and digital enterprises, as well as related data on the digitalization of cultural and tourism enterprises, are all obtained by searching the EPSDATA database.

4.2. Variable Setting

4.2.1. Dependent Variable

Cultural and tourism integration innovation aims to integrate cultural and tourism resource elements, business formats, and industrial sectors, leveraging business model transformation to innovate cultural and tourism formats, thereby enhancing the added value of cultural and tourism, enriching visitor experiences, and increasing the comprehensive benefits of cultural and tourism destinations. The dynamic process of cultural

and tourism integration innovation relies on foundational supports such as capital and institutional frameworks. This enables the revitalization and innovation of cultural resources, including large-scale cultural heritage and folk arts, which evolve into a range of new digital cultural and tourism formats of varying scales, such as digital cultural tourism, digital cultural and creative products, and digital performances. This fosters a two-way interaction and value co-creation between cultural dissemination and tourism consumption, improving the development efficiency of the cultural and tourism industry. Based on this, this study refers to the theoretical analysis of Lu Renjing and Yu Riji (Lu & Yu, 2022) and incorporates the measurement indicator methods of Yang Shasha and other scholars (Yang & Hu, 2024) to construct an indicator system for cultural and tourism integration innovation capability from three dimensions: “Foundation-Carrier-Effect.” The integrated foundational innovation capability is measured by fixed asset investment. In line with the characteristics of cultural and tourism integration innovation and based on industrial statistics, the investment in fixed assets in culture, sports, and entertainment is selected for measurement. The integrated carrier innovation capability reflects the number of human resources and enterprises involved in cultural and tourism integration innovation. This study uses two indicators for measurement: the number of employees in the culture, sports, and entertainment sectors, and the number of digital innovation-oriented cultural and tourism enterprises. The effect of integration innovation reflects the comprehensive socio-economic and cultural outcomes brought about by the integration and development of the cultural and tourism industries. Considering the comprehensive multiplier effects of tourism industry development, such as poverty alleviation, cultural promotion, and enhancement of visitor well-being, this study measures the effect of integration innovation by the comprehensive revenue encompassing all current cultural and tourism expenditures of visitors at the destination. The construction of the evaluation index system for Culture-Tourism Integration Innovation is shown in Table 1.

Table 1. Evaluation Index System for Culture-Tourism Integration Innovation.

Indicators	Weight
Number of Employees in Culture, Sports, and Entertainment	19.83%
Fixed Asset Investment in Culture, Sports, and Entertainment	23.07%
Number of Digital Content and Media Enterprises	42.01%
Total Tourism Revenue	15.09%

4.2.2. Core Explanatory Variable

Based on the rich connotation of the digital economy, this study adopts the “carrier-application-environment” analytical framework to guide the selection of evaluation indicators. This framework systematically covers the “hard support-soft integration-long-term ecosystem” aspects of the digital economy, dynamically adjusts in line with regional realities, and forms a scientific and operable evaluation system. The carrier layer serves as the foundational support for the development of the digital economy and can be measured in terms of infrastructure. The application layer reflects the integration effectiveness of the digital economy with the real economy and its actual value creation, with digital industrialization and industrial digitalization as its core components. The environment layer pertains to the soft support conditions in policy and talent. Drawing on Wang Jun’s research (J. Wang et al., 2021), this study illustrates the carriers of digital economy development from two aspects: traditional infrastructure and new digital infrastructure. According to CAICT (2017), which identifies digital industrialization and industrial digitalization as the two main components of the digital economy, digital industrialization is reflected in both

the scale of digital enterprises and the drive of digital factors, while industrial digitalization is measured through the three sectors of agriculture, industry, and services.

The governance environment of the digital economy is reflected through innovation environment and talent pool. Based on the above analyses, the evaluation index system for the digital economy in this study is formed, as shown in Table 2.

Table 2. Evaluation index system for the digital economy.

Primary Indicators	Secondary Indicators	Tertiary Indicators	Weight
Digital Economy Development Vehicles (W1) 16.47%	Traditional Infrastructure (W11) 2.49%	Fixed Broadband Internet Subscribers (W111)	2.49%
	New-Type Digital Infrastructure (W12) 13.98%	Mobile Phone Users (W121)	1.80%
		New-Technology Infrastructure Construction (W122)	6.47%
		Computing Power Infrastructure Construction (W123)	5.71%
Digital Industrialization (W2) 45.69%	Scale of Digital Enterprises (W21) 14.61%	Digital Product Manufacturing (W211)	5.02%
		Digital Product Services (W212)	3.70%
		Digital Technology Application Services (W213)	5.89%
	Digital Factor-Driven Development (W22) 31.08%	Internet-based Wholesale and Retail (W221)	12.98%
		Internet-based Finance (W222)	9.66%
		Digital Content and Media (W223)	8.44%
Industrial Digitalization (W3) 20.40%	Agricultural Digitalization (W31) 4.51%	Total Power of Agricultural Machinery (W311)	2.02%
	Industrial Digitalization (W32) 8.66%	Electricity Consumption in Rural Areas (W312)	2.49%
		Number of Industrial Enterprises Above Designated Size in High-Tech Industries (W321)	8.66%
	Services Digitalization (W33) 7.23%	Digital Inclusive Finance Index (W331)	1.17%
Development Environment for the Digital Economy (W4) 17.44%	Innovation Environment (W41) 5.35%	Postal Service Revenue (W332)	6.06%
		R&D Expenditure (W411)	5.35%
	Talent Pool (W42) 12.09%	Number of Students Enrolled in Higher Education Institutions (W421)	5.16%
		Number of Persons Employed in Information Transmission, Computer Services, and Software Industry (W422)	6.93%

4.2.3. Mediating Variable

The digital economy does not directly produce the products or business models of cultural and tourism integration innovation. Its primary role lies in empowering and optimizing the factors of production in the cultural and tourism industry, such as enhancing environmental support capabilities, stimulating new tourism demands, and optimizing tourism supply. Within the regional development of culture and tourism, these elements are collectively reflected in the regional development potential. Regional cultural and tourism development potential refers to the future value and support capacity of a region's cultural and tourism development value, socio-economic effectiveness, innovation capability, and its support systems. It is latent and can be tapped into through certain internal and external drivers of cultural and tourism integration, thereby fostering environmental, economic, social, and technological capacities for the sustainable development of culture and tourism. The evaluation of urban cultural tourism development potential is systematic in nature and difficult to measure using a single univariate index. This study follows six guiding principles—scientificity, validity, comprehensiveness, compatibility, representativeness, and operability. Drawing on the evaluation index system for tourism development potential along China's Belt and Road provinces, as constructed by Chen (H. Chen & Rahman, 2018), and referring to relevant indexes in existing studies on cultural, tourism, and heritage development potential (Snowball & Courtney, 2010; Dukanovic et al., 2021), we establish

four criterion layers: cultural tourism supply potential, environmental support potential, consumption demand potential, and scientific and technological innovation potential. We then derive the logical interrelationships among these layers, which together form the theoretical framework for evaluating cultural tourism development potential in this paper. Several alternative approaches have been used for development potential evaluation, including SWOT analysis, descriptive analysis, item response theory, GIS, and stakeholder assessment. Most of these methods adopt a supply-side perspective, and the predominance of supply-side factors often leads to one-sided results (Y. Y. Chen et al., 2021). To mitigate this issue, some studies have incorporated conceptual factor layers specific to their research objects, but this tends to prevent a purely market-based evaluation (Feng et al., 2014). In contrast, the present study employs the entropy weight method to calculate the entropy and difference coefficient of each factor, thereby determining the factor weights. This study will apply the evaluation index system for cultural and tourism development potential (Table 3) developed by the research team based on an integrated approach of technical and comprehensive evaluation, combined with the intrinsic characteristics of cultural tourism, to measure cultural and tourism development potential (Y. Chen et al., 2023).

Table 3. Three-level evaluation index system for the development potential of culture and tourism.

Rule Layers	Sub-Rule Layers	Factor Layers	Weight
Environmental Supporting Potential (X1) 20.95%	Public Environment Supply Capacity (X11) 15.25%	Highway passenger volume (X111)	2.90%
		Civil aviation passenger volume (X112)	8.57%
		Per capita urban road area (X113)	2.13%
		Harmless treatment rate of domestic waste (X114)	1.48%
		Total telecommunications business volume (X115)	4.03%
	Natural Environment Support Capacity (X12) 6.43%	Number of days with good air quality (X121)	1.82%
		Greening coverage rate in built-up areas (X122)	1.48%
		Per capita park green space area (X123)	1.58%
		Regional population density (X124)	1.56%
	Economic Environment Support Capacity (X13) 12.10%	Proportion of the tertiary industry in regional GDP (X131)	1.80%
		Proportion of fixed assets investment in the tertiary industry (X132)	1.68%
		Total amount of foreign capital actually utilized (X133)	4.89%
		Fixed assets investment in municipal public utilities construction (X134)	5.06%
		Urbanization rate (X135)	1.71%
Cultural and tourism demand potential (X2) 19.62%	Cultural and tourism demand capacity (X21) 14.57%	Domestic tourist visits (X211)	2.59%
		Inbound tourist visits (X212)	4.71%
	Cultural and tourism purchasing power (X22) 6.52%	Engel coefficient (X221)	−1.49%
		Per capita GDP (X222)	2.00%
		Resident education, culture, and entertainment consumer price index. (X223)	1.41%
Cultural and tourism supply potential (X3) 24.57%	Industrial scale contribution capacity (X31) 12.78%	Number of A-grade tourist attractions (X311)	4.91%
		Number of accommodation and catering enterprises (X312)	3.57%
		Number of public toilets (X313)	2.08%
		Number of cultural heritage sites (X314)	2.51%
		Number of cultural institutions (X315)	2.93%
	Economic benefit potential (X32) 13.62%	Total tourism revenue (X321)	3.05%
		Tourism foreign exchange income (X322)	5.57%
		Employment share of the tertiary industry (X323)	1.79%
		Number of employees in culture, sports, and entertainment industries (X324)	2.94%
		Number of employees in accommodation and catering industries (X325)	3.70%
Scientific and technological innovation potential (X4) 34.86%	Scientific and technological innovation capacity. (X41) 18.73%	Number of R&D personnel (X411)	3.90%
		R&D expenditure (X412)	4.40%
		Number of patents granted. (X413)	5.77%

Literature Resources: (Y. Chen et al., 2023).

The development of digital technology has significantly influenced the extent to which traditional resources such as cultural heritage, natural landscapes, and historical stories are digitized (through methods like 3D scanning and digital twins) and integrated into digital platforms (such as digital museums and online collections), that is, the degree of digitalization of cultural and tourism enterprises. Digitalization of cultural and tourism enterprises is the process by which these enterprises leverage digital technology and hardware systems to promote digitalization of their production, with the aim of achieving quality improvement and efficiency enhancement (F. Wu et al., 2021). Based on this analysis, the digitalization of cultural and tourism enterprises can be understood as the promotion of diversified digitalization in cultural and tourism resources, tourism services, and experience scenarios through digital technologies and hardware equipment. The characteristic information is reflected in the annual reports of enterprises with summarizing and guiding nature, where aspects such as digital transformation, product digitization, big data technology, digital technology application, digital labor force, and virtual experience scenarios are all within the scope of measurement characteristics. This study measures the digitalization of cultural and tourism enterprises using the ratio of digital cultural and tourism enterprises to cultural and tourism enterprises.

4.2.4. Control Variable

In order to reduce the interference of omitted variables on the regression results and to more accurately test the impact of the digital economy on the innovation in cultural and tourism integration, this study selects the following control variables: city GDP, education expenditure, transportation convenience (choosing the road mileage as the proxy variable), and city openness (represented by the ratio of total goods import and export value to city GDP). Based on the above analysis, the variable definitions and data sources of this study are shown in Table 4.

Table 4. Variable definitions and data sources.

Variables	Indicators	Measurement Methods	Data Sources
Innovation in Cultural and Tourism Integration	Cultural and Tourism Integration Innovation Index (C&T)	Score Calculated by Entropy Method	Statistical Yearbooks of Each City
Digital Economy	Digital Economy Development Index (Digital)	Score Calculated by Entropy Method	Statistical Yearbooks of Each City, EPSDATA
Digitalization of Cultural and Tourism Enterprises	Digital Transformation Level of Cultural and Tourism Enterprises (Edt)	Number of Digital Cultural Enterprises/Number of Cultural Enterprises	Statistical Yearbooks of Each City, EPSDATA
Development Potential of Cultural and Tourism Industry	Cultural and Tourism Development Potential Index (CTDP)	Score Calculated by Entropy Method	Statistical Yearbooks of Each City
Economic Support	GDP (Gdps)	—	Statistical Yearbooks of Each City
Cultural Support	General Budget Education Expenditure (Ee)	—	Statistical Yearbooks of Each City

Table 4. Cont.

Variables	Indicators	Measurement Methods	Data Sources
Transportation Support	Transportation Accessibility (Tpc)	—	Statistical Yearbooks of Each City
Opening-up	Urban Openness (Or)	GDP Total Value of Import and Export of Goods/Urban GDP	Statistical Yearbooks of Each City
Temporal Attributes	Year Dummy Variable (Year)	Each Year from 2009 to 2023	—
City Scale	City Type (Ctp)	Megacity Value 0, Super-large City Value 1, Large City Value 2, Small and Medium-sized City Value 3	Statistical Yearbooks of Each City

4.3. Model Assumptions and Empirical Strategy

4.3.1. Baseline Regression Model

To examine the direct impact of the digital economy on empowering innovation in the cultural and tourism integration, the benchmark econometric model constructed in this study is as follows:

$$C\&T_{it} = \alpha_0 + \alpha_1 Digital_{it} + \alpha_2 Controls_{it} + City + Year + \varepsilon_{it} \quad (1)$$

In the formula, i and t represent the city and the year respectively. $C\&T_{it}$ is the cultural and tourism integration innovation index of city i in year t , $Digital_{it}$ is the digital economy index of city i in period t , $Controls_{it}$ represents the related control variables, $City$ represents the city fixed effect, $Year$ represents the year fixed effect, α_0 is the constant term, α_1 and α_2 are the estimated coefficients, and ε_{it} is the random error term.

4.3.2. Mediating Effect Model

To empirically examine the channel mechanism through which the digital economy empowers innovation in the cultural and tourism integration, this study constructs the following mediation effect model

$$M_{it} = \beta_0 + \beta_1 Digital_{it} + \beta_2 Controls_{it} + \varepsilon_{it} \quad (2)$$

$$C\&T_{it} = \gamma_0 + \gamma_1 Digital_{it} + \gamma_2 M_{it} + \gamma_3 Controls_{it} + \varepsilon_{it} \quad (3)$$

where the explained variable $C\&T_{it}$, the explanatory variable $Digital_{it}$, and the control variables $Controls_{it}$ are as previously defined; M_{it} represents the mediating variable, which in this study denotes the development potential of culture and tourism and the digitalization of cultural and tourism enterprises.

5. Results

5.1. Baseline Regression Analysis

To eliminate dimensional differences, relevant data from the digital economy and the cultural–tourism integration innovation index system were normalized, and comprehensive indices were calculated using the entropy method. To enhance model accuracy, logarithmic transformation was applied to control variables with relatively large numerical values, such as city GDP, education expenditure, and transportation accessibility. Missing data are supplemented using the exponential smoothing technique and linear interpolation method.

Furthermore, to eliminate the impact of outliers on the research, continuous variables are winsorized at the 1st and 99th percentiles. The descriptive statistics of the relevant variables are presented in Table 5.

Table 5. Descriptive statistics of relevant variables.

	Variables	Sample Size	Mean	Median	Standard Error	Minimum	Maximum
Explained Variable	Innovation In Cultural and Tourism Integration	645	0.075	0.039	0.103	0.003	0.555
Explanatory Variable	Digital Economy	645	0.075	0.040	0.098	0.005	0.533
Mediating Variable	Development Potential of Culture and Tourism	645	0.183	0.162	0.081	0.101	0.564
	Digitalization of Cultural and Tourism Enterprises	645	0.315	0.247	0.194	0.077	0.934
Control Variable	Urban GDP	645	16.690	16.690	0.841	14.770	18.660
	Education Expenditure	645	13.220	13.220	0.642	11.780	14.780
	Transportation Accessibility	645	9.472	9.537	0.444	8.269	10.290
	Urban Openness	645	0.099	0.040	0.133	0.001	0.631

Without considering endogeneity issues, this study employs the Hausman test to discriminate between the Random Effects (RE) and Fixed Effects (FE) models. The test yields a p -value of 0.000, strongly rejecting the null hypothesis that the RE model is preferable. Consequently, we adopt a two-way (city-year) fixed-effects model for the baseline regression, with results reported in Table 5. It is worth noting that the reported overall R^2 is relatively high; this is primarily because the city and year fixed effects absorb substantial time-invariant city-specific characteristics (e.g., geographic location, cultural endowments, administrative rank) as well as common temporal trends. To isolate these confounding factors and accurately capture the net explanatory power of the core explanatory variable over the dependent variable's fluctuations, we follow the reviewer's suggestion to prioritize reporting the within R^2 , which excludes the influence of fixed effects. The result Table 6 shows that the within R^2 values for Models M11 and M12 are 0.587 and 0.626, respectively. This indicates that even after controlling for time-invariant intrinsic differences across cities, the core independent variable still explains approximately 58.7% to 62.6% of the annual variation in 'culture-tourism integration innovation' within the same city—a level of goodness-of-fit that falls within a robust and reasonable range for panel FE models. Specifically, Model M11 includes only year and city fixed effects without any control variables. The results show that the digital economy has a significantly positive impact on culture-tourism integration innovation at the 1% level, with a coefficient of 0.6955. This implies that a one-unit increase in the digital economy level leads to an approximate 0.6955-unit increase in integration innovation, providing preliminary evidence supporting Hypothesis H1 after controlling for inherent city and year differences. Upon introducing control variables in Model M12, the coefficient for the digital economy remains significantly positive at the 1% level (coefficient = 0.6830), further corroborating the robustness of Hypothesis H1.

Table 6. Basic regression results.

Variables	M11	M12
	Innovation in Cultural and Tourism Integration	Innovation in Cultural and Tourism Integration
Digital Economy	0.6955 *** (28.84)	0.6830 *** (24.44)
Urban GDP		0.0006 (0.07)
Education Expenditure		0.0198 * (2.09)
Transportation Accessibility		−0.0077 (−0.43)
Urban Openness		−0.0852 *** (−4.13)
Constant Term	0.0227 *** (11.02)	−0.1675 (−0.72)
City Fixed Effects City FE	YES	YES
Year Fixed Effects Year FE	YES	YES
Sample Size	645	645
Overall R ²	0.945	0.947
Within R ²	0.587	0.626
F	831.8490	176.1682
p	0.0000	0.0000

Note: * and *** indicate that the regression coefficients are significant at the 10%, and 1% levels, respectively, with *t*-values in parentheses.

5.2. Endogeneity Treatment

Considering that there might be a causal relationship between the digital economy and the innovation in cultural and tourism integration, that is, the digital economy can enhance the innovation ability of cultural and tourism integration, and conversely, the cultural and tourism integration innovation can also promote the development of the digital economy. At the same time, the control variables might have overlooked the omitted variables that have an impact on the explained variable, the cultural and tourism integration innovation. Specifically, the reverse facilitating effect of culture-tourism integration innovation on the digital economy may manifest in three key dimensions. First, novel digital consumption scenarios emerging from integration efforts—such as immersive cultural experiences and digital creative products—generate fresh demand for digital technology applications, thereby compelling the iterative upgrading of digital technologies. Second, the abundant cultural data resources accumulated within the culture and tourism sectors—including digitized cultural heritage assets and tourist behavioral data—provide unique data-factor support for digital economic development. Third, successful practices in culture-tourism integration offer demonstration effects and real-world validation scenarios for the cross-industry diffusion of digital technologies (Holzmann & Gregori, 2023). Precisely because of this bidirectional interplay, this study employs the instrumental variable (IV) approach to address potential endogeneity concerns and identify the net causal effect of the digital economy on culture-tourism integration innovation. The Durbin-Wu-Hausman test results indicate that there is an endogeneity problem in the model, and the instrumental variable method can be used. Taking the lagged one period of the digital economy as the instrumental variable, the two-stage least squares method is used to re-examine the impact of the digital economy on the cultural and tourism integration innovation. Using the one-period lag of the digital economy index as the instrumental variable is primarily justified on the following grounds. First, temporally, the lagged digital economy is a historical variable, whereas current culture-tourism integration innovation represents a contemporaneous

outcome. It is logically impossible for present innovation performance to retroactively influence the previous year's level of digital economic development, thereby ruling out endogeneity concerns arising from reverse causality. Second, the model incorporates a set of control variables—including city-level GDP, education expenditure, transportation accessibility, and degree of openness—which effectively absorb confounding pathways whereby historical development levels and economic fundamentals might indirectly affect current innovation outcomes via the lagged digital economy. Furthermore, as reported in Table 7, the coefficient on the lagged digital economy in the first-stage regression is significantly positive at the 1% level, and the F-statistic exceeds 10, comfortably passing the weak instrument test. This confirms that the instrumental variable is strongly correlated with the endogenous explanatory variable. After dealing with the endogeneity problem, the digital economy still significantly empowers cultural and tourism integration innovation at the 1% level, verifying the validity of the benchmark regression results.

Table 7. Endogeneity test results.

Variables	First Stage	Second Stage
	Digital Economy	Innovation in Cultural and Tourism Integration
Instrumental Variable IV	0.9311 *** (83.49)	
Digital Economy		0.6449 *** (22.27)
Constant Term	−0.4750 ** (−4.88)	
Control Variable	YES	YES
City Fixed Effects City FE	YES	YES
Year Fixed Effects Year FE	YES	YES
Sample Size	602	602
R ²	0.9914	0.9492
p	0.0000	0.0000

Note: ** and *** indicate that the regression coefficients are significant at the 5% and 1% levels, respectively, with *t*-values in parentheses.

5.3. Robustness Tests

In order to further verify the robustness of the benchmark regression results, this study conducted the following robustness tests based on the above-mentioned tests, and the results are shown in Table 8.

Considering the significant impact of the COVID-19 pandemic in 2020 on the global economy and the cultural and tourism industry, the relationship between the digital economy and cultural–tourism integration innovation may experience short-term abnormal fluctuations. Therefore, this study excluded the samples from 2020 to 2023 to eliminate the interference of exogenous events such as the pandemic, and conducted a benchmark regression on the samples from 2009 to 2019. In Model M21, the regression coefficient of the digital economy on the cultural and tourism integration innovation is 0.9205 and is significant at the 1% level. The results are consistent in direction and significance with the benchmark regression model M12, and the regression coefficient is larger. This indicates that after excluding certain samples, the enabling effect of the digital economy on the innovation capacity of cultural–tourism integration remains robust and demonstrates a stronger influence. By replacing the econometric model with a random effects model, Model M22 shows that the digital economy is still significantly enhancing the innovation capacity of cultural–tourism integration at the 1% level.

Table 8. Robustness test results.

Variables	M12	M21	M22	M23
	Innovation in Cultural and Tourism Integration	Innovation in Cultural and Tourism Integration	Innovation in Cultural and Tourism Integration	Innovation in Cultural and Tourism Integration
Digital Economy	0.6830 *** (24.44)	0.9205 *** (22.39)	0.8882 *** (28.91)	0.6099 *** (22.89)
Constant Term	−0.1675 (−0.72)	0.0474 (0.17)	−0.2045 *** (−3.71)	−0.3499 (−1.46)
Control Variable	YES	YES	YES	YES
City Fixed Effects	YES	YES	NO	YES
Year Fixed Effects	YES	YES	YES	YES
Sample Size	645	473	645	645
R ²	0.947	0.951		0.944
F	176.1682	138.9534		157.9657
p	0.0000	0.0000	0.0000	0.0000

Note: *** indicate that the regression coefficients are significant at the 1% levels, respectively, with *t*-values in parentheses.

The comprehensive index of the digital economy used in the benchmark regression covers four dimensions: the digital economy development carrier, digital industrialization, industrial digitalization, and the digital economy development environment. To further verify the robustness of the results, only the two core dimensions of digital industrialization and industrial digitalization were retained. These two dimensions reflect the supply and demand sides of digital technology, respectively, and serve as the direct drivers of cultural and tourism integration innovation. The digital economy development carrier and the digital economy development environment may suffer from issues such as strong exogeneity and high correlation with inherent urban attributes. Removing them can reduce interference from measurement errors on the core mechanism. Using the newly derived index as an explanatory variable for the benchmark regression, the digital economy in model M23 still exhibits a significant positive impact on cultural–tourism integration innovation.

All of the above methods confirm the robustness of the benchmark regression results, thereby further strengthening and validating Hypothesis H1.

5.4. Heterogeneity Analysis

Due to variations in resource endowments and development stages, both the digital economy and cultural and tourism innovation capabilities exhibit heterogeneity among cities of different sizes. According to the latest (2014) national urban size classification standards and 2023 data on the permanent urban populations of each city, the 43 prefecture-level cities in the middle and lower reaches of the Yellow River are divided into four groups: cities with a permanent urban population exceeding 10 million are classified as megacities; those with 5 million to 10 million as super-large cities; those with 1 million to 5 million as large cities; and those below 1 million as small and medium-sized cities. Before conducting grouped regression tests, a descriptive statistical analysis of the differences in the digital economy and cultural and tourism integration innovation across cities of different sizes was performed, with the results shown in Table 9. It can be observed that the digital economy level of the four city types decreases in order of city size: megacities have the highest digital economy index, while small and medium-sized cities have the lowest, with a mean difference of 0.27. Super-large cities exhibit the strongest innovation capabilities in cultural and tourism integration, whereas small and medium-sized cities

show the weakest, with a mean difference of 0.246. These findings lay the groundwork for analyzing the heterogeneous impact of the digital economy on the innovation in cultural and tourism integration.

Table 9. Differences in cultural and tourism integration innovation and digital economy among various cities.

Cultural and Tourism Integration Innovation Index					Digital Economy Index				
City Classification	Sample Size	Mean	Median	Standard Deviation	City Classification	Sample Size	Mean	Median	Standard Deviation
Megacities	30	0.250	0.207	0.111	Megacities	30	0.289	0.244	0.158
Super-large cities	75	0.258	0.212	0.164	Super-large cities	75	0.214	0.172	0.150
Large cities	465	0.044	0.037	0.031	Large cities	465	0.048	0.037	0.037
Small and medium-sized cities	75	0.012	0.011	0.007	Small and medium-sized cities	75	0.019	0.015	0.013

The results of the grouped regression by city size are shown in Table 10. For super-large cities and large cities, the regression coefficients of the digital economy on cultural and tourism integration innovation are significantly positive at the 1% level. For small and medium-sized cities, the coefficient is positive but not statistically significant. In contrast, for megacities, the regression coefficient is significantly negative at the 10% level. This indicates that in super-large and large cities, the digital economy can significantly enhance their innovation capacity of cultural and tourism integration. In small and medium-sized cities, the promoting effect is not yet significant, while in megacities, a significant inhibiting effect is observed. The reasons for this are as follows: On one hand, the high concentration of digital industries—such as internet services and fintech—in megacities may induce governments and enterprises to prioritize resource allocation toward the digital economy. This can generate a “resource crowding-out” effect on the capital and policy support essential for culture-tourism integration innovation. Existing literature substantiates this concern: [Autor et al. \(2020\)](#) demonstrate that in markets dominated by “superstar firms,” resources increasingly concentrate in leading digital enterprises, potentially crowding out traditional industries. Similarly, [Acemoglu and Restrepo \(2020\)](#) argue that technological progress is not sector-neutral; automation and digitization may substitute for, rather than complement, investment and labor in conventional sectors. On the other hand, megacities have entered an advanced stage of digital development. Consequently, the marginal contribution of mere digital technology investment to culture-tourism integration innovation is beginning to diminish, subjecting these hubs to the constraint of “diminishing digital dividends” ([Brynjolfsson et al., 2021](#)) and narrowing the scope for further digital enablement. Notably, due to the limited megacity subsample size ($N = 30$), the negative coefficient is only marginally significant at the 10% level ($p = 0.0725$). Therefore, the aforementioned explanations should be construed as exploratory inferences pending further validation. In super-large and large cities, where the digital economy is well-developed and the cultural and tourism industry is a crucial pillar of economic growth, innovation in cultural and tourism integration relies more on digitalization to address existing shortcomings. Consequently, the digital economy can significantly boost their innovation capabilities in this area. In contrast, small and medium-sized cities started developing their digital economies later and at a lower level. The driving force of the digital economy for cultural and tourism integration innovation is still in its initial exploratory stage, which explains why the promoting effect is not yet significant.

Table 10. Heterogeneity test results.

Variables	M31 Megacities	M32 Super-Large Cities	M33 Large Cities	M34 Small and Medium-Sized Cities
	Innovation in Cultural and Tourism Integration	Innovation in Cultural and Tourism Integration	Innovation in Cultural and Tourism Integration	Innovation in Cultural and Tourism Integration
Digital Economy	−1.3726 * (−3.05)	0.7430 *** (6.04)	0.1839 *** (3.32)	0.1527 (0.95)
Constant Term	15.5012 * (2.31)	0.1887 (0.17)	−0.2460 (−1.25)	−0.0506 (−0.27)
Control Variable	YES	YES	YES	YES
City Fixed Effects	YES	YES	YES	YES
Year Fixed Effects	YES	YES	YES	YES
Sample Size	30	75	465	75
R ²	0.973	0.961	0.751	0.690
F	2.9995	28.9544	7.0127	1.1160
p	0.0725	0.0000	0.0000	0.3637

Note: * and *** indicate that the regression coefficients are significant at the 10% and 1% levels, respectively, with *t*-values in parentheses.

5.5. Mediating Effect Analysis

The results of the mediation test are shown in Table 11. Model M41 and Model M43 indicate that the digital economy can significantly enhance the cultural and tourism development potential and the digitalization of cultural and tourism enterprises; Model M42 and Model M44 indicate that the two mediating variables have a significant positive impact on cultural and tourism integration innovation. The above results show that the digital economy can significantly improve the innovation capacity of cultural and tourism integration through the two mediating paths of cultural and tourism development potential and digitalization of cultural and tourism enterprises. The mediating effects of the two are 15.95% and 2.62% respectively. H2 and H3 are confirmed.

The results reveal that the mediating effect of development potential of culture and tourism (15.95%) markedly outweighs that of digitalization of cultural and tourism enterprises (2.62%). This gap can be interpreted through the following lenses: First, in terms of transmission mechanisms, the development potential of culture and tourism is a comprehensive indicator encompassing multiple dimensions—environmental support, market demand, industrial supply, and technological innovation. The digital economy can transmit its effects through multiple sub-pathways, essentially forming a “multi-path transmission bundle.” In contrast, enterprise digitalization operates via a single transmission channel, which inherently constrains the magnitude of its mediating effect. Second, regarding the target of influence, the development potential of culture and tourism acts upon the “industrial ecosystem.” Its enhancement benefits all culture- and tourism-related entities within the region, generating an inclusive effect that improves the overall industrial ecology. In contrast, enterprise digitalization only affects specific firms that have implemented transformation initiatives, resulting in limited coverage. Third, considering the stage of development, the digitalization of cultural and tourism enterprises in the middle and lower reaches of the Yellow River remains largely in its nascent phase. Many enterprises are still confined to basic informatization and have yet to enter a genuine stage of digital transformation; consequently, the transmission chain remains fragmented and inefficient. Fourth, from a theoretical perspective, enterprise digital transformation is inherently a long-term process characterized by “initial investment followed by delayed returns” (Trenerry et al., 2021). During the sample period (2009–2023), most enterprises remained in the investment stage;

consequently, the mediating effect had not yet fully materialized. In sum, the divergence in mediating effects between these two pathways reflects a fundamental distinction between “systemic empowerment at the industrial ecosystem level” and “incremental transformation at the individual enterprise level.”

Table 11. Mediating effect test results.

Variables	Benchmark Regression	Mediating Effect of Cultural and Tourism Development Potential		Mediating Effect of Digitalization of Cultural and Tourism Enterprises	
	M12 Innovation in Cultural and Tourism Integration	M41 Development Potential of Culture and Tourism	M42 Innovation in Cultural and Tourism Integration	M43 Development Potential of Culture and Tourism	M44 Innovation in Cultural and Tourism Integration
Digital Economy	0.6830 *** (24.44)	0.2883 *** (15.28)	0.5741 *** (17.94)	0.5498 *** (5.41)	0.6651 *** (23.36)
Development Potential of Culture and Tourism			0.3778 *** (6.36)		
Digitalization of Cultural and Tourism Enterprises					0.0326 ** (2.88)
Constant Term	−0.1675 (−0.72)	−0.0249 (−0.16)	−0.1581 (−0.70)	0.0326 ** (2.88)	−0.2154 (−0.92)
Proportion of the Mediating Effect			15.95%		2.62%
Control Variable	YES	YES	YES	YES	YES
City Fixed Effects	YES	YES	YES	YES	YES
Year Fixed Effects	YES	YES	YES	YES	YES
Sample Size	645	645	645	645	645
R ²	0.947	0.961	0.951	0.802	0.948
F	176.1682	74.7426	163.5047	9.1717	150.0159
p	0.0000	0.0000	0.0000	0.0000	0.0000

Note: ** and *** indicate that the regression coefficients are significant at the 5% and 1% levels, respectively, with *t*-values in parentheses.

6. Discussion

6.1. The Overall Empowerment Effect of the Digital Economy on Cultural–Tourism Integration Innovation

The baseline regression results indicate that the digital economy exerts a significant positive effect on enhancing cultural–tourism integration innovation capacity (coefficient = 0.683, significant at the 1% level). This finding is broadly consistent with the prevailing consensus in the existing literature. Furthermore, the mechanism analysis confirms that the digital economy has a significantly positive impact on culture–tourism integration, with technological innovation acting as a mediating channel.

This study advances the current understanding in two key respects. First, it shifts the analytical focus from general “cultural–tourism industry integration” to the specific construct of “innovation capacity of cultural and tourism integration,” developing a dedicated evaluation index system tailored to this dimension. Second, it identifies and quantifies the heterogeneous effects of two distinct mediation pathways, thereby unpacking the concrete transmission architecture through which the digital economy empowers cultural–tourism integration innovation.

6.2. Heterogeneous Effects of Mediation Pathways and Their Theoretical Implications

This study identifies two distinct mediation pathways through which the digital economy enhances cultural–tourism integration innovation capacity: the mediated effect via development potential of culture and tourism accounts for 15.95%, whereas the effect via

digitalization of cultural and tourism enterprises stands at merely 2.62%. The pronounced disparity between these two pathways carries notable theoretical implications.

The strong mediating role of development potential indicates that the digital economy primarily empowers integration innovation by upgrading the “fundamental conditions” of regional cultural–tourism sectors—namely, environmental support capacity, market demand potential, industrial supply capacity, and technological innovation capacity. This mechanism resonates with R. Tang (2024), who finds that the digital economy fosters culture–tourism synergy by expanding market potential. However, this study advances the literature by conceptualizing and systematically testing development potential as a multidimensional, composite mediator, revealing its essential character as a “multi-pathway transmission bundle.” By contrast, the notably weak mediation effect of enterprise digitalization (2.62%) constitutes a striking counter-finding. It stands in tension with the more optimistic expectations found in prior work—for instance, existing studies suggest that digital-intelligent transition yields significant gains in cultural–tourism firms’ innovation performance, with fixed-asset investment playing a pivotal mediating role; another study, based on a sample of Chinese A-share listed companies, finds that corporate digital transformation significantly improves stock liquidity (H. Liu et al., 2024). Yet those studies predominantly focus on listed large-scale firms or samples from China’s developed eastern regions. Our sample, by comparison, centers on small and medium-sized cultural–tourism enterprises in the middle and lower reaches of the Yellow River Basin, where most firms remain at an early stage of digital transformation. This divergence suggests that the empowering effect of enterprise digitalization is likely characterized by marked regional heterogeneity and developmental stage-dependence: in areas with relatively thin digital infrastructure and a prevalence of smaller firms, the upfront costs of the “investment phase” may offset short-term innovation gains, muting the mediated effect. This interpretation aligns with Gong and Ribiere’s (2021) theoretical framework, which posits digital transformation as a multidimensional, multi-level organizational change. According to their view, firm-level digital transformation outcomes are constrained by intersecting factors—technical capacity, organizational readiness, and strategic resource allocation—such that isolated digital investments struggle to generate discernible mediation effects in the short run.

6.3. Heterogeneity in City Size and the “Negative Effect of Megacities”

The heterogeneity analysis reveals a counterintuitive finding: the digital economy exerts a significant negative effect on cultural–tourism integration innovation in megacities (coefficient = -1.3726 , significant at the 10% level), whereas it produces significant positive effects in super-large and large cities. In small and medium-sized cities, the effect remains positive but statistically insignificant. This result stands in sharp contrast to the prevailing consensus in the literature that the digital economy generates uniformly positive impacts. While most existing studies report the empowering benefits of the digital economy, our findings suggest that this effect is not universal—in megacities characterized by high saturation of digitalization, further increasing investment in digital technologies may encounter diminishing marginal returns and even reach an inflection point where net effects turn negative.

Existing research offers theoretical and empirical insights into this phenomenon. Regarding resource crowding-out, Y. Wang et al. (2025), using a sample of 285 Chinese cities, find that the digital economy significantly crowds out the development of the real economy; this conclusion remains robust after employing instrumental variable estimation and introducing the “Broadband China” policy shock as an exogenous intervention. With respect to diminishing marginal returns, Y. Wu (2025), drawing on data from Chinese listed companies, demonstrates that digital transformation negatively affects financial

performance in the current period, mediated by increased financing constraints. This suggests that upfront costs and organizational frictions impede short-term profitability.

Building on this foundation, this study posits that the negative effect of the digital economy on culture-tourism integration innovation in megacities can be understood through the following three dimensions:

First, the resource crowding-out effect. Megacities exhibit a high concentration of digital industries. Large enterprises in sectors such as the internet, fintech, and artificial intelligence attract substantial capital, talent, and policy resources by virtue of their dominant market positions. In contrast, the cultural-tourism industry—as a component of traditional services—often occupies a disadvantaged position in resource allocation and struggles to receive support commensurate with that afforded to the digital sector. This disparity results in insufficient factor supply essential for culture-tourism integration innovation.

Second, the law of diminishing marginal returns. During the initial and intermediate stages of digitalization, the introduction of digital technologies significantly enhances resource allocation efficiency and product innovation capabilities within the cultural-tourism sector. However, once digitalization surpasses a certain threshold, the marginal returns generated by additional investment in digital technologies begin to decline, while the associated transition costs—such as organizational restructuring, talent cultivation, and data governance—continue to rise. Megacities have already entered this phase of “diminishing marginal returns,” wherein the net effect of digital technology investment on culture-tourism integration innovation may shift from positive to negative.

Third, structural mismatch in innovation. The digital advantages of megacities manifest primarily in technology-intensive domains. Yet culture-tourism integration innovation requires not only technical support but also the in-depth exploration of cultural resources, the sustained production of creative content, and the scenario-based creation of visitor experiences. A structural mismatch between the supply of digital technologies and the actual demands of culture-tourism innovation may prevent digital investments from effectively translating into tangible innovation outputs.

The theoretical implication of this finding is that the impact of the digital economy on industrial innovation is not a simple linear relationship, but rather a nonlinear process contingent upon contextual factors such as city size, stage of development, and industrial structure. While the prevailing literature predominantly emphasizes the positive driving force of the digital economy on industrial development, the “negative effect of megacities” identified in this study suggests that the empowering effects of the digital economy are bounded. Once city size exceeds a certain threshold and digitalization reaches a state of high saturation, the “crowding-out effect” of the digital economy on traditional industries may outweigh its “empowerment effect.” This finding extends the traditional “linear empowerment” perspective in the field of digital economy and industrial innovation, offering empirical clues for constructing a theoretical framework centered on the “contingency of digital economy empowerment.”

It should be noted, however, that due to the limited sample size of megacities ($N = 30$), the negative coefficient is only marginally significant at the 10% level ($p = 0.0725$). Consequently, the aforementioned explanations remain exploratory inferences that warrant further validation with larger samples.

6.4. Practical Value Analysis of the Study Conclusions

This study confirms the significantly positive driving effect of the digital economy on cultural-tourism integration innovation, with robust findings. Existing studies, utilizing panel data from 30 Chinese provinces, have demonstrated that the digital economy significantly promotes the integration of cultural and tourism industries, operating through

mediating channels such as policy support, industrial structure optimization, and technological innovation (Q. Liu et al., 2025). Focusing on 41 cities in the Yangtze River Delta, R. Tang (2024) found that ‘mechanism tests showed that the digital economy can promote high-quality synergistic development of the cultural and tourism industry through channels such as promoting cultural and tourism product innovation and enhancing market potential.’ Further evidence from 108 cities in the Yangtze River Economic Belt reinforces this consensus (Y. Chen et al., 2026). Collectively, these studies indicate that the core conclusion—regarding the digital economy’s role in driving cultural–tourism integration—is highly replicable across different regions and not an isolated phenomenon specific to the middle and lower reaches of the Yellow River. In developed countries characterized by sophisticated digital infrastructure and mature market mechanisms, the theoretical framework proposed in this study exhibits a high degree of direct applicability. This is primarily because these nations typically possess more advanced capabilities in digital R&D, infrastructure, and application scenarios, resulting in deeper and broader penetration of the digital economy into the cultural and tourism sectors. Furthermore, the well-established industrial chains and market mechanisms in developed countries facilitate the implementation of digital economy-driven product innovations and business model transformations. Regarding developing countries—such as China—existing research indicates that our conclusions hold significant referential value. Studies have shown that digital transformation and technologies exert positive impacts on cultural and tourism development in these contexts (Rodrigues et al., 2024). These practical observations suggest that while the fundamental logic of the digital economy driving cultural–tourism integration innovation is valid in developing countries, the specific implementation pathways and resultant outcomes may vary considerably depending on local national conditions.

7. Conclusions and Implications

7.1. Main Conclusions

Drawing on panel data from 43 cities in the middle and lower reaches of the Yellow River spanning 2009 to 2023, this study employs a two-way fixed effects model, instrumental variable (IV) approach, and mediation effect model to empirically examine the impact of the digital economy on the innovation capacity of cultural and tourism integration, along with its underlying mechanisms and heterogeneity across city sizes. The main findings are as follows: ① The digital economy significantly enhances the innovation capacity of cultural and tourism integration. Baseline regression results indicate that a one-unit increase in the digital economy index leads to a 0.683-unit improvement in innovation capability ($p < 0.01$). This conclusion remains robust after addressing endogeneity concerns and conducting a battery of robustness checks. ② The digital economy drives improvements in the innovation capacity of cultural and tourism integration through two mediating pathways. Specifically, development potential of culture and tourism exerts a strong mediating effect, accounting for 15.95% of the total effect, whereas digitalization of cultural and tourism enterprises exhibits a weak mediating effect, contributing only 2.62%. The divergence in mediating effects reflects a fundamental distinction between “systemic empowerment at the industrial ecosystem level” and “incremental transformation at the individual enterprise level.” ③ The impact of the digital economy on the innovation capacity of cultural and tourism integration varies significantly across cities of different sizes. The effect is significantly positive in super-large cities and large cities, positive but statistically insignificant in small–medium cities, and surprisingly negative in megacities—with a coefficient of -1.3726 , significant at the 10% level.

7.2. Policy Implications

Building on the foregoing findings, this study proposes the following policy recommendations: ① Continue advancing digital infrastructure development to unleash the enabling potential of the digital economy for culture-tourism integration innovation. The overall effect and mediation mechanisms identified in this study confirm that the digital economy exerts a significant positive driving force on integration innovation. Cities in the middle and lower Yellow River region should sustain and scale up investments in new digital infrastructure—including 5G networks, big data centers, and artificial intelligence—while simultaneously enhancing the comprehensive potential of regional culture-tourism development. This entails optimizing public environmental provision, expanding cultural and tourism market scale, and strengthening industrial innovation capacity, thereby cultivating a favorable industrial ecosystem for digital economy-enabled integration innovation. ② Formulate differentiated digital culture-tourism policies tailored to cities of varying sizes. For super-large and large cities, policymakers should sustain the positive momentum generated by the digital economy by incentivizing cultural and tourism enterprises to leverage digital technologies for product innovation and service upgrades. For small-medium cities, priority should be given to strengthening digital infrastructure and enhancing the digital capabilities of local enterprises, thereby establishing foundational conditions for the digital economy to enable integration innovation. For megacities, however, a more cautious approach is warranted: authorities should prudently assess the marginal effects of the digital economy, optimize the allocation efficiency of digital resources within the cultural and tourism sectors, and guard against resource crowding-out and diminishing marginal returns caused by excessive investment. ③ Prioritize the cultivation of digital transformation capabilities among culture-tourism enterprises, but avoid excessive haste. This study finds that the mediating effect of enterprise digitalization is relatively weak (2.62%), indicating that in developing regions such as the middle and lower Yellow River basin, corporate digital transformation remains firmly in the “investment phase” rather than the “harvest phase.” Consequently, policymakers should focus on establishing long-term mechanisms to build enterprise digital capabilities—including strengthening digital talent development, improving technology service platforms, and reducing the costs of digital retrofitting—rather than pursuing short-term digital transformation targets. As the regional culture-tourism ecosystem improves holistically, the mediating role of enterprise digitalization is expected to strengthen progressively.

For megacities, it is imperative to prudently assess the marginal effects of the digital economy and optimize the allocation efficiency of digital resources within the cultural and tourism sectors, thereby preventing resource crowding-out and diminishing marginal returns caused by overinvestment. Specifically: First, establish a benefit evaluation mechanism for digital culture-tourism investments. Conduct ex-ante and ex-post assessments of large-scale digital culture-tourism projects in megacities to ensure genuine returns on investment, rather than pursuing the mere accumulation of technology. Second, promote the deep coupling of digital technologies with culture-tourism content. Guard against the formalistic tendency of “digitalization for its own sake,” and prioritize how technological applications tangibly enhance the tourist experience and cultural value. Third, guide the appropriate reallocation of digital resources toward the cultural and tourism sectors. Utilize policy levers to balance resource allocation between the digital economy and cultural-tourism industries, thereby mitigating the “crowding-out effect.”

7.3. Research Limitations and Future Directions

This study has several limitations that warrant attention. First, constrained by data availability, we were unable to obtain city-level, sector-specific fixed-asset investment

data to directly test the hypothesized resource crowding-out effect. Consequently, our interpretation of the negative effect observed in megacities relies primarily on theoretical inference drawn from the literature. Second, the subsample sizes for megacities ($N = 30$) and small–medium cities ($N = 75$) are relatively modest, resulting in limited statistical power. Accordingly, the related findings should be regarded as exploratory in nature. Third, while this research focuses on the unidirectional driving effect of the digital economy on the innovation capacity of cultural and tourism integration—and addresses potential endogeneity via instrumental variable estimation—the possible bidirectional interplay between the two remains insufficiently examined. Finally, although the middle and lower Yellow River region serves as a representative “developing region” within China, caution is advised when generalizing the findings to developed regions or contexts characterized by different institutional environments.

Future research could extend in the following directions: First, employing more refined identification strategies—such as dynamic panel models or natural experiments—to investigate the dynamic, mutually reinforcing mechanisms between the digital economy and culture-tourism integration innovation. Second, utilizing enterprise-level microdata to directly examine the causal effect of digital transformation on the innovation performance of culture-tourism enterprises. Third, extending the scope of study to other regions to test the external validity of the findings presented herein. Finally, subject to data availability, introducing more precise instrumental variables to further sharpen causal inference.

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Abbreviations

The following abbreviations are used in this manuscript:

UNESCO	United Nations Educational, Scientific and Cultural Organization
IP	Intellectual Property
NPCs	non-player characters
EPSDATA	Express Professional Superior Data

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