Impact of Civil Aviation Opening on Xinjiang' s Tourism Economy: Postprint

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Abstract

Based on Xinjiang city-level panel data, this study summarizes the driving mechanism of civil aviation opening on regional tourism economy, employs multi-period difference-in-differences and mediation effect models to analyze the direct and moderating effects of civil aviation opening on Xinjiang' s tourism economy, and examines the mediation effects of different high-speed transportation mode combinations on Xinjiang' s tourism economy. The research findings indicate: (1) In summarizing the driving mechanism of civil aviation opening on regional tourism economy, civil aviation infrastructure construction and civil aviation tourism demand constitute the external pull and internal push factors affecting the tourism economy. (2) Xinjiang' s tourism economy exhibits an evolutionary trend of "high growth, high volatility" and a spatial evolution pattern of "edge multi-point agglomeration → central agglomeration diffusion" . (3) Civil aviation opening effectively reduces tourism time costs and exerts a positive and significant impact on Xinjiang' s tourism economy, with the validation model passing a series of robustness checks. (4) The moderating effect of civil aviation tourism demand on the tourism economies of northern and southern Xinjiang demonstrates distinct differential characteristics. The impact of civil aviation opening shows significant variation across northern/southern Xinjiang regions and cities with different tourism consumption intensities. (5) Different combinations of high-speed transportation modes generate complex mediation effects and diverse coopetition relationships for Xinjiang' s tourism economy.

Full Text

Preamble

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Research on the Impact Effect of Civil Aviation Opening on Xinjiang' s Tourism Economy

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Abstract: Based on Xinjiang's city-level panel data, this study summarizes the driving mechanism of civil aviation opening on regional tourism economy. Using a multi-period difference-in-differences (DID) model and mediation effect model, it analyzes both the direct and moderating effects of civil aviation opening on Xinjiang's tourism economy, and examines the mediating effects of different rapid transportation mode combinations. The findings reveal: (1) In the driving mechanism, civil aviation facility construction and civil aviation tourism demand constitute external pull and internal push forces affecting tourism economy. (2) Xinjiang's tourism economy exhibits a "high growth, high volatility" evolutionary trend and an "edge multi-point aggregation—center agglomeration diffusion" spatial pattern. (3) Civil aviation opening effectively reduces tourism time costs and positively and significantly impacts Xinjiang's tourism economy, with the model passing a series of robustness tests. (4) The moderating effects of civil aviation tourism demand quantity and quality show significant differences between southern and northern Xinjiang, with heterogeneous impacts across regions and cities with different tourism consumption intensities. (5) Different rapid transportation mode combinations generate complex mediating effects and multiple competition-cooperation relationships for Xinjiang's tourism economy.

Keywords: civil aviation opening; tourism economy; multi-period DID model; influence effect; Xinjiang

Introduction

The 20th Party Congress report in 2022 emphasized promoting high-quality development and accelerating the construction of a transportation powerhouse. The 14th Five-Year Plan for Culture and Tourism proposes building a dual-circulation tourism pattern, with the core being the coordination of comprehensive transportation systems to promote regional integrated development and open channels. Advancing the integrated development of "transportation + tourism" represents a critical pathway to support high-quality tourism economic development in Xinjiang. Tourism relies on spatial nodes connected by transportation networks to facilitate efficient allocation and rational flow of regional tourism elements. The 2017 *Opinions on Promoting the Integrated Development of Transportation and Tourism* required constructing a "fast-in, slow-tour" transportation network to enable rapid long-distance travel to and from destinations. As a typical representative of rapid transportation, civil aviation's network of airports (nodes) and flight routes (edges) dramatically compresses tourist travel time, accelerates transformation of traditional travel modes, and has become a

key link in tourism transportation network construction. With the advancement of the Silk Road Economic Belt strategy, tourism has become a strategic pillar industry in Xinjiang. Xinjiang boasts abundant tourism resources, yet suffers from the "long travel, short tour" phenomenon due to lagging transportation infrastructure, preventing resource advantages from translating into economic advantages. Civil aviation has become the preferred choice for out-of-province tourists visiting Xinjiang, as it is less affected by complex terrain and variable climate, helping optimize peripheral location conditions. Urumqi International Airport' s strategic position as an international aviation hub has become increasingly important, driving Xinjiang' s transformation from a "transportation network endpoint to an Asia-Europe transportation hub center."

In practice, research on promoting coordinated civil aviation and tourism development has formed a multi-dimensional academic landscape, focusing on tourism influencing factors, regional tourism economic impacts, and specific civil aviation case discussions. Research paradigms and regional characteristics show significant differences. International studies prefer macro perspectives from the national level, analyzing civil aviation' s impact on inbound tourism, with the integrity of global aviation alliance systems and international tourism statistics data being closely related. Scholars have further emphasized aviation transport' s key role in shaping global patterns. For example, Su et al. explored the relationship between aviation transport development, economic growth, and inbound tourism, finding bidirectional causality between air passenger volume and economic growth. Domestic research is more micro-practice oriented, often analyzing specific civil aviation cases at the city scale. For instance, Cai et al. examined aviation traffic' s impact on tourism economy, finding that aviation transport advantages directly and spillover-affect tourism economic efficiency. Existing research on rapid transportation competition-cooperation mechanisms primarily focuses on high-speed rail, including binary coordination studies of high-speed rail vs. civil aviation and high-speed rail vs. highways, as well as three-dimensional integration analysis of high-speed rail, civil aviation, and highways. Research path evolution aligns with China' s comprehensive three-dimensional transportation network construction phases.

However, existing research still has shortcomings: (1) No universal theoretical model has been formed to explain how civil aviation opening drives tourism economy, with the driving mechanism lacking in-depth analysis; (2) Most studies select economically developed eastern regions or coastal tourism advantage areas, with insufficient research on western underdeveloped regions and border-crossing tourism zones; (3) Most use cross-sectional data to analyze civil aviation' s static effects, making it difficult to capture dynamic effects during civil aviation network expansion, and lacking quantitative analysis of how civil aviation demand quantity and quality moderate tourism economy; (4) Most select single indicators and advantage measures for civil aviation development, with few studies using dummy variables to verify complex mediating effects and multiple competition-cooperation relationships of different rapid transportation modes affecting tourism economy.

This paper uses Xinjiang city-level panel data from 2005–2019. Based on competition-cooperation theory, it summarizes the driving mechanism of civil aviation opening on regional tourism economy, employs multi-period DID and mediation effect models to analyze the direct effects of civil aviation opening on Xinjiang' s tourism economy, explores the moderating effects of civil aviation demand quantity (flight frequency) and quality (passenger throughput) on Xinjiang' s tourism economy, and combines competition-cooperation theory to test the mediating effects of different rapid transportation modes on Xinjiang' s tourism economy. By constructing exogenous event shocks through the multi-period DID model and controlling endogeneity, this study better identifies causal effects.

1. Theoretical Mechanism and Research Hypotheses

The rise of mass tourism has spiked transportation demand, prompting China to gradually build a "fast-in, slow-tour" tourism transportation network. Scholars have increasingly focused on competition-cooperation relationships among different rapid transportation modes. High-speed rail' s large capacity and high speed create obvious substitution effects on civil aviation; increasing private car ownership expands the self-driving tourism market, while civil aviation' s air corridors facilitate medium- and long-distance travel, creating complementary effects; intercity trains and highways have high transfer connection rates. The competition-cooperation relationships among different rapid transportation modes produce complementary or substitution effects on civil aviation opening. Based on contribution, closeness, and prospect factors, multiple rapid transportation modes jointly enhance tourism accessibility along routes through transfer connections, forming synergistic effects that accelerate rapid flow of tourism economic elements and trigger agglomeration-diffusion effects.

Tourism economy is subject to the combined effects of civil aviation facility construction and civil aviation tourism demand. Civil aviation facility construction (quantity and grade) forms external pull forces on tourism economy, while civil aviation tourism demand quantity (flight frequency) and quality (passenger throughput) constitute internal push forces that directly boost per capita income (economic foundation), enhance tourism organization capacity (supply-demand link), and indirectly affect investment levels (government support), service industry levels (endogenous drivers), and tourism resource abundance (development prerequisites), thereby promoting high-quality tourism economic development. Higher per capita income drives civil aviation facility construction and feeds back to investment levels; tourism organization capacity stimulates civil aviation supply-demand and rationally allocates tourism resources; investment levels and per capita income grow synchronously, integrating and upgrading service capacity; management adapts to investment trends and expands tourism resource production capacity.

Civil aviation facility construction (external pull) and civil aviation tourism demand (internal push) differentiate the impact effects of civil aviation opening (geographic location, consumption intensity). For geographic location heterogeneity, optimizing rapid transportation network layout can mitigate local "hot competition," broaden factor flow channels, and strengthen intensive management. For consumption intensity heterogeneity, establishing a "fast-carrying-slow, strong-leading-weak" linkage mechanism can optimize tourism resource matching, balance economic "cold cooperation," and promote collaborative operations.

Tourism resources follow spatial agglomeration-dispersion laws, frequently flowing to promote increasingly close regional tourism connections and support high-quality tourism economic development. Civil aviation dramatically compresses spatiotemporal costs, facilitating rapid flow of tourism elements and once surpassing railways and highways. In 2020, China's civil aviation passenger volume rose to the world's top position, becoming a key link in tourism transportation network construction. With the advancement of the "Tourism Revitalizes Xinjiang" strategy, tourism has become a strategic pillar industry in Xinjiang. Based on this analysis, we propose **Hypothesis 1**: Civil aviation opening has a significant positive impact on regional tourism economy.

The construction of civil aviation airports in tourism destinations optimizes transportation networks and promotes high-quality tourism economic development. Airport quantity determines civil aviation network coverage area and extends its reach; airport grade determines airport capacity, ensuring flight frequency and passenger volume, and granting tourists flexible travel choices. Civil aviation tourism demand quantity (flight frequency) and quality (throughput) drive civil aviation transport network optimization, increase tourist flow, adjust and upgrade destination tourism market structure, promote internal pull forces for tourism economy, boost per capita income (economic foundation), coordinate investment levels (government support), integrate service industry levels (endogenous drivers), accelerate rational development of tourism resources (development prerequisites), and improve travel intermediary organization efficiency (supply-demand link). Differences in tourism economic development and infrastructure construction lead to regional deviations in civil aviation demand, which have heterogeneous effects on optimizing regional tourism economic structure and increasing tourist leisure time, expanding tourism economic disparities. Based on this analysis, we propose **Hypothesis 2**: Civil aviation opening has differential impacts on regional tourism economy depending on city-level airport flight frequency and passenger throughput.

Tourists in cities with different tourism consumption intensities have varying demands. With steady socioeconomic improvement, tourists pursue higher-level requirements for travel efficiency and comfort, making civil aviation demand closely related to tourist income levels. Compared with intercity trains and highways, civil aviation's high costs inevitably increase travel expenses. The level of economic development and per capita consumption in cities with civil aviation

opening affects tourists' transportation mode selection preferences. Compared with medium and high consumption intensities, price-sensitive low-consumption-intensity tourists find it difficult to accept high-cost civil aviation travel, creating heterogeneous characteristics in how civil aviation opening affects tourism economy across cities with different consumption intensities. Based on this analysis, we propose **Hypothesis 3**: Civil aviation opening produces differential impacts on regional tourism economy due to varying city-level tourism consumption intensities.

In the process of civil aviation, intercity trains, and highways collaboratively building integrated networks, interactive patterns emerge and derive complex mediating effects and competition-cooperation relationships. According to competition-cooperation theory, intercity trains' rapid network operation advantages overlap with civil aviation' s medium- and long-distance transport demand satisfaction, easily triggering passenger competition. Intercity trains' affordable prices, frequent schedules, and convenient layouts partially segment civil aviation passenger flow and reshape regional passenger flow patterns. Meanwhile, highways' flexible options and civil aviation' s direct-flight models reasonably connect, filling civil aviation' s small-scale transport limitations. Based on this analysis, we propose **Hypothesis 4**: Different rapid transportation modes produce multiple mediating effects on regional tourism economy.

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2. Data and Methods

2.1 Data Sources

As a core area of the Silk Road Economic Belt and a transportation powerhouse construction pilot unit, Xinjiang currently has 25 airports, the most among all provinces in China and an important aviation channel connecting Asia and Europe. This study selects Xinjiang as the research area. To avoid COVID-19 impacts, city-level panel data from 2005–2019 were collected (descriptive statistics in). Statistical data were sourced from the *Xinjiang Statistical Yearbook* (2006–2020) and annual national economic and social development statistical bulletins of each city. Tourism scenic spot data were obtained from the Xinjiang Uygur Autonomous Region Culture and Tourism Department website. Civil aviation data were sourced from annual China Civil Aviation Airport Production Statistics Bulletins, with missing data for some years supplemented using linear interpolation.

Considering investment progress and construction cycles, construction of facilities in cities along routes and surrounding transportation stations may lag behind the gradual opening of different rapid transportation modes. Meanwhile, rapid transportation' s radiation and driving effects on tourism enterprises show delayed performance and extended driving effects. Therefore, cities with rapid transportation modes opened or upgraded before October 1st of a given year

are considered opened in that year; otherwise, they are considered opened the following year.

2.2 Research Methods

1) Multi-period Difference-in-Differences Model. This study treats civil aviation opening as a quasi-natural experiment, with cities that have opened civil aviation as the treatment group and those without as the control group. It uses a multi-period DID model to analyze the impact effect of civil aviation opening on regional tourism economy.

The model is specified as:

$$PTC_{it} = \alpha_i + \beta DTCA_{it} + \gamma X_{it} + \mu_i + \delta_t + \varepsilon_{it}$$

where PTC_{it} (dependent variable) represents tourism economy; α_i is the constant term; $DTCA_{it}$ (core explanatory variable) is the dummy variable for civil aviation opening, with coefficient β representing the impact effect; X_{it} denotes control variables; γ is their estimated coefficient; i indicates city; t indicates time; μ_i and δ_t are region and time fixed effects; and ε_{it} is the random error term.

2) Mediation Effect Model. To verify the impact paths of different rapid transportation modes on tourism economy, this study draws on Wen et al.' s mediation effect model to verify the multiple competition-cooperation relationships among civil aviation, intercity trains, and highways affecting Xinjiang' s tourism economy.

The stepwise regression equations are:

$$PTC_{it} = \alpha_0 + \beta_0 DTCA_{it}, HSR_{it}, HW_{it} + \gamma_0 X_{it} + \mu_i + \delta_t + \varepsilon_{it}$$

$$M_{it} = \alpha_1 + \beta_1 DTCA_{it}, HSR_{it}, HW_{it} + \gamma_1 X_{it} + \mu_i + \delta_t + \varepsilon_{it}$$

$$PTC_{it} = \alpha_2 + \beta_2 DTCA_{it}, HSR_{it}, HW_{it} + \sigma M_{it} + \gamma_2 X_{it} + \mu_i + \delta_t + \varepsilon_{it}$$

where $DTCA_{it}, HSR_{it}, HW_{it}$ represents the pairwise interactions among civil aviation opening, intercity trains, and highways; M_{it} is the mediating variable; σ is the estimated impact of rapid transportation per capita mileage on the other tourism economy; γ is the regression coefficient of control variables; β is the direct effect of different rapid transportation modes (civil aviation opening, intercity train opening, highway opening) on Xinjiang' s tourism economy; and β' is the mediating effect.

2.3 Variable Selection

Dependent Variable: Tourism economy (PTC). With tourism consumption upgrading, using single-factor indicators cannot fully reflect tourism economic benefits. This study selects per capita tourism consumption (ratio of total

tourism revenue to total visitors) as the tourism economy measure to evaluate destination attractiveness and tourism industry development level.

Core Explanatory Variables: Include civil aviation opening, civil aviation demand quantity, and quality. Civil aviation opening ($DTCA$) uses the interaction term of regional dummy variable ($Treat_i$) and time dummy variable ($Time_t$). Civil aviation demand quantity (FS) uses flight frequency (thousands of times). Civil aviation demand quality (APT) uses airport passenger throughput (10^4 persons).

Mediating Variables: Include intercity trains and highway opening. Intercity train opening is represented by dummy variable ($DTHSR$). Highway opening is represented by dummy variable ($DTHW$).

Control Variables: Drawing on Li et al. and Wang et al., this study selects per capita income ($pgdp$), investment level (inv), service industry level (ser), tourism resource abundance (dtr), and tourism organization capacity (toa) as control variables. Based on the *Tourism Scenic Spot Quality Grade Evaluation Management Measures* (National Tourism Administration Order No. 23) and *Classification and Evaluation of Tourism Scenic Spot Quality Grades* (GB/T17775-2003), 1A-5A scenic spots are weighted and summed to calculate city-level tourism resource abundance.

The sample is divided into non-opened and opened groups based on civil aviation opening. The mean and median per capita tourism consumption in opened cities are significantly higher than in non-opened cities at the 1% level, providing preliminary evidence that civil aviation opening can drive high-quality tourism economic development.

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3. Empirical Analysis

3.1 Spatiotemporal Evolution of Xinjiang' s Tourism Economy

Temporal Evolution (Figure 2): Xinjiang' s per capita tourism consumption shows a "high growth, high volatility" trend, peaking in 2008 (¥1,200 · person^{-1}) and 2017 (¥1,400 · person^{-1}), characterized by long-term slow rise and short-term rapid decline under rapid transportation advantage driving, following cyclical fluctuation patterns. Rapid transportation modes dominated by civil aviation have a positive impact on Xinjiang' s tourism economy with a 1–3 year slow release period. After reaching stage peaks, rapid decline occurs. Tourism economy is stimulated and improved through rapid transportation optimization, aligning with Xinjiang' s rapid transportation development stages. In recent years, the marginal effect of civil aviation opening has shown a clear diminishing trend.

Spatial Evolution (Figure 3): Using natural breakpoint classification, Xinjiang' s per capita tourism consumption is divided into high, medium, and

low intensities. Consumption intensity generally shows an "edge multi-point aggregation—center agglomeration diffusion" pattern with rapid transportation advantage changes. In 2007, China Southern Airlines unified operations under its service standards, enhancing brand effects and strengthening transportation radiation capacity to Xinjiang' s peripheral cities, causing explosive growth of "small but refined" high-consumption tourists in underdeveloped tourism areas like Karamay, Kizilsu Kirghiz Autonomous Prefecture, and Hotan, where tourist numbers were low but revenues ranked mid-level. In 2012, as other city airports opened successively, consumption intensity shifted to cities with higher resource and transportation advantages. The 叠加 opening of Altay and Kanas airports established Altay region' s tourism dominance. In 2014, the Lanzhou-Xinjiang high-speed rail opening drove tourism economic growth along the Hami-Urumqi axis, with medium-consumption-intensity cities distributed contiguously. In 2019, the Fuxing intercity train opened, and China Express Airlines built overnight bases at Korla, Aksu, and Karamay airports, promoting southern Xinjiang tourism resource development. Low-consumption-intensity cities were scattered and nested. Under comprehensive rapid transportation advantages, the Urumqi-Changji area and Bortala Mongol Autonomous Prefecture became consumption hotspots. In 2020, the Tarim Basin highway circle was completed, boosting tourism consumption heat in Kashgar and Hotan regions.

3.2 Parallel Trend Test

To avoid estimation bias caused by endogeneity, this study uses Stata software for parallel trend tests (Table 2). The dynamic effect of civil aviation opening' s lagged impact is examined by selecting 3 periods before opening and 5 periods after opening to plot Xinjiang' s per capita tourism consumption dynamic effect diagram (Figure 4). The coefficient β before opening is insignificant and fluctuates near 0, while coefficients β after opening are significantly positive and gradually increase, significantly affecting city-level tourism economy, indicating the model passes the parallel trend test.

3.3 Baseline Regression Analysis

To eliminate heteroskedasticity, non-dummy variables are log-transformed. Regression results are shown in Table 3. Regression (1) shows that under time fixed effects, civil aviation opening significantly increases per capita tourism consumption, effectively promoting Xinjiang' s tourism economic development, verifying Hypothesis 1. From the chain reaction triggered by spatiotemporal compression, civil aviation' s efficient operation enables more tourists to flow in within unit time. Saved time variables can stimulate more tourism consumption, driving tourism economy prosperity. Among control variables, per capita income, investment level, service industry level, tourism resource abundance, and tourism organization capacity respectively reflect economic foundation, government support, endogenous drivers, development prerequisites, and supply-demand links —key factors affecting Xinjiang' s tourism economic development. Regions with

higher per capita income have better tourist consumption bases, and leveraging civil aviation' s spatiotemporal compression advantages injects strong vitality into local tourism markets. Optimized service industry levels and tourism organization capacity help enhance tourist satisfaction and experience, increasing per capita tourism consumption. Investment level and tourism resource abundance significantly negatively impact per capita tourism consumption, with the latter' s absolute coefficient value being smaller. Strong tourism development momentum and robust mass tourism demand exist, yet insufficient tourism investment and imbalanced tourism resource development may suppress Xinjiang' s tourism economic development.

3.4 Robustness Tests

Robustness tests are conducted by changing civil aviation opening time nodes (Table 4). Treating civil aviation opening 1 year before and after as current-year opening, core explanatory variables $DTCA_1$ and $DTCA_2$ are constructed and estimated respectively on the basis of $DTCA$ lagging 1 and 2 periods. Regardless of whether control variables are included, the regression coefficients of $DTCA_1$ and $DTCA_2$ are significantly positive, basically consistent with baseline regression results, confirming robustness. Propensity score matching balance tests and fictitious civil aviation opening time tests are also conducted, with results still supporting Hypothesis 1.

3.5 Heterogeneity and Moderating Effect Analysis

The interaction terms of civil aviation opening with civil aviation demand quantity ($DTCA \times FS$) and quality ($DTCA \times APT$) are introduced to verify significant heterogeneous characteristics of civil aviation opening's impact on Xinjiang' s tourism economy due to different geographic locations and per capita tourism consumption intensity changes (Table 5). Specific regression results are as follows:

Geographic Location Heterogeneity: In regressions (10)–(11), civil aviation opening significantly positively and negatively impacts southern and northern Xinjiang' s tourism economies respectively. Southern Xinjiang has weak rapid transportation infrastructure and slow intercity train extension. Civil aviation opening effectively promotes southern Xinjiang' s tourism economy by enhancing rapid transportation network levels and strengthening spatial tourism connections with the outside world to release development potential. Northern Xinjiang has better intercity train development foundations, and tourists prefer short-distance, low-cost intercity trains, weakening civil aviation' s passenger absorption capacity in northern Xinjiang' s tourism market and showing negative spatial spillover effects. After 2015, Xinjiang' s civil aviation airports completed initial coverage, with civil aviation construction entering a decline period and construction potential weakening, while intercity trains remain in a growth development stage. Due to transportation substitutability, they seize northern Xinjiang' s civil aviation market share, causing non-equilibrium utiliza-

tion of transportation resources. In regression (11), southern Xinjiang's tourism economy is more significantly positively moderated by $DTCA \times FS$, as southern Xinjiang's airport quantity and grade are inferior to northern Xinjiang's. Although each airport has large passenger throughput, flight frequency is low, making civil aviation opening conducive to stimulating marginal effects on southern Xinjiang's tourism economic development. $DTCA \times FS$ and $DTCA \times APT$ both significantly negatively moderate northern Xinjiang's tourism economy. Northern Xinjiang has better civil aviation development foundations but weaker tourism economy promotion effects. The competition-cooperation mechanism between civil aviation and intercity trains needs improvement, and network connectivity requires strengthening, verifying Hypothesis 2.

Consumption Intensity Heterogeneity: In regressions (12)-(14), civil aviation opening significantly positively impacts medium-intensity cities' tourism economies while negatively impacting high- and low-consumption-intensity cities. Ultra-high-consumption-intensity cities are distributed along northern Xinjiang's intercity train lines, relying on existing rapid transportation to stimulate tourism economic momentum. Competition between civil aviation and intercity trains may produce partial inhibitory effects, limiting tourism economic development. Low-consumption-intensity cities have obvious rapid transportation advantages and disadvantages, with lagging economic development and single tourism formats. Civil aviation transport and maintenance costs target middle- and high-income groups. Medium-consumption-intensity cities have good economic foundations and north-south Xinjiang border location advantages. Good cooperation between civil aviation and intercity trains makes them more significantly positively moderated by $DTCA \times FS$, connecting civil aviation, highways, and intercity trains to build a coordinated rapid transportation network. This helps break free from the "shackles" of being a national transportation network endpoint and stimulates Xinjiang's tourism economy endogenous drivers, verifying Hypothesis 3.

3.6 Mediation Effect Test

Civil aviation, intercity train, and highway opening are used as mediating variables for mediation effect tests (Table 7). Civil aviation and intercity train openings significantly positively impact Xinjiang's tourism economy, while highways show an insignificant positive effect. Impact intensity ranking is civil aviation > intercity train > highway. Compared with single rapid transportation modes, regression coefficient absolute values decrease but significance remains unchanged under different rapid transportation mode combinations, verifying mediation effects exist.

Intercity trains and highways show partial mediation effects on civil aviation opening's impact on tourism economy; civil aviation and intercity trains show partial mediation effects on highway opening's impact on tourism economy; civil aviation and highways show masking effects on intercity train opening's impact on tourism economy. Civil aviation and highways have bidirectional coopera-

tion, cooperating across land-air dimensions, with remote tourist introduction and local tourist dispersion relying on coordinated operations. Intercity trains and highways have unidirectional cooperation, with highways providing passenger flow support and extension space for intercity trains, while intercity trains help highways activate regional tourism vitality by connecting cities along routes. Intercity trains and civil aviation have unidirectional competition, overlapping in passenger markets, transport distances, and service positioning, with competition intensifying during peak tourism seasons. Multiple rapid transportation modes have complex mediating effects and multiple competition-cooperation relationships, verifying Hypothesis 4. Complex competition-cooperation relationships have equilibrium points and directionality. In the short term, one party shows strong competitiveness, which may transform into bidirectional competition. In the long term, multi-party competition conflicts ease and cooperation is gradually established, forming stable development space. Competition and cooperation may coexist among multiple rapid transportation modes within the same period, creating tourism economy "hot and cold zones."

4. Discussion

Xinjiang has vast territory but scattered tourism resources. Civil aviation opening saves tourists' time costs and serves as an important engine for Xinjiang's high-quality economic development. Based on push-pull theory, this study summarizes the driving mechanism of civil aviation opening on regional tourism economy and explores its interactive relationship with regional tourism economy. The study finds that civil aviation opening significantly positively impacts Xinjiang's tourism economy, consistent with conclusions analyzing civil aviation's positive impact on inbound tourism economy from heterogeneity and spatial spillover perspectives, supporting the conclusion that civil aviation positively affects tourism economy. This study argues that intercity trains, highways, and civil aviation have multiple competition-cooperation relationships, aligning with Sun et al.'s view that high-speed rail competes and cooperates with cars and aviation, where different transportation modes coexist in competition and cooperation. This study innovatively uses multi-period DID and mediation effect models to verify complex mediating effects and multiple competition-cooperation relationships of different rapid transportation mode combinations affecting tourism economy, finding that intercity trains, highways, and civil aviation have masking and mediating effects on Xinjiang's tourism economy. This can provide decision-making basis and practical guidance for Xinjiang's "aviation + tourism" deep integrated development.

Future improvements can be made in: (1) Exploring civil aviation's driving mechanism on regional tourism economy based on multi-dimensional influencing factors such as technological development, policy environment, seasonality, and cyclicality; (2) Quantifying civil aviation system development levels using multi-source data and employing mixed research methods to investigate civil

aviation' s impact effects on regional tourism economy; (3) Discussing civil aviation opening' s impact laws on regional tourism economy at macro scales like the Silk Road Economic Belt or micro scales like county level.

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5. Conclusions and Recommendations

5.1 Conclusions

(1) Civil aviation construction provides external pull forces for tourism economy, while civil aviation tourism demand constitutes internal push forces. Xinjiang' s tourism economy shows "high growth, high volatility" wave-like evolution, characterized by long-term slow rise and short-term rapid decline under rapid transportation advantage driving, with cyclical fluctuations. The spatial evolution pattern is "edge multi-point aggregation—center agglomeration diffusion," with medium- and low-consumption-intensity cities showing contiguous distribution and scattered nested distribution respectively.

(2) Baseline regression shows that civil aviation opening significantly promotes Xinjiang' s tourism economic development. Propensity score matching balance tests and fictitious civil aviation opening time tests confirm that civil aviation opening significantly increases Xinjiang' s per capita tourism consumption, with robust regression models.

(3) Heterogeneity analysis verifies that civil aviation tourism demand quantity and quality have significantly different moderating effects on southern and northern Xinjiang' s tourism economies. Civil aviation opening produces polarized significant impacts on southern and northern Xinjiang' s tourism economies. Heterogeneous impact effects across different consumption-intensity cities are: medium consumption intensity (significantly positive) > low consumption intensity (insignificantly negative) > high consumption intensity (significantly negative).

(4) Intercity trains and highways show partial mediation effects on civil aviation opening' s impact on tourism economy; civil aviation and intercity trains show partial mediation effects on highway opening' s impact on tourism economy; civil aviation and highways show masking effects on intercity train opening' s impact on tourism economy. Complex mediating effects and multiple competition-cooperation relationships exist among the three.

5.2 Recommendations

(1) The local "hot competition" between civil aviation and intercity trains limits northern Xinjiang' s tourism transportation resource utilization efficiency, while economic "cold cooperation" traction prevents civil aviation advantages in low-tourism-consumption-intensity cities from being

realized. It is urgent to gradually improve the comprehensive tourism transportation network in southern and northern Xinjiang to resolve the non-equilibrium development situation of tourism resources.

(2) **Mitigate local "hot competition" and strengthen intensive management.** First, sort out northern Xinjiang' s tourism transportation routes, focusing on cities with overlapping civil aviation and intercity train advantages to improve the connectivity and convenience of short-, medium-, and long-distance tour route combinations, establishing a reasonably competitive and mutually beneficial comprehensive tourism transportation network. Second, during southern Xinjiang' s intercity train planning phase, emphasize coordinated development with civil aviation, strive to connect air-land transportation networks in central tourism cities, and simultaneously use highways to connect characteristic tourism villages to develop distinctive tourism highway products.

(3) **Balance economic "cold cooperation" and promote collaborative operations.** Low-consumption-intensity cities should use rapid transportation to actively approach central tourism cities, establishing a "fast-carrying-slow, strong-leading-weak" tourism linkage development mechanism to share the tourist source dividends of high-consumption-intensity cities. High-consumption-intensity cities can construct north-south Xinjiang tourism transportation corridors to divert local tourist sources to low-consumption-intensity cities, developing characteristic tourism transportation routes and civil aviation tourism products. This will help build Xinjiang' s Silk Road Economic Belt tourism distribution center and Asia-Europe important international aviation channel, promoting Xinjiang' s transformation from a transportation network endpoint to an Asia-Europe transportation hub center.

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Note: Figure translations are in progress. See original paper for figures.