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The Impact of Digital Economy on Tourism in the Three Northeastern Provinces of China

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Abstract. Based on an empirical analysis of data from 15 tourist cities in the three northeastern provinces of China from 2003 to 2022, this study finds that: (1) There is a nonlinear U-shaped relationship between the digital economy and tourism revenue in the region. This conclusion remains robust after both robustness and endogeneity tests. (2) Heterogeneity tests reveal that the digital economy exerts a more significant impact on local tourism revenue in Heilongjiang Province, regions with higher levels of digital economy development, and regions with higher per capita GDP.

Keywords: digital economy, tourism industry, three northeastern provinces of China

1. Introduction

As a key component of the modern service sector, the tourism industry plays a vital role in promoting employment, fostering coordinated regional development, optimizing the urban–rural spatial structure, and enhancing cultural dissemination. It has thus become a strategic pillar of the national economy. In March 2017, the digital economy was included in the State Council's Government Work Report, marking its elevation to a national strategic priority. China's tourism market has continued to exhibit strong growth. However, regional imbalances in the development of the digital economy remain evident, with a clear digital divide between more developed regions—such as the Beijing-Tianjin-Hebei area, the Yangtze River Delta, and the Pearl River Delta—and the less developed central and western regions. The northeastern region of China, endowed with rich resources such as ice and snow tourism, historical and cultural heritage, and ecological landscapes, has cultivated distinctive tourism industry clusters. Nonetheless, these developments have been constrained by issues such as insufficient regional coordination mechanisms and lagging infrastructure, which call for innovation and upgrading of traditional tourism models.

The digital economy, driven by technological penetration and innovation, is gradually becoming the core engine of tourism development. In 2024, China's National Development and Reform Commission (NDRC) emphasized the proactive deployment of digital infrastructure, thereby reinforcing policy support for the digital transformation of the tourism industry. Under the guidance of the Tourism Development Plan for the Northeast Region, the three northeastern provinces have

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been actively exploring pathways for integrating the digital economy with tourism development. However, the current development process faces significant structural challenges, notably the relatively underdeveloped digital infrastructure and low level of digital integration within the industry [1]. Against this backdrop, the present study systematically examines the impact of the digital economy on the development of the tourism industry in the tourist cities of China's three northeastern provinces, grounding its inquiry in both practical concerns and theoretical logic.

2. Theoretical analysis

2.1. The impact of the digital economy on industrial development

Existing research demonstrates that the digital economy plays a significant role in driving industrial development. Studies have confirmed that the digital economy can improve resource misallocation, facilitating the concentration of technology, capital, and talent in highly efficient sectors [2]; enhance the quality of the real economy [3]; and, through consumption empowerment, innovation empowerment, and opening-up empowerment, significantly promote the development of the domestic–international dual circulation model [4]. Moreover, it drives industrial structural upgrading and efficient factor mobility, improves the level of common prosperity, and supports high-quality economic development and China's modernization [5].

2.2. Factors influencing the tourism industry

In research on the tourism industry of the three northeastern provinces, scholars have largely focused on leveraging various factors to promote its development. Existing studies have explored the integration pathways of ice and snow culture, sports, and the tourism industry, providing insights for the high-quality development of the regional ice and snow economy [6]. Furthermore, the development efficiency of ice and snow tourism in Northeast China is influenced by multiple factors such as urban pressure, status, and response [7]. Research has found that the digital economy directly or indirectly promotes the development of the tourism industry through three main channels: technological innovation, consumer demand, and institutional change [8]. By reducing consumers' information acquisition costs [9], the digital economy improves the tourism industry structure on both the supply and demand sides [10], and by increasing tourism investment [11], it drives the high-quality development of the tourism sector.

2.3. Literature review and commentary

Existing research has explored the relationship between the digital economy and tourism industry from multiple dimensions, but important gaps remain. There has been insufficient attention to regional differences in how industries are affected by the digital economy; analyses of factors influencing tourism in the three northeastern provinces have not fully considered the digital economy as a critical variable. Additionally, academic research on the digital economy has overly focused on developed regions such as the Yangtze River Delta, while neglecting the northeastern provinces. This study addresses these gaps by incorporating the digital economy as a key factor in research on tourism development in the three northeastern provinces. It also offers a new perspective on the study of the digital economy in Northeast China, providing important theoretical and practical significance for promoting the digital transformation and upgrading of the regional tourism industry.

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3. Research hypothesis

In the early stages, the development of the digital economy is not yet mature, and the high costs required may crowd out resource allocation to the tourism sector. Additionally, the transformation and upgrading of traditional enterprises takes time, and internal adjustments within firms can disrupt daily operations. As a result, the digital economy may suppress the growth of domestic tourism revenue in the short term. However, once the digital economy index surpasses a threshold inflection point, its positive effects on the tourism industry become increasingly apparent: digital platforms can reduce operating costs, big data technologies enable precise marketing, management efficiency improves, and higher-quality, more personalized products and services can be delivered. These mechanisms collectively contribute to increasing domestic tourism revenue. Based on the above analysis, this study proposes the following hypothesis:

H1: The impact of the digital economy on domestic tourism revenue in the three northeastern provinces exhibits a nonlinear characteristic, presenting a U-shaped curve relationship.

4. Research design

4.1. Sample selection and data sources

This study selects 15 tourist cities in the three northeastern provinces of China from 2003 to 2022 as the research sample. Data are primarily sourced from the China City Statistical Yearbook, National Economic and Social Development Statistical Bulletins of each prefecture-level city, among others. To ensure data validity, samples with a high proportion of missing values for relevant variables were excluded. After applying these screening criteria, the study obtained an unbalanced panel dataset with 300 observations. To mitigate the influence of extreme values, all continuous variables were Winsorized at the 5% level on both ends.

4.2. Variable definitions and measurement

The dependent variable is tourism industry development (Tri). Drawing on existing research, this study uses domestic tourism revenue as a proxy for tourism industry development.

The core explanatory variable is the digital economy (Dig and Dig^2). To ensure consistency and avoid bias from differences in statistical standards, characteristic tourism cities with constrained digital economy development and seven autonomous regions with significant data availability issues were excluded. The final sample includes the following 15 cities in the three northeastern provinces: Dalian, Harbin, Shenyang, Changchun, Dandong, Chaoyang, Yingkou, Jinzhou, Jilin, Tonghua, Songyuan, Mudanjiang, Heihe, Qiqihar, and Daqing. Based on the availability of city-level data, this study calculates the comprehensive development level of the digital economy from two dimensions: internet development and digital financial inclusion. For measuring digital financial development, it uses the China Digital Inclusive Finance Index jointly compiled by the Peking University Digital Finance Research Center and Ant Financial Services Group [12]. The selected indicators balance data availability and representativeness, effectively reflecting the level of digital economy development. This study computes digital economy indices for 15 prefecture-level cities from 2003 to 2022. Table 1 presents the selected variables and descriptions for the digital economy index.

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Table 1. Digital economy index variables and definitions

First-level Index	Second-level Index	Third-level Index	Weight	Index Attribute
Digital Economy Index	Internet Penetration Rate	Number of Internet Users per 100 People	0.3	+
	Internet-related Employment	Proportion of Computer Services and Software Practitioners	0.25	+
	Internet-related Output	Per Capita Telecom Business Volume	0.2	+
	Mobile Internet Users	Number of Mobile Phone Users per 100 People	0.15	+
	Digital Financial Inclusion Development	China Digital Financial Inclusion Index	0.1	+

In addition, drawing on previous studies, this paper includes per capita GDP (pGDP), tertiary industry share (Thr), degree of government intervention (Gov), level of openness (Open), and urbanization level (City) as control variables to minimize the influence of other factors on the empirical results.

4.3. Descriptive statistics

Table 2 reports the descriptive statistics of the main variables. The mean of tourism industry development (Tri) is 263.876, with a maximum value of 2172.24, indicating significant variation in tourism development levels across regions, with some cities performing particularly well in this sector. The digital economy (Dig) variable has a mean of 35.749 and a standard deviation of 13.513. Its maximum value is 6614.374, and its minimum value is 13.31, reflecting substantial differences in the level of digital infrastructure and development among regions.

Table 2. Descriptive statistics of main variables

Variable	Obs	Mean	Std. Dev.	Min	Max
Tri	300	263.876	364.075	1.51	2172.24
Dig	300	35.749	13.513	13.31	81.329
Dig^2	300	1459.932	1196.16	177.156	6614.374
pGdp	300	4.327	2.833	.36	14.78
Thr	300	.428	.101	.11	.68
Gov	300	.177	.097	.031	.535
Open	300	.213	.28	0	2.13
City	300	.517	.141	.252	.914

4.4. Model specification

To test the proposed hypothesis, this study constructs the following panel regression model:

$$\mathrm{Tri}_{i,t} = \beta_0 + \beta_1 Dig + \beta_2 Dig_{i,t}^2 + \sum_j \beta_j \times Control_{i,t} + \gamma_t + \mu_i + \varepsilon_{i,t} \quad (1)$$

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where: $Tri_{i,t}$ represents domestic tourism revenue for city i in year t (the dependent variable); $Dig_{i,t}$ and $Dig_{i,t}^2$ denotes the level of digital economy development in city i at time t (the core explanatory variable); Controls is a vector of control variables that vary across cities and years and may influence tourism development; γ_t represents year fixed effects; μ_i denotes city fixed effects; $\varepsilon_{i,t}$ is the random error term.

5. Empirical results analysis

5.1. Empirical analysis of the impact of the digital economy on domestic tourism revenue in the three northeastern provinces

Columns (1)–(6) in Table 3 present the baseline regression results for the impact of the digital economy on domestic tourism revenue in the three northeastern provinces. The estimated coefficients for Dig and Dig^2 are consistently significant across all specifications. Specifically, the coefficient on Dig is negative, while the coefficient on Dig^2 is positive, indicating a U-shaped relationship in the regression curve. This finding supports Hypothesis H1. The underlying explanation is that in the early stages of digital economy development, significant resource consumption is required, while the digital economy itself remains underdeveloped and the level of industrial integration is low. As a result, it cannot effectively promote tourism development, or its positive effects are insufficient to offset the incurred costs. Therefore, before crossing the threshold inflection point, digital economy development suppresses the growth of the tourism sector. After surpassing the inflection point, as the digital economy continues to develop and technologies mature, resources can be utilized more efficiently, and the digital economy begins to have significant positive effects on tourism development.

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Table 3. Baseline regression results

	(1)	(2)	(3)	(4)	(5)	(6)
	Tri	Tri	Tri	Tri	Tri	Tri
Dig	-30.385***	-19.636*	-20.293*	-20.235*	-20.868**	-22.783**
	(-2.659)	(-1.854)	(-1.908)	(-1.912)	(-1.981)	(-2.159)
Dig^2	0.226***	0.143*	0.147*	0.135*	0.135*	0.144*
	(2.790)	(1.902)	(1.951)	(1.789)	(1.792)	(1.923)
pGdp		89.947***	88.946***	80.292***	81.131***	84.244***
		(7.126)	(7.001)	(5.965)	(6.056)	(6.256)
Thr			-203.505	-247.057	-419.760	-440.154
			(-0.747)	(-0.908)	(-1.473)	(-1.549)
Gov				-481.715*	-576.298**	-579.751**
				(-1.874)	(-2.214)	(-2.235)
Open					130.478*	133.630**
					(1.944)	(1.998)
City						-360.161*
						(-1.737)
_cons	676.855***	323.222	417.320	504.018*	596.527**	806.043***
	(2.638)	(1.344)	(1.536)	(1.837)	(2.153)	(2.676)
N	300	300	300	300	300	300
R2	0.451	0.540	0.541	0.547	0.554	0.559
F	10.341	14.041	13.432	13.142	12.902	12.618

Note: ***, **, and * indicate significance at the 1%, 5%, and 10% levels. Values in parentheses are clustered standard errors, the same applies hereafter.

6. Robustness checks

6.1. Regression with lagged digital economy variable

Considering that the impact of digital economy development on the tourism industry may exhibit lagged effects, this study further tests the robustness of the previous results by including the one-period lag of the core explanatory variable in the regression model. This approach also helps alleviate endogeneity concerns. The specific results are reported in Model (2) of Table 4. The regression results show no substantial differences in the sign or significance of the coefficients for the lagged digital economy index, supporting the robustness of the baseline findings.

6.2. Propensity score matching (PSM) endogeneity test

Despite these efforts, the model may still suffer from endogeneity issues arising from sample selection bias. The propensity score matching (PSM) method can help balance other confounding factors apart from the key independent variable, mitigating the impact of selection bias on the

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results. Based on the median level of digital economy development across cities, this study constructs treatment and control groups. Control variables are used as matching covariates (all of which pass balance tests). Using a 1:1 nearest-neighbor matching approach, the study re-estimates the regression. The results, shown in Column (5) of Table 4, indicate that the coefficient on Dig remains significantly negative, while the coefficient on Dig^2 remains significantly positive, further validating the robustness of the results.

Table 4. Robustness check results

	The explanatory variable lags by one period		PSM
	Tri	Tri	Tri
Dig l	-35.229***	-24.207**	
	(-2.938)	(-2.146)	
Dig^2 l	0.260***	0.158*	
	(2.966)	(1.907)	
Dig			-17.237***
			(-3.010)
Dig^2			0.175***
			(2.731)
Controls	Yes	Yes	Yes
_cons	789.148***	749.581**	-418.290**
	(2.956)	(2.417)	(-2.573)
N	285	285	300
R2	0.448	0.550	0.565
F	10.128	11.965	13.644

Note: ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively. Values in parentheses are clustered standard errors, the same applies hereafter.

7. Heterogeneity tests

7.1. Regional heterogeneity analysis

To examine whether the effect of the digital economy on tourism varies across cities in different provinces, this study conducts heterogeneity tests by province. The regression results are presented in Table 5. In Column (3), for Heilongjiang Province, the coefficients of Dig and Dig^2 are statistically significant at the 10% and 1% levels, respectively. The regression curve exhibits a U-shaped relationship, supporting Hypothesis H1. This result may be attributed to more advanced integration of the digital economy and the tourism industry in Heilongjiang, as well as stronger industry–academia–research collaboration. Even at the same level of digital economy development, Heilongjiang can generate greater positive impacts on tourism compared to the overall three northeastern provinces. Alternatively, to achieve the same level of digital economy development, Heilongjiang requires less cost and resource consumption than the regional average. By contrast, in Columns (1) and (2), the coefficients of Dig and Dig^2 are not statistically significant for Liaoning

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and Jilin Provinces, suggesting that the digital economy does not have a significant impact on tourism in these provinces.

Table 5. Regional heterogeneity test results

	Liaoning Province	Jilin Province	Heilongjiang Province
	(1)	(2)	(3)
	Tri	Tri	Tri
Dig	0.207	-10.869	-25.115*
	(0.027)	(-0.117)	(-1.754)
Dig^2	-0.017	0.364	0.432***
	(-0.222)	(0.182)	(2.662)
Controls	Yes	Yes	Yes
_cons	-382.509**	-235.021	174.918
	(-2.222)	(-0.225)	(0.440)
N	120	80	100
R2	0.853	0.900	0.870
F	61.387	41.812	30.648

*Note: ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively. Values in parentheses are clustered standard errors (same below).

7.2. Heterogeneity analysis based on digital economy development level

To investigate whether the effect of the digital economy on tourism differs among cities with varying levels of digital economy development, the sample is divided into two groups based on the average digital economy index. As shown in Columns (1) and (2) of Table 6, the estimated coefficients of Dig are not statistically significant in either group. However, in the high-level group, the coefficient of Dig^2 is significant at the 10% level. This finding suggests that once the digital economy surpasses a certain threshold, its marginal promotional effect on tourism becomes stronger.

7.3. Grouping by per capita GDP (pGDP)

To explore whether the impact of the digital economy on tourism varies across cities with different levels of economic development, the sample is divided into high and low groups based on per capita GDP (pGDP). As shown in Table 6, Column (3) (the high economic development group) yields estimated coefficients for Dig and Dig^2 that are negative and positive, respectively, both statistically significant. This result is consistent with the U-shaped relationship found in the baseline regression. In Column (4) (the low economic development group), the coefficients for Dig and Dig^2 are not statistically significant, suggesting that in economically less developed areas, the weak economic foundation limits the ability of digital technologies to effectively boost tourism revenue.

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Table 6. Heterogeneity test results by digital economy development level and pGDP

	High level of digital economy	Low level of digital economy	High level of economic development	Low level of economic development
	(1)	(2)	(3)	(4)
	Tri	Tri	Tri	Tri
Dig	-26.492	-14.775	-28.975***	5.172
	(-1.543)	(-0.463)	(-2.619)	(0.880)
Dig^2	0.305*	0.211	0.224*	-0.076
	(1.884)	(0.299)	(1.831)	(-0.731)
Controls	Yes	Yes	Yes	Yes
_cons	-721.708*	206.663	-1399.866***	-212.599*
	(-1.803)	(0.498)	(-4.255)	(-1.933)
N	150	150	148	150
R2	0.672	0.656	0.608	0.509
F	27.405	6.703	26.546	15.496

*Note: ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively. Values in parentheses are clustered standard errors (same below).

8. Conclusion and policy recommendations

Based on panel data from 15 tourist cities in the three northeastern provinces of China from 2003 to 2022, this study systematically examines the impact of the digital economy on domestic tourism revenue and reaches the following conclusions: The digital economy exhibits a significant "U-shaped" nonlinear effect on the tourism industry. In the early stages of digital economy development, resource crowding-out effects constrain tourism development, and the initial benefits of digitalization are insufficient to offset development costs. However, once the digital economy crosses a threshold inflection point, its promotional impact on the tourism sector becomes significant. Heterogeneity test results further reveal that the impact of the digital economy on local tourism development is more pronounced in Heilongjiang Province, regions with higher levels of digital economy development, areas with higher tourism income, and regions with higher per capita GDP. These advantages are closely related to more mature digital industry foundations and better policy adaptability, which make it easier to realize the digital economy's positive effects.

In the context of an urgent need for digitally empowered tourism transformation, regional coordinated development, and the distinctive prominence of the Northeast's ice and snow economy, this study proposes the following targeted policy recommendations to address challenges such as lagging digital infrastructure and insufficient industry integration:

First, local and central governments should adopt a long-term strategic perspective to leverage the sustained positive role of the digital economy in promoting high-quality tourism development. The three northeastern provinces should continue to intensify efforts to develop the digital economy, strengthen policy support, improve security protections, accelerate digital infrastructure

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construction, and energize the data market. Greater investment and subsidies should be directed to relevant enterprises to enhance innovation capacity and promote digital economy development.

Second, local governments should fully recognize that regional disparities in digital economy development may constrain overall economic coordination, and therefore strengthen regional cooperation mechanisms to accelerate the process of regional integration. The three northeastern provinces can promote cross-regional collaboration in the digital economy and tourism sectors by establishing regular communication platforms and inter-provincial resource-sharing cooperation platforms. Such measures can facilitate resource sharing, enable the free cross-regional flow of production factors, narrow the "digital divide," and promote coordinated regional development.

Finally, local governments should, in formulating development strategies, systematically analyze and draw lessons from Heilongjiang Province's advantages and successful experiences—such as proactive digital infrastructure deployment and abundant ice and snow natural resources—while also taking into account their own resource endowments and industrial structures. By adapting and learning from these models, each region can develop its own unique path for digital economy development and digital empowerment of the tourism industry, thereby more fully realizing the digital economy's potential to promote tourism development.

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