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Exploring the rationality and potential mismatches in the tourism driven economic development of Shanxi, China: An input-output analysis

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Abstract

As Shanxi Province transitions from a resource-dependent economy to one increasingly driven by tourism, assessing whether its tourism spatial structure generates coherent and equitable economic benefits is vital. This study applies an input-output framework combined with spatial econometric methods to evaluate the rationality of Shanxi's tourism development. By constructing a Tourism Economic Linkage Model, the research measures how tourism investments translate into local economic linkages, backward and forward multiplier effects and inter-industry connections. Findings reveal significant mismatches between planned tourism clusters and the actual distribution of economic benefits. While some cities exhibit strong input-output linkages that amplify tourism's local impact, others remain poorly integrated, resulting in resource misallocation and limited spillover effects. The Spatial Mismatch Index (SMI) further quantifies these disparities, highlighting zones where benefits fail to materialize as intended. This analysis underscores the need for policymakers to look beyond spatial blueprints and measure how tourism spending circulates within local economies. By demonstrating how input-output analysis can be combined with spatial techniques to detect structural gaps, this study provides empirical evidence to refine regional tourism strategies, strengthen supply chains and promote more balanced regional development. The findings offer practical insights for Shanxi and similar regions seeking to ensure that tourism's promise of sustainable growth is realized through effective economic linkages and spatial coherence.

Keywords: Comprehensive evaluation function, input-out analysis, rationality evaluation**,** Spatial Econometric Model, Spatial Mismatch Index (SMI), tourism spatial structure

Introduction

How regions design their spatial structures is central to building economic resilience and equitable growth. The connections between cities, industries and communities shape productivity and how benefits are distributed (Sun et al., 2017). Early urban theorists like Auerbach (1913) and Zipf (1949) revealed predictable patterns in city size, refined by Gabaix (1999) and expanded by Mandelbrot's (1977) fractal theory to explain urban complexity. In China, rational spatial planning has long underpinned balanced development goals: Lu (1989) stressed efficient agglomeration, while Wan and Tu (1992) argued for aligning industrial layouts with local needs. This thinking remains vital today as urbanization, climate pressures

and shocks like COVID-19 test the adaptability of cities. Smart city concepts and integrated governance now guide this evolution (Gössling, 2021; Kunjuraman, 2023), echoed in China's 14th Five-Year Plan (The People's Government of Shanxi Province, 2021).

However, spatial blueprints alone do not guarantee that tourism can deliver balanced economic returns. Scholars increasingly highlight the need to examine whether the spatial arrangement of tourism assets produces tangible economic linkages, an area where input-output analysis is especially valuable. While early studies explored rank-size rules and fractal forms (Auerbach, 1913; Zipf, 1949; Mandelbrot, 1977), recent work shows that static models miss the dynamic flows that tourism generates (Ma et al., 2020). By tracing how spending ripples through local supply chains, input-output models clarify whether tourism hubs anchor real multiplier effects (Sun et al., 2017). Some integrate fractal measures (Encalada-Abarca et al., 2022) and network analysis (Gan et al., 2021; You et al., 2022), offering richer views of how nodes generate spillovers. As digital tools and AI improve scenario testing (Chang et al., 2023; Aziz et al., 2024), new opportunities emerge to close gaps between planning and reality while minimizing environmental costs (Bunsen & Finkbeiner, 2022).

Yet many studies still rely on static or subjective measures (Wang et al., 2020b). A more robust input-output approach, combined with spatial econometrics, can reveal mismatches and guide more balanced development. Balanced development refers to a spatial pattern in which economic growth, tourism benefits and infrastructural investments are distributed equitably across regions, preventing overconcentration in a single urban pole. In the context of Shanxi Province, balanced development would mean that tourism-driven growth radiates not only from Taiyuan, the designated pole, but also diffuses through the 人-shaped tourism corridor and the three tourism belts to stimulate peripheral counties. When balance is achieved, rural and secondary cities experience multiplier effects through job creation, improved connectivity and diversified local economies. Conversely, if development remains overly centralized in Taiyuan, spatial inequalities widen, leaving peripheral areas underdeveloped and socially vulnerable, thereby undermining the intended regional integration.

The integration of an input–output framework with spatial econometrics provides a more rigorous way to examine these dynamics. While traditional models often rely on static or subjective measures of regional linkage (Wang et al., 2020b), a combined approach allows researchers to trace how tourism-related expenditures, labor mobility, and infrastructure investments circulate within and between cities. Input-output analysis captures the flow of goods and services across sectors, identifying which industries benefit most from tourism expansion, whereas spatial econometrics quantifies spatial dependence and spillover effects between neighboring cities. This synergy enables the detection of spatial mismatches such as strong tourism concentration but weak intercity linkages and reveals how economic activities in one area stimulate or inhibit those in others.

Through this combined method, the study tests whether Shanxi's well-planned tourism spatial framework anchored by the "one pole driving" model, 人-shaped corridor, and three tourism belts functions as intended in generating local linkages and promoting balanced growth (The People's Government of Shanxi Province, 2021). Despite abundant tourism assets, including the Yungang Grottoes and the Ancient City of Pingyao, Shanxi's tourism growth has weakened under the compounded impacts of COVID-19 and broader economic slowdown (Betcherman et al., 2023). If the spatial imbalances remain uncorrected, there is a risk of reversing recent poverty alleviation achievements and re-entrenching regional disparities.

This study addresses this gap by testing whether Shanxi's well-planned tourism spatial framework built around its "one pole driving" model, 人-shaped corridor, three tourism belts and Taiyuan as its hub actually produces the local linkages envisioned (The People's Government of Shanxi Province, 2021). Despite rich resources and major sites like the

Yungang Grottoes and Pingyao Ancient City, Shanxi's tourism growth has faltered under COVID-19 and broader economic headwinds (Betcherman et al., 2023). If unchecked, these risks stalling recent poverty alleviation gains.

By measuring real input-output linkages and spatial mismatches, this study aims to help Shanxi and similar regions refine tourism investments, strengthen local supply chains and ensure tourism's promise translates into tangible, resilient development.

Tourism spatial structure rationality: Definition and conceptual dimensions

Tourism spatial structure rationality refers to the degree to which the spatial distribution, organization and interconnection of tourism elements such as destinations, transportation networks, service facilities and market flows achieve an optimal configuration that supports coordinated, efficient and sustainable regional development. Conceptually, it reflects the balance between concentration and diffusion of tourism activities across space, ensuring that core and peripheral areas are functionally integrated within a coherent regional system. A rational tourism spatial structure maximizes accessibility, strengthens functional linkages, promotes equitable benefit distribution and minimizes environmental and social costs.

The concept comprises several interrelated dimensions. First, the structural dimension concerns the hierarchical arrangement of tourism centers and their spatial relations whether the system exhibits excessive centralization or healthy polycentricity. Second, the functional dimension focuses on the degree of interaction among tourism nodes, including flows of tourists, capital and information, reflecting the efficiency of intercity or interregional linkages. Third, the network dimension examines connectivity within the tourism system, measured by accessibility indices and transportation integration, which determine how effectively tourists can circulate through the network. Fourth, the equilibrium dimension assesses spatial balance in tourism development, ensuring that growth benefits extend beyond dominant cores to stimulate peripheral or rural destinations. Finally, the sustainability dimension considers environmental carrying capacity and socio-cultural resilience, emphasizing long-term stability of tourism systems.

In empirical evaluations, tourism spatial structure rationality is often assessed through indicators such as spatial concentration indices (e.g., Gini or Herfindahl coefficients), accessibility measures, spatial autocorrelation statistics (Moran's I, Getis-Ord G*) and network efficiency metrics derived from spatial econometric or GIS-based analyses. A rational structure typically exhibits moderate concentration coupled with strong horizontal linkages and positive spatial spillover effects among neighboring regions. Conversely, irrational structures are characterized by spatial polarization, weak interconnectivity and inefficient resource allocation, leading to uneven regional development.

In this study, tourism spatial structure rationality serves as a critical analytical framework for evaluating whether Shanxi's tourism spatial planning organized around its "one pole driving" model, 人-shaped corridor and three tourism belts achieves balanced, networked and sustainable regional outcomes as envisioned in provincial policy.

Literature review: Evaluating tourism spatial structure rationality through input-output analysis

Input-output analysis remains one of the most rigorous tools for systematically tracing how economic systems function and how sectors interconnect (Miller & Blair, 2021; Peypoch et al., 2021). Tourism, far from being an isolated activity, is deeply embedded within these

intersectoral flows, relying on a web of inputs and outputs that shape its real economic footprint (Demeter et al., 2021). Within this context, the spatial structure of tourism reflects how destinations develop, evolve and interact across a given territory over time (Ma et al., 2020). This study argues that an input-output framework provides an indispensable lens for testing whether a region's tourism spatial arrangement is truly rational and economically coherent.

At its core, input-output analysis maps the interdependencies that bind industries together, highlighting how inputs flow through production processes to generate outputs (Bunsen & Finkbeiner, 2022). For tourism, this means looking beyond visitor numbers or revenue headlines to understand how money, resources and services circulate within and between local economies. Such flows underpin how tourism nodes emerge, expand and sustain themselves and whether they deliver balanced benefits or produce hidden inefficiencies.

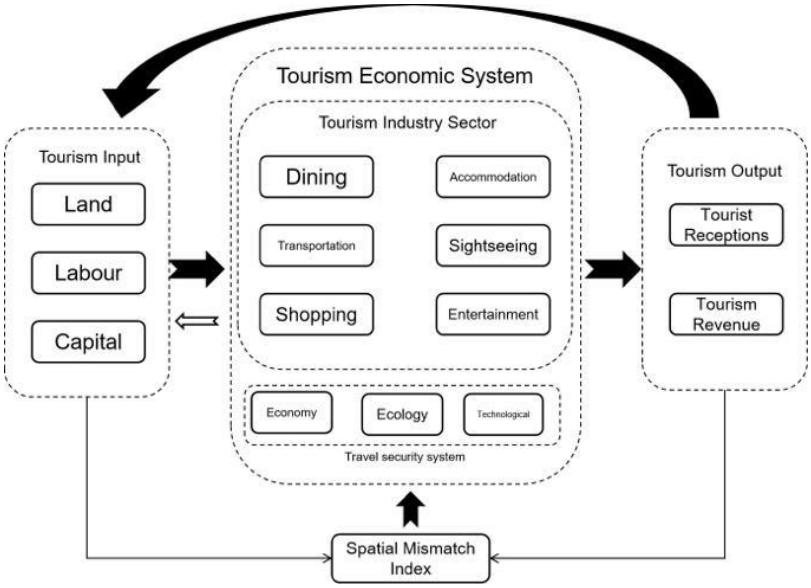
The central idea here is that a rational tourism spatial structure hinges on a clear, proportionate relationship between inputs and outputs. Outputs such as tourism revenue, visitor capacity, or service production measure how well the sector performs over time (Ouyang et al., 2020). Inputs, including capital investment, labor, natural assets, infrastructure and governance capacity directly condition these outcomes (Gillman, 2021). The balance between these elements ultimately determines how well tourism clusters, corridors and growth pole's function and whether they anchor lasting economic linkages.

In this sense, inputs serve as the foundation for outputs; when this relationship is well-calibrated, spatial patterns tend to be more efficient, resilient, and regionally equitable (Wang et al., 2020a). Conversely, misalignments between what goes in and what comes out can drain resources, weaken local multiplier effects and leave some areas underdeveloped or disconnected from broader economic circuits. Input-output analysis thus offers a clear, evidence-based means to diagnose such gaps and guide more strategic spatial planning.

In theory, increasing inputs for example, by boosting infrastructure investment or enhancing workforce skills should expand outputs proportionally. However, this relationship often breaks down due to resource misallocations, technological bottlenecks, or sudden shifts in market conditions (Liao et al., 2021). Understanding where and why these mismatches occur has become an important focus for tourism scholars and planners alike.

A growing body of work now tackles this problem directly by quantifying mismatches and developing models to explain them under various regional and sectoral scenarios (Egidi et al., 2020; González-García et al., 2020; Chi & Liu, 2023; Wang et al., 2024; Tang & Luo, 2022). Among these, spatial mismatch theory is especially relevant because it not only measures disparities between inputs and outputs but also reveals deeper structural misalignments that weaken the intended linkages. In this study, we adopt the Spatial Mismatch Index (SMI) to expose gaps between what the tourism system invests and what it delivers on the ground. The Spatial Mismatch Index (SMI) has been used in various studies, especially in urban economics, labor geography and regional planning. It measures the degree of spatial separation between where people live and where jobs or services are located. The method has been effectively applied in studies on employment accessibility in U.S. metropolitan areas (Kain, 1968; Gobillon et al., 2007), housing and job distribution in European cities (Houston, 2005) and more recently in China's urban and tourism development research (Wang et al., 2020; Zhao & Wang, 2022). Its effectiveness lies in quantifying how uneven spatial distribution affects economic opportunities and regional balance. In tourism studies, SMI helps identify mismatches between tourism resources, facilities and demand centers, guiding planners toward more balanced and efficient spatial structures.

By systematically assessing this balance, the goal is to identify where resource allocation and planning adjustments can close these gaps, ultimately fostering a more efficient, equitable and sustainable tourism spatial structure for Shanxi (see Figure 1).



Source: Authors

Figure 1. Tourism spatial structure rationality evaluation model

For its empirical grounding, this study situates its analysis within the Pole-Axis theory, focusing specifically on cities in Shanxi Province. This spatial theory, first articulated by Lu (2001), explains how socio-economic systems evolve by concentrating activity in strategic 'poles' that gradually radiate development outward along designated 'axes. These axes often transport corridors or infrastructural backbones connect key urban centers, enabling a networked structure that supports balanced regional growth (Lu, 2002).

Within this framework, tourism nodes act as functional growth poles. They anchor flows of visitors, investment and services, shaping how tourism activities cluster, disperse and ultimately restructure the spatial economy (Lu, 2024). Over time, well-positioned tourism poles consolidate their roles as urban hubs, while transport routes and supporting infrastructure form the axes that bind these nodes into a coherent whole (Lu, 2024). The strength and efficiency of these linkages often determine whether a region's tourism development simply stays localized or generates broader spillover effects that benefit surrounding areas.

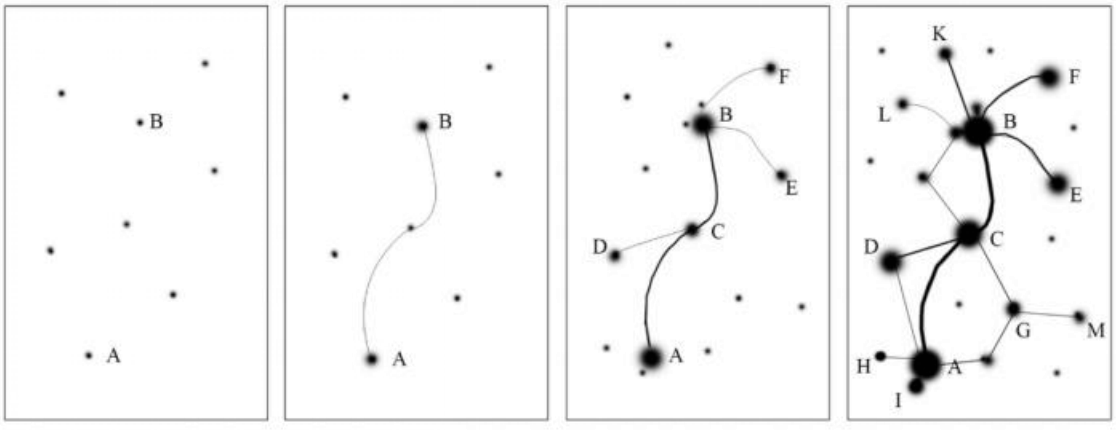
The Pole–Axis Theory provides a robust theoretical foundation for analyzing regional spatial organization and development dynamics. Originally derived from growth pole theory, it posits that regional development is driven by dominant urban centers (poles) whose influence radiates outward along defined development axes, thereby fostering spatial diffusion of economic activities and promoting coordinated growth among peripheral areas. The theory emphasizes the interplay between concentration (the growth-driving role of the pole) and diffusion (the spread of development benefits through axes and networks), making it particularly suitable for analyzing the spatial rationality and connectivity of tourism systems.

In the context of Shanxi Province, the adoption of the Pole–Axis framework is highly relevant because the province's tourism spatial strategy explicitly follows a "one pole driving, multi-axis linkage" model centered on Taiyuan as the core growth pole. This framework conceptualizes tourism development as radiating from Taiyuan through the 人-shaped tourism corridor and three major tourism belts, intended to integrate cultural, ecological and heritage destinations such as the Yungang Grottoes, Mount Wutai and Pingyao Ancient City into a cohesive network. By applying the Pole–Axis perspective, this study can empirically assess

whether these planned linkages translate into actual spatial interactions and functional complementarities among tourism nodes.

Furthermore, the Pole–Axis framework facilitates the measurement of tourism spatial structure rationality by revealing the balance between concentration and diffusion of tourism flows. It allows researchers to evaluate whether development is overly polarized around Taiyuan or effectively distributed along the tourism belts. When combined with spatial econometric techniques, the theory helps quantify spatial dependence and spillover effects, revealing how tourism growth in one area influences neighboring regions. This integrated approach advances understanding of how tourism networks evolve, how regional disparities emerge and how policy interventions can enhance intercity connectivity and regional balance. Thus, employing the Pole–Axis Theory not only aligns conceptually with Shanxi's provincial spatial plan but also provides a rigorous analytical lens to test the functional efficiency, spatial balance and rationality of its tourism development model.

In this context, the rationality of tourism spatial structures cannot be assessed in isolation from their economic dynamics. By positioning cities across Shanxi Province as core tourism poles, this study evaluates whether their spatial arrangement aligns with the region's underlying input-output flows. Are investments, labor and resources feeding into these nodes translating into robust local returns and stronger backward and forward linkages? Or do mismatches persist that weaken the intended ripple effects? By embedding the Pole-Axis framework within a tourism input-output lens, this research not only extends theoretical debates in tourism geography but also provides actionable insights for planners and policymakers. Ultimately, it highlights how tourism spatial strategies can be recalibrated to strengthen regional connectivity, correct inefficiencies, and support more balanced and sustainable development trajectories across Shanxi.



Source: modified by Meng et al., 2009

Figure 2. The evolvement phases of pole-axis system's spatial structure

Method and study area

This study focuses on Shanxi Province, situated in northern China. Renowned for its deep cultural heritage and historic landmarks, Shanxi holds significant potential for tourism development. The province's diverse geography ranging from mountains to plains shapes both its tourism patterns and its spatial configuration. In recent years, Shanxi has positioned tourism as a core driver of regional economic growth, supported by a strategic spatial framework

designed to optimize the sector's development (The People's Government of Shanxi Province, 2021). This research critically assesses the effectiveness of this framework by examining its contribution to tourism-driven economic growth and identifying spatial mismatches within the province's tourism system. The study covers a spectrum of urban and rural areas across Shanxi, each with unique tourism resources, infrastructure conditions and economic profiles.

Tourism is an integrated industry combining transport, accommodation, sightseeing, entertainment and other activities (Huang et al., 2019). As Lu (1989) argued, a rational spatial structure must reflect the balanced relationship between natural conditions, the economy, the environment, productivity and industrial layout. Guided by this system's perspective, this study constructs a comprehensive index system to evaluate the rationality of Shanxi's tourism spatial structure. Drawing on the Cobb-Douglas production function, land, labor and capital are key inputs in production (Munguía et al., 2019); however, given the complexity of tourism land use, land is excluded (Song & Li, 2019). Inputs are therefore framed around labor and capital: core tourism functions such as dining, accommodation, transport, sightseeing, shopping and entertainment define capital elements, while labor inputs are measured by the number of employees in the tertiary sector (Ladkin, 2011), with registered population and college students included as proxies for available labor. In line with recent studies (Kunjuraman, 2023; Gössling, 2021; Chang et al., 2023), economic, environmental and technological innovation factors are also incorporated to ensure a robust system. Tourism outputs are represented by domestic tourist numbers and tourism revenue (Chaabouni, 2019). Due to COVID-19 disruptions and gaps in international visitor data, only domestic indicators are used. A full summary of variables is shown in Table 1.

Table 1. Tourism spatial Structure Rationality Evaluation Index system

Target layer	Criterion layer	Weight	Indicator layer	Weight
Input	B1 Transportation accessibility	0.1216	Highway mileage (km)	0.1699
			Number of buses/electric vehicles in operation (units)	0.4469
			Number of cruise taxis in operation (units)	0.3833
	B2 Economic development foundation	0.0934	Per capita disposable income (yuan)	0.2609
			Fixed asset investment in the tertiary sector (100 million yuan)	0.4393
			GDP per capita (yuan)	0.2998
	B3 Labour and talent protection	0.1459	Number of employees in the tertiary sector (10,000 persons)	0.2077
			Registered population (persons)	0.1516
			Number of enrolled college students (persons)	0.6407
	B4 Ecological environment protection	0.1093	Green coverage rate in built-up areas (%)	0.1703
			Number of days with standard air quality (days)	0.1309
			Total green space area (hectares)	0.5518

Target layer	Criterion layer	Weight	Indicator layer	Weight
			Comprehensive ambient air quality index	0.1471
	B5 Technological support and capacity	0.3535	Number of patent authorizations (items)	0.2530
			Number of scientific research and technical service units (units)	0.2372
			Number of colleges and universities	0.2427
			Number of full-time college faculty (persons)	0.2671
	B6 Tourism industry institutions	0.1764	Number of A-level tourist attractions	0.0913
			Number of cultural centres and public libraries	0.1057
			Number of museums	0.1099
			Number of accommodation and catering establishments	0.3901
			Number of travel agencies and related service companies	0.3030
Output	A1 Tourist reception volume	0.4409	Number of tourist arrivals (per 10,000 persons)	0.4409
	A2 Tourism revenue level	0.5591	Tourism revenue (100 million yuan)	0.5591

Data for this study are sourced from the Statistical Yearbook of Shanxi Province, the China Urban Statistical Yearbook and the National Economic and Social Development Statistics Bulletin of various cities within Shanxi Province. Due to the lag effect between input and output in economic systems, the input data for the current year should be adjusted to correspond with the output levels of the subsequent year (Wang et al., 2021). Accordingly, the input data used in this analysis corresponds to 2022, while the output data pertains to 2023. Additionally, data on the number of travel agencies and related service enterprises are obtained from the Qichamao website for 2021 (https://www.qichamao.com/). These data sources have been thoroughly evaluated to ensure the reliability and accuracy of the research (Gössling, 2021; Wang et al., 2020a; Munguía et al., 2019).

Variable selection for input-output analysis

To rigorously assess the dynamics of tourism-driven economic development in Shanxi, this study adopts an input-output analytical framework. Within this approach, tourism output serves as the dependent variable, while a range of carefully selected input variables capture the resources and conditions shaping tourism performance across the province's diverse spatial units.

A tailored Tourism Input-Output Evaluation Index System was developed to operationalize this framework. This system is designed to clarify how different inputs contribute to measurable outputs and to detect any imbalances or inefficiencies in resource allocation and benefit distribution at various geographic scales. Tourism Input Indicators include capital investments in infrastructure such as transport facilities, lodging capacity and related amenities alongside measures of human capital, like the availability of trained personnel

and management expertise. Accessibility variables, including the extent and quality of road and rail connections, are also crucial, as they directly influence tourist mobility and destination appeal. Additionally, socioeconomic indicators, such as population size, local income levels and broader regional development indices, provide context for how underlying conditions support or constrain tourism investment.

Tourism Output Indicators capture the tangible economic returns of these investments, primarily through metrics such as total tourism revenue and visitor numbers. These outputs reflect the capacity of local tourism systems to convert inputs into sustained economic gains. Spatial Discrepancy Indicators are incorporated to illuminate mismatches within the input-output relationship. For instance, the Spatial Mismatch Index (SMI) helps identify areas where substantial inputs yield disproportionately low outputs or conversely, where minimal inputs generate significant returns thus revealing critical leverage points for policy adjustment and resource reallocation.

Through this integrated input-output lens, the study provides a clearer understanding of how tourism resources are mobilized and converted into economic benefits across Shanxi's spatial landscape. This approach not only underscores the rationality of the province's tourism structure but also highlights priority areas where strategic intervention could enhance efficiency and foster more balanced regional development**.**

Analysis methods

To systematically quantify the alignment between tourism inputs and outputs, this study employs a utility function combined with the entropy weighting method, following Tang and Luo (2022). This approach standardizes the data and objectively derives the weight of each indicator (see Table 1). Based on these calculated weights, comprehensive scores are generated for each criterion layer, along with an overall evaluation score for the target layer. The comprehensive score AAA is computed as:

$$A = \sum_{i=1}^{m} \quad w_i u_{ij} \times 100 \qquad (1)$$

where A denotes the overall evaluation score, *i* represents the indicator number, *m* is the total number of indicators, w_i is the entropy-derived weight for indicator *i*, *and* u_{ij} is its efficacy coefficient for region *j*. To facilitate meaningful comparison and interpretation, scores are scaled by 100, with higher values indicating stronger tourism-driven influence on surrounding areas.

For spatial analysis, the comprehensive scores for each city are classified using the natural breaks method in ArcGIS 10.8. This method groups cities into five categories A (highest), B (higher), C (medium), D (lower) and E (lowest) capturing gradations in the strength of tourism development across Shanxi.

a) Spatial Mismatch Index (SMI)

To assess the spatial coherence between tourism investments and outcomes, this study applies the Spatial Mismatch Index (SMI), originally proposed by Martin (2001) and adapted from the dissimilarity index commonly used in segregation studies. Owing to its versatility, the SMI has found wide application in spatial research and here serves to gauge the alignment between tourism inputs and outputs across different areas.

The SMI is defined as:

$$SMI = \frac{1}{n}\sum_{i=1}^{n} \quad |SMI_i| \qquad (2)$$

$$SMI_i = \frac{1}{2p} \times (\frac{A_i}{A} \times P - P_i) \quad (3)$$

where SMI_i measures the degree of spatial dislocation for city *i*. Here, A_i is the comprehensive tourism output score for city *i*, *A* is the aggregate output score for Shanxi, P_i is the tourism input score for city *i* (or for a specific input dimension) and P_i denotes the corresponding provincial total.

A higher SMI or SMI_i value indicates a greater misalignment between tourism inputs and outputs, signaling inefficiencies in spatial distribution that warrant policy intervention. Conversely, lower values imply more balanced development. A positive SMI suggests outputs exceed input levels pointing to advanced output performance while a negative value signals that tourism outputs lag behind the level of investment.

b) Spatial econometric model

Given the inherent spatial interdependence within tourism systems, spatial econometric models are well suited to examine the determinants of rationality in tourism spatial structures. Spatial dependencies and spillover effects often shape how tourism investments translate into outcomes, making these models particularly valuable. Widely used formulations including the Spatial Lag Model (SLM), Spatial Error Model (SEM), and Spatial Autoregressive Model (SAR) allow for robust estimation that accounts for these spatial interactions (Shazhad & Aruga, 2024; Gyódi & Nawaro, 2021).

Through this integrated use of input-output analysis, mismatch diagnostics, and spatial econometric modeling, the study provides a rigorous basis for understanding the strengths and weaknesses of Shanxi's tourism-driven economic development and offers empirical insights to inform more balanced policy interventions.

Results and discussion

As detailed in Table 2, Taiyuan emerges in Group A, contributing 34.3% of Shanxi's total comprehensive input score. As the provincial capital, Taiyuan benefits from its robust foundation in technology, education, culture, healthcare and an extensive transportation network, which collectively position it as the primary locus of tourism-related inputs within the province.

Jinzhong, classified in Group B, ranks second overall. Its advantageous proximity to Taiyuan and the capital's pronounced diffusion effects have strengthened Jinzhong's regional integration, spurring closer intercity collaboration that further boosts its tourism investment capacity. Group C comprises Datong, Changzhi, Yuncheng and Linfen, cities that display mixed performance across key input dimensions. For example, Datong ranks second provincially for transportation accessibility, yet its moderate scores in other input factors constrain its overall standing. In Group D, Jincheng, Xinzhou and Lvliang record comparatively lower levels of tourism industry input, reflecting gaps in infrastructure or supporting resources that limit their competitive position. Finally, Yangquan and Shuozhou fall into Group E, registering the lowest input scores in the province. Although these cities maintain moderate performance in aspects such as economic foundations and environmental stewardship, deficits in other critical input areas dampen their overall potential for tourism-driven growth.

Table 2. Descriptive statistics of Tourism industry input and comprehensive scores of each dimension in cities in Shanxi

City	Input		B1	B2	B3	B4	B5	B6
	Score	Grade	Score	Score	Score	Score	Score	Score
Taiyuan	93.95	A	83.60	98.41	98.90	86.62	98.97	89.12
Datang	20.63	C	47.25	28.78	15.30	38.67	4.19	24.17
Yangquan	9.17	E	13.33	30.66	1.61	28.88	1.83	3.66
Changzhi	22.86	C	28.44	40.26	18.32	44.06	9.75	26.67
Jincheng	15.13	D	20.58	46.74	7.37	30.51	2.62	16.59
Shuozhou	9.32	E	9.41	37.50	2.59	23.57	2.81	4.12
Jinzhong	34.28	B	21.55	31.67	49.88	49.20	27.67	35.54
Yuncheng	24.49	C	26.30	12.62	33.13	28.75	16.10	36.54
Xinzhou	12.55	D	15.78	8.43	11.96	23.10	2.45	26.70
Linfen	18.64	C	26.40	17.12	20.81	19.17	6.45	36.42
Lvliang	13.19	D	17.86	16.31	13.47	19.83	3.37	23.67

Descriptive statistics of tourism industry output in Shanxi Province

Using the same methodological framework, the comprehensive tourism output scores for each city were calculated, with the results summarized in Figure 4. Taiyuan records the highest output score, affirming its leading position in both visitor arrivals and tourism-generated revenue within the province. Ranked just below Taiyuan are Jinzhong, Datong, Linfen, and Xinzhou, all of which benefit from rich tourism resources and a concentration of high-quality attractions. Significantly, these cities are home to Shanxi's three designated World Heritage Sites, which play a pivotal role in driving tourist flows and boosting local revenue. Collectively, these cities fall into Category B, reflecting their relatively advanced stage of tourism industry development.

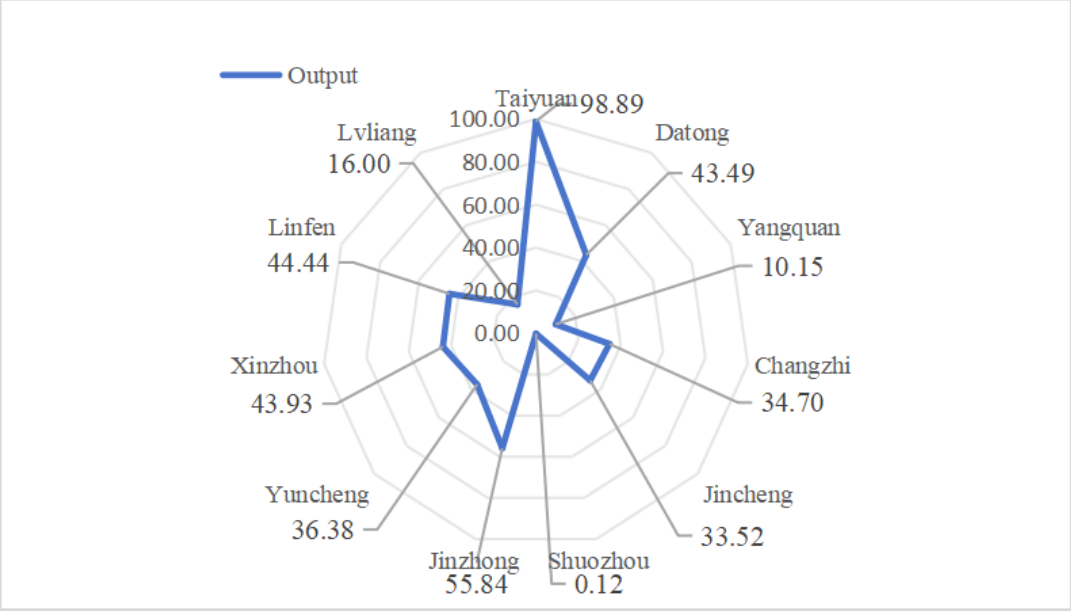


Figure 4. Radar chart of tourism output of cities in Shanxi Province

Jincheng, Yuncheng, and Changzhi are categorized as C-level, while Yangquan and Lvliang fall under D-level. Shuozhou has the lowest tourism output, classified as E-level, with a comprehensive score representing only 0.12% of Taiyuan's total score, the lowest in the province. This is primarily attributed to the scarcity of A-level tourist attractions in Shuozhou, which account for just 1.5% of the province's total A-level attractions, coupled with the absence of 5A-level attractions, resulting in limited appeal to tourists.

The rationality of tourism spatial structure in Shanxi Province

To investigate the underlying factors constraining the development of tourism in Shanxi, the Spatial Mismatch Index (SMI) (formulas (2)-(3)) was employed to assess the relationship between tourism input and output. Based on the methodology proposed by Wang et al. (2020a) (refer to Table 3), the results of the SMI analysis for Shanxi Province were categorized into four distinct types: Tourism Output Ahead Type I, Tourism Output Slightly Ahead Type II, Tourism Output Slightly Lagging Type III and Tourism Output Lagging Type IV. The detailed results are presented in Table 4.

Table 3. Types and significance of spatial dislocation of tourism output

Dislocation type	Division basis	Representative meaning
Tourism output ahead (I)	SMIi>0, and SMIi>SMI	Tourism output has significantly advanced, weakening the rationality of the tourism spatial structure.
Tourism output slightly ahead (II)	SMIi>0, and SMIi<SMI	Tourism output has slightly advanced, strengthening the rationality of the tourism spatial structure
Tourism output slightly lagging (III)	SMIi<0, and |SMIi|<SMI	Tourism output lags slightly, strengthening the rationality of the tourism spatial structure
Tourism output lagging (IV)	SMIi<0, and |SMIi|>SMI	Tourism output lags significantly, weakening the rationality of the tourism spatial structure

Source: Wang et al., 2020a

The computed SMI value for Shanxi Province is 0.0146, indicating a moderate level of irrationality in the province's tourism spatial structure. Further examination of the relationship between tourism output and six key input dimensions reveals varying degrees of spatial mismatch, ranked in terms of rationality from highest to lowest as follows: tourism industry organization (0.0108), ecological environment protection (0.0137), transportation accessibility (0.0142), labour force assurance (0.0207), economic development foundation (0.0245) and technological support assurance (0.0334).

These results suggest that certain input factors are more effectively aligned with tourism output, while others exhibit a significant mismatch. In response, it is recommended that the Shanxi Provincial Government implement region-specific regulatory policies aimed at enhancing the rationality of the tourism spatial structure.

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Table 4. SMI and type between tourism output and input in Shanxi Province

City	B1		B2		B3		B4		B5		B6		SMIi	
Taiyuan	-0.0162	IV	-0.0151	III	-0.0625	IV	0.0081	II	-0.1624	IV	-0.0194	IV	-0.0529	IV
Datang	-0.0240	IV	0.0130	II	0.0241	I	0.0028	II	0.0402	I	0.0147	I	0.0145	II
Yangquan	-0.0093	III	-0.0294	IV	0.0092	II	-0.0246	IV	0.0070	II	0.0065	II	-0.0046	III
Changzhi	-0.0042	III	-0.0131	III	0.0080	II	-0.0146	IV	0.0139	II	0.0003	II	-0.0001	III
Jincheng	0.0070	II	-0.0233	III	0.0267	I	0.0013	II	0.0327	II	0.0145	I	0.0126	II
Shuozhou	-0.0150	IV	-0.0507	IV	-0.0046	III	-0.0299	IV	-0.0078	III	-0.0062	III	-0.0168	IV
Jinzhong	0.0322	I	0.0239	II	-0.0244	IV	0.0042	II	-0.0116	III	0.0119	I	0.0044	II
Yuncheng	0.0012	II	0.0265	I	-0.0170	III	0.0069	II	-0.0021	III	-0.0130	IV	-0.0011	III
Xinzhou	0.0272	I	0.0412	I	0.0307	I	0.0232	I	0.0457	I	0.0113	I	0.0297	I
Linfen	0.0107	II	0.0300	I	0.0152	II	0.0288	I	0.0349	I	-0.0031	III	0.0192	I
Lvliang	-0.0096	III	-0.0030	III	-0.0055	III	-0.0061	III	0.0096	II	-0.0174	IV	-0.0049	III
SMI	0.0142	-	0.0245	-	0.0207	-	0.0137	-	0.0334	-	0.0108	-	0.0146	-

a. Tourism output ahead: Managing overextension and strategic upgrading in Xinzhou and Linfen

Xinzhou and Linfen stand out as tourism outputs ahead of cities, where output performance exceeds what their current input levels might sustainably support. In Xinzhou, tourism revenues and visitor flows have outpaced the city's foundational investments in infrastructure, human capital, and supporting industries, raising concerns about overuse and potential strain on existing resources. To secure long-term growth, Xinzhou must expand targeted investments in transport connectivity, accommodation capacity and workforce development to ensure that its input base aligns with its tourism scale.

Linfen, meanwhile, demonstrates output levels that are slightly ahead of its current input strength, though signs of underutilized organizational and environmental potential remain. Strengthening environmental management, attracting skilled professionals, advancing technological capabilities and enhancing organizational efficiency will be critical to sustaining Linfen's tourism performance and avoiding overextension that could hamper resilience and competitiveness.

b. Balancing tourism input and output: Strategic directions for Datong, Jincheng, Jinzhong and Other Cities

Datong, Jincheng and Jinzhong fall into the tourism output slightly ahead category, reflecting a more stable alignment between inputs and outputs, an indicator of healthier development. In Datong, however, output still trails its strong transportation accessibility, suggesting untapped potential. Future strategies should focus on fully leveraging this transport advantage to attract more visitors and boost revenues.

For Jincheng, advancing human capital and fostering tourism-related industries will be essential to strengthen its competitive edge and maintain the delicate balance between inputs and outputs. In Jinzhong, mobilizing its robust base of skilled labor and expanding investment in transport infrastructure and tourism organizations will help drive sector transformation and sustained growth.

In contrast, Yangquan, Changzhi, Yuncheng and Lvliang represent the tourism output slightly lagging type, where outputs remain somewhat below input levels, but the relationship is generally coordinated. For Yangquan and Changzhi, prioritizing ecological resource management and leveraging natural assets will help draw more visitors and translate investment into concrete returns. In Yuncheng, the emphasis must shift from extensive growth to improving quality, expanding the service sector and strengthening the local economy to unlock tourism's full potential. Lvliang, meanwhile, should reinforce its tourism industry organizations to better convert input resources into sustained output gains.

At the other end of the spectrum, Taiyuan and Shuozhou illustrate the tourism output lagging type, where significant input resources remain underutilized. Taiyuan, despite its advantages in infrastructure, technology and labor, still relies heavily on an extensive growth model. A shift towards more intensive, innovation-driven tourism development is vital to close the input-output gap. Shuozhou similarly must optimize its assets in transport, economic base and environmental quality to ensure inputs are translated into tangible, sustainable tourism output.

Impact of tourism input factors on output in Shanxi: A spatial error model analysis

To examine the influence of diverse tourism input factors on output and to guide the regulation of Shanxi's tourism spatial structure, this study models tourism output as the dependent

variable and incorporates multiple dimensions of input as independent variables. All indicators were standardized and the analysis was conducted using GeoDa software. Based on spatial correlation testing following the framework of Zhang et al. (2022), the Spatial Error Model (SEM) demonstrated the highest statistical significance and best fit. Log-likelihood values confirm that the SEM outperforms alternative models, making it the most robust for capturing the spatial spillover effects of tourism-related variables on tourist flows. Accordingly, the discussion here focuses on the SEM results.

As shown in Table 5, the SEM achieves an exceptionally high R2R^2R2 of 0.998, indicating excellent explanatory power. All variables are statistically significant at the 1% level ($p < 0.01$), underscoring the robustness of the findings.

Variant	SAR	SLM	SEM
X1 (Transportation Accessibility)	0.134941	0.120807	-0.24373***
X2 (Economic Development Foundation)	-0.97423	-0.828842	-1.45532***
X3 (Labour Force)	-1.83676	-1.66296	-4.58387***
X4 (Ecological Environment)	2.45309	2.16155	1.36777***
X5 (Technological Support)	0.520613	0.482919	2.45577***
X6 (Tourism Industry Infrastructure)	1.97096	1.83078**	2.48447***
R2R^2R2	0.883765	0.885629	0.998157
LogL	2.50215	2.5735	4.445721
AIC	8.99571	10.853	5.10856
SC	11.781	14.0362	7.89382

*Note: * p = 0.1; ** p = 0.05; *** p = 0.01.*

The analysis reveals several critical relationships. Notably, transportation accessibility shows a significant negative correlation with tourism output, suggesting that while extensive transport networks facilitate access, they may also generate congestion and diminish destination attractiveness if not well managed. Similarly, the economic development foundation is negatively correlated with tourism output, indicating that higher local income levels and living costs can drive up travel expenses, potentially deterring visitors. This underscores the need for policies that balance economic growth with price stability to maintain affordability for tourists.

Labour force availability emerges as the most influential factor but with a notable negative effect, suggesting that an oversupply of labour can intensify competition and lower service quality if workforce development is not well coordinated. Disparities in labour skill levels across regions further affect tourists' experiences, pointing to the need for targeted training and strategic workforce planning.

Conversely, the ecological environment is positively correlated with tourism output, reaffirming that well-preserved natural landscapes and environmental quality remain vital assets for attracting visitors. Cities should therefore prioritize ecological conservation as a core component of sustainable tourism development.

Finally, technological support and tourism industry infrastructure both exhibit strong positive correlations with output. This highlights the value of continued investment in smart tourism initiatives such as smart scenic sites and digital visitor services alongside improvements to physical infrastructure and service facilities that enhance the overall tourist experience. Collectively, these findings provide actionable insights for local policymakers and stakeholders seeking to optimize the allocation of tourism input factors, reduce inefficiencies and promote sustainable, balanced growth across Shanxi's tourism sector.

The findings of this study indicate that Shanxi Province remains at an early stage of tourism development, marked by a pronounced *single-core* or *dual-core* spatial structure centered primarily around Taiyuan and to a lesser extent, Jinzhong. This pattern aligns with the Taiyuan–Jinzhong cultural and tourism integration strategy articulated by the Shanxi Provincial Government (The People's Government of Shanxi Province, 2021) and corroborates earlier research conclusions (Jin et al., 2013; Yao & Guo, 2014).

However, a closer examination of specific spatial mismatch patterns reveals both consistencies and divergences when compared with prior studies. The output-input dynamics identified for Datong, Changzhi and Lvliang are broadly consistent with the spatial classifications proposed by Wang et al. (2020a). In contrast, cities such as Taiyuan display notable differences, which can be traced to variations in theoretical underpinnings, indicator selection, and methodological design. These discrepancies underscore how distinct analytical approaches can yield differing interpretations of tourism spatial efficiency and highlight the added value of the input-output framework employed in this study. By capturing the interdependencies among tourism resources, infrastructure, and outputs more comprehensively, this framework offers greater explanatory power for assessing the rationality of spatial structures.

Going forward, Shanxi's tourism development strategy must prioritize the reallocation of resources to address uneven growth trajectories and improve the alignment between input factors and tourism outputs across cities. A gradual transition towards a more balanced and networked spatial structure can be achieved by adopting a *pole-axis* development model. In this approach, primary development "poles" act as growth engines along designated development "axes," which in turn stimulate surrounding areas, fostering the emergence of integrated industrial belts.

Practically, this means optimizing the use of limited financial, human, and material resources by leveraging Taiyuan and Jinzhong's existing advantages. Major infrastructure, such as the Da Xi High-Speed Railway, can strengthen connectivity among key cities including Datong, Shuozhou, Xinzhou, Taiyuan, Jinzhong, Linfen, and Yuncheng, forming the backbone of a primary tourism industrial belt. Meanwhile, complementary transport corridors such as the Yellow River No.1 Tourism Highway and the Taihang No.1 Highway can interlink Xinzhou, Lvliang, Linfen, and Yuncheng to establish secondary and tertiary belts.

By progressively building out these interconnected corridors and hubs, Shanxi can move beyond its core-dominated pattern towards a diversified, networked tourism landscape. This staged, coordinated expansion will facilitate the more efficient diffusion of tourism benefits, enhance the resilience of the province's tourism economy, and ultimately support the upgrading and rationalization of its tourism spatial structure.

Empowering tourism development in Shanxi Province: Strategic pathways for sustainable growth

To accelerate the sustainable development of Shanxi Province's tourism sector, an integrated set of strategic actions must be prioritized. Foremost among these is the enhancement of regional infrastructure and connectivity. Expanding the high-speed rail network notably through projects like the Da-Xi High-speed Railway alongside better utilization of arterial routes such as the Yellow River No.1 Tourism Highway, will significantly improve intercity links. Strengthened transport corridors will not only boost accessibility but also help position Shanxi as a more compelling destination for both domestic and international tourists (Wang et al., 2020a).

Equally vital is fostering innovation within the tourism industry and diversifying the range of tourism products on offer. By embracing digital technologies including virtual

tourism, smart tourism platforms and data-driven marketing Shanxi can enrich the visitor experience and appeal to new market segments (Azmi et al., 2023). Moreover, curating distinctive, place-based experiences such as heritage trails, eco-tourism and adventure tourism will enhance the province's competitive edge and contribute to the resilience and sustainability of its tourism offerings (Wang et al., 2020b).

Human capital remains a cornerstone of any thriving tourism system. Targeted training initiatives should be scaled up to equip local communities with the skills needed for quality service delivery in hospitality, guiding and tourism management (Gössling, 2021). At the same time, policies that encourage local entrepreneurship and support the growth of small and medium tourism-related enterprises can stimulate broader economic participation, reduce over-reliance on a few urban cores and ensure more equitable sharing of tourism's economic benefits across Shanxi's diverse regions (Chang et al., 2023).

Finally, embedding sustainability at the heart of all tourism planning is imperative for safeguarding Shanxi's cultural and ecological assets. Adopting greener practices from low-carbon transport solutions and eco-certified accommodations to stricter conservation measures will help balance growth with environmental stewardship (González-García et al., 2020). By integrating environmental safeguards into the tourism development agenda, Shanxi can avoid the pitfalls of unsustainable expansion and position itself as a model for balanced tourism development in China (Demeter et al., 2021).

Collectively, these strategies call for robust coordination among government, industry stakeholders and local communities. By aligning investment, innovation, capacity building and sustainability imperatives, Shanxi can optimize its tourism spatial structure and chart a path towards more inclusive, resilient and long-term economic growth.

Conclusion

This study developed an input-output-based framework to evaluate the rationality of tourism spatial structures and applied it across 11 cities in Shanxi Province. The findings reveal varying degrees of spatial imbalance, confirming the model's value in pinpointing misalignments between tourism inputs and outputs and highlighting areas where targeted policy adjustments are needed.

By clarifying how key factors from infrastructure and human capital to ecological resources and technological capacity interact to shape tourism output, the model offers practical insights for optimizing resource allocation within sustainable thresholds. This capacity to diagnose and adjust input-output relationships is the study's principal contribution, providing a replicable basis for improving tourism planning and governance.

Ultimately, these insights underscore the importance of aligning investments with local capacities and conditions, ensuring that tourism growth is equitable, efficient and environmentally responsible. As Shanxi moves forward, implementing these evidence-based recommendations will be critical for evolving its tourism sector into a more balanced, networked and sustainable driver of regional development.

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