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Research on industrial linkages and economic contributions of the low-altitude tourism industry: a case study of Zhengzhou

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Abstract. To support local governments in designing subsidy policies, this study examines the driving effects of the low-altitude tourism industry on related sectors and its contribution to regional economic development. First, the RAS method is used to iteratively update a multi-regional input–output table at the urban scale and construct a single-region input–output table for the target year. Next, based on input–output theory, a measurement model is developed to analyze the industrial linkages and economic contributions of the low-altitude tourism sector. An empirical analysis is then conducted using Zhengzhou as a case study. The results show that in 2023, among the backward-linked industries of Zhengzhou's low-altitude tourism sector, the strongest linkage is with non-metallic mineral products, while among forward-linked industries, the strongest linkage is with finance and insurance. The total economic contribution reaches 1.479 billion yuan, with an industrial multiplier of 1:7.42, aligning closely with field survey findings. Finally, targeted policy recommendations are proposed.

Keywords: low-altitude tourism, municipal input–output table, RAS method, regional economy, industrial linkage

1. Introduction

In recent years, China has increased its strategic support for the integrated development of low-altitude transportation and tourism. The Guiding Opinions of the General Office of the State Council on Promoting the Development of the General Aviation Industry (2016) called for advancing the integration of general aviation with tourism. The Several Opinions on Promoting the Integrated Development of Transportation and Tourism jointly issued by the Ministry of Transport and other authorities in 2017 supported the development of low-altitude tourism routes. More recently, the Implementation Plan for Innovation and Application of General Aviation Equipment (2024–2030) issued by the Ministry of Industry and Information Technology and other ministries (2024) listed "low-altitude tourism" as a demonstration project for consumer application, signaling a period of strong policy momentum for the industry. As an emerging form of integrated low-altitude transportation and tourism, low-altitude tourism relies on small aircraft to provide short-distance sightseeing experiences. Its advantages—low flight altitude and short travel range—offer panoramic aerial views and align with the trend of consumption upgrading. The development of this sector not only generates direct revenue from project operations but also stimulates growth in related industries. However, in the early stages of development, government subsidies remain essential for market activation and demand cultivation. Existing statistical approaches often rely on simple aggregation of output values, which cannot answer policy-critical questions such as: How much regional value added is generated by 1 yuan of low-altitude tourism revenue? How much does it stimulate associated industries? To support evidence-based policymaking, there is an urgent need to construct a scientific evaluation system at the municipal level to accurately measure the industrial linkages and economic contributions of the low-altitude tourism sector.

Currently, extensive research has examined low-altitude tourism, industrial linkages, and economic contributions. Studies on low-altitude tourism mainly focus on development prospects, project spatial layout, service system construction, and consumer intentions. Youtang Liu [1] predicted significant development opportunities for China's low-altitude tourism industry under the background of low-altitude airspace liberalization. YongGuang Jin [2], using Guilin as a case study, discussed site selection and spatial layout for low-altitude tourism projects and analyzed their comprehensive benefits from economic, social, and environmental perspectives. Li Yan et al. [3], drawing on the low-altitude economy, constructed an intelligent cultural tourism service system for Anhui Province based on the Kano model and stakeholder theory, proposing a cultural tourism blueprint and information architecture. Luo Tianyang [4] proposed an integrated service model that incorporates low-altitude technologies into

Guangzhou's smart tourism ecosystem, identifying their key role in transforming urban tourism systems. Wanqing Zhou [5], based on TAM–TPB theory and using questionnaires and structural equation modeling, empirically examined factors influencing low-altitude tourism consumption intentions. Yingchun Shen [6] argued that the rapid development of the "low-altitude + culture and tourism" model is expected to unlock a substantial consumer market and offered corresponding recommendations. Regarding industrial linkage and economic contribution studies, many scholars have employed input–output theory. Zuo Bing et al. [7] used input–output analysis to estimate tourism total factor productivity and the economic impacts of tourism industry linkages. Zhao Bing et al. [8], using input–output models from 2007 to 2020, examined industrial linkages and economic contributions of China's air transport sector. Lina Sui [9] converted provincial input–output tables into city-level tables using the location entropy method and applied input–output analysis to quantify the direct, indirect, and total contributions of urban transportation to GDP. The authors' team [10], using Jiangsu Province as a case study, calculated the direct contributions of leading firms in various segments of the low-altitude economy via the income approach and built a model based on input–output theory to estimate the sector's contribution to regional economic development. Fernanda Souza Pereira et al. [11] used income-based input–output analysis to assess the spillover effects and contributions to output, employment, and income of Brazil's cultural industries. Zhang S et al. [12] used input–output analysis to evaluate industrial linkages and final demand in smart agriculture.

In sum, existing research on low-altitude tourism primarily examines micro-level issues such as development prospects, spatial layout, and consumer intentions, with relatively little quantitative analysis of industrial linkages and economic contributions. Meanwhile, although scholars have applied input–output theory to study the economic effects of tourism, aviation, and other sectors—demonstrating its feasibility—research has not yet extended to the specific domain of low-altitude tourism, nor has it conducted precise assessments based on municipal input–output tables. This constitutes a clear academic gap. To address this gap, this study establishes a municipal input–output table, develops a measurement model for the industrial linkages and economic contributions of the low-altitude tourism industry, and conducts empirical analysis accordingly.

2. Research methods and qualitative analysis

2.1. Research methods

2.1.1. Input–output method

The application of the input–output method in China began in the 1960s and developed rapidly after the reform and opening-up. According to regulations issued by the General Office of the State Council, a nationwide input–output survey is conducted and an input–output table is compiled in years ending in "2" and "7," while extended input–output tables are compiled in years ending in "0" and "5" [13].

2.1.2. RAS method

The traditional process of compiling input–output tables is complex and time-consuming, which leads to inherent limitations in data timeliness. This makes the traditional approach insufficient for supporting the fast-paced development of China's low-altitude tourism sector. After reviewing various domestic and international improvement schemes, this study adopts the RAS method proposed by British economist Stone and colleagues (1960). Following decades of refinement, the RAS method has become widely recognized for its speed, low cost, and high accuracy [14].

2.2. Qualitative analysis

2.2.1. Internal mechanism of industrial linkages in the low-altitude tourism sector

Industries linked to low-altitude tourism may be categorized into backward-linked and forward-linked sectors. With respect to backward linkages, low-altitude tourism functions as a demander, consuming physical inputs such as aircraft manufacturing, aviation fuel supply, and maintenance services, and making corresponding payments. These transactions constitute its contribution to backward-linked industries. With respect to forward linkages, low-altitude tourism functions as a supplier, providing core services—such as aerial sightseeing and short-distance air commuting—to the tourism, cultural, and related industries. The revenue generated from these services flows forward to those sectors, forming its contribution to forward-linked industries. This bidirectional structure—"physical input → value flow"—constitutes the core pathway through which low-altitude tourism interacts with various sectors of the national economy, shaping value circulation and spillover effects. It also represents the fundamental mechanism through which its economic contributions are generated.

2.2.2. Categories of low-altitude tourism's contribution to regional economic development

The economic contributions of the low-altitude tourism industry to a regional economy can be classified into direct, indirect, and induced effects. Direct contributions refer to immediate economic gains generated through the industry's own operations, including the output value, employment, and tax revenue created by aircraft operations, sightseeing services, and related core activities. Indirect contributions arise when low-altitude tourism stimulates growth in related industries through backward linkages (e.g., demand for aircraft manufacturing, aviation fuel, and other intermediate inputs) and forward linkages (e.g., providing low-altitude services to tourism and cultural sectors). Induced contributions reflect the long-term spillover effects: income increases among industry workers stimulate additional consumption in sectors such as accommodation, catering, food, and tobacco. Together, these three categories form a complete system for evaluating the economic contributions of the low-altitude tourism industry to regional development.

3. Construction of industrial linkage and economic contribution measurement models

3.1. Construction of the municipal input–output table for the target year

Heran Z [15] has conducted long-term research and compiled city-level multi-regional input–output tables (Multi-Regional Input–Output Table, MRIO hereafter), which have been widely recognized [16-18]. One of the authoritative domestic databases —the China Emissions Accounts and Datasets (CEADs)—regularly publishes city-level MRIO tables. This study constructs the municipal input–output table for the target year based on CEADs' city-level MRIO data.

Step 1: Obtain the 2015 city-level MRIO table from CEADs and convert it to CSV format using Python. In the MRIO table, the intermediate flow data represent economic transactions of each sector in every city. The 42-sector intermediate matrix (Z), final use (F), value added (VA), import (IM), export (EX), and total output (X) are extracted to convert the city-level MRIO into a city-level single-region input–output (SRIO) table, as illustrated in Figure 1.

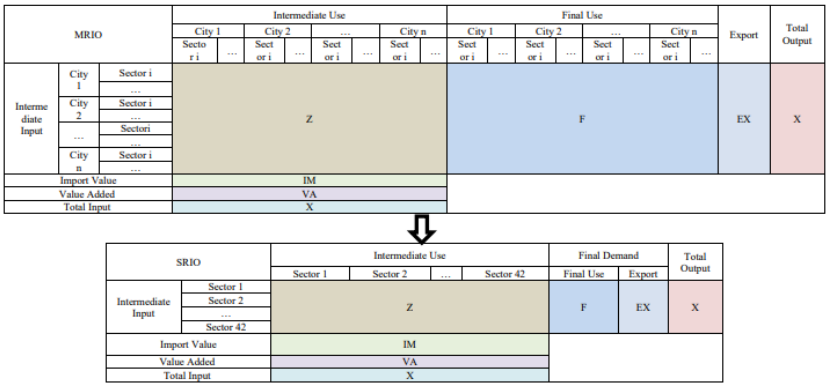

Figure 1. Conversion from city-level MRIO to SRIO table

Step 2: Due to data availability, only the Z (intermediate matrix) data from the SRIO table are retained. Other data are supplemented using local statistical yearbooks, customs data, and other sources to compile the baseline-year input–output table.

Step 3: The RAS method is used to iteratively update the intermediate matrix to the target year. Starting from the latest 42-sector table, the method adjusts the direct consumption coefficient matrix under known target-year constraints. By alternately adjusting row multipliers (R) and column multipliers (S) until row and column totals match the control data, the updated intermediate matrix for the target year is obtained (Figure 2).

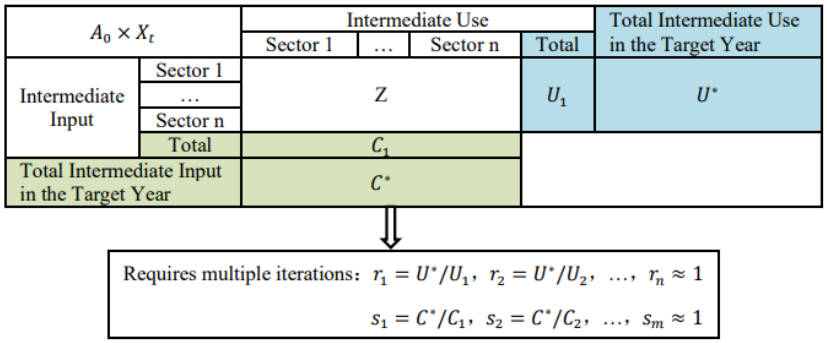

Figure 2. Schematic of RAS method for adjusting the target-year intermediate matrix

Step 4: Supplement the remaining data from statistical yearbooks, customs, and other sources, and combine them with the updated intermediate matrix to compile the full input–output table for the target year.

3.2. Framework for industrial linkages and economic contribution of low-altitude tourism

Combining ICAO Document 292, the current state of low-altitude tourism, and data availability, and referencing the National Statistics Classification for Tourism and Related Industries (2018) and prior research by the authors' team, low-altitude tourism is defined as comprising projects related to "food, accommodation, transportation, sightseeing, shopping, and entertainment." Each project is mapped to relevant sectors within the 42-sector input–output table (hereafter, IO industries) as shown in Table 1.

Table 1. Composition of low-altitude tourism-related industries and their contributions

Contribution IO Industry	Direct Contribution	Indirect Contribution		Induced Contribution	Total Contribution
		Forward	Backward		
Wholesale and Retail Trade					
Transportation, Storage and Post					
Accommodation and Catering					
Leasing and Business Services					
Water Conservancy, Environment and Public Facilities Management					
Paper Printing and Stationery, Sports Goods					
Information Transmission, Software and Information Technology Services					
Finance					
Resident Services, Repair and Other Services					
Education					
Culture, Sports and Entertainment					
Public Administration, Social Security and Social Organizations					

*Note: Finance includes only the finance and insurance sectors.

3.3. Industrial linkage coefficient measurement model

To calculate backward linkage coefficients, direct and total consumption coefficients are required.

Direct consumption coefficient $a_{ij}\,(i, j = 1,2,\ldots,n)$ is defined as the ratio of the intermediate input of sector i to the total output of sector j, represented by the matrix A, expressed as a formula:

$$a_{ij} = \frac{x_{ij}}{X_j}\,(i, j = 1,2,\ldots,n) \tag{1}$$

Total consumption coefficient $b_{ij}\,(i, j = 1,2,\ldots,n)$ captures both direct and total consumption, represented by the matrix B, expressed as a formula:

$$B = (I - A)^{-1} - I \tag{2}$$

To calculate forward linkage coefficients, direct and total allocation coefficients are needed.

Direct allocation coefficient $h_{ij}(i, j = 1, 2, \ldots, n)$ represents the extent to which sector i drives production in sector j, represented by matrix H, expressed as a formula:

$$h_{ij} = x_{ij}/X_i \tag{3}$$

Total allocation coefficient $g_{ij}(i, j = 1, 2, \ldots, n)$ reflects production distribution linkages, represented by matrix G, expressed as a formula:

$$G = (I - H)^{-1} - I \tag{4}$$

3.4. Economic contribution measurement model

The calculation of economic contribution requires value-added coefficients.

Value-added coefficient $\overline{Z_j}(i, j = 1, 2, \ldots, n)$ describes the value added per unit output of sector j, represented by matrix $\overline{Z}^T$, expressed as a formula:

$$\overline{Z_j} = Z_j/X_j \tag{5}$$

Based on these coefficients, the economic contribution model is constructed as follows. Direct contribution (W_1), the calculation method is as follows:

$$W_1 = \overline{Z}^T X_j \tag{6}$$

Indirect contribution (W_2), where ΔX is the vector of sectoral output changes, the calculation method is as follows:

$$W_2 = \overline{Z}^T B \Delta X + \overline{Z}^T G \Delta X \tag{7}$$

Induced contribution (W_3), where c is the consumption multiplier and C_i is total sectoral consumption, the calculation method is as follows:

$$W_3 = (W_1 + W_2) \times \frac{c}{1-c}, c = \frac{C_i}{Z_j} \tag{8}$$

Total contribution (W), the calculation method is as follows:

$$W = (W_1 + W_2 + W_3) \tag{9}$$

Industrial multiplier ratio (D), the calculation method is as follows:

$$D = \boldsymbol{W}_1/\boldsymbol{W} \tag{10}$$

4. Empirical analysis: a case study of Zhengzhou

4.1. Overview of low-altitude tourism development in Zhengzhou

As a national central city and a key node in the Belt and Road Initiative, Zhengzhou possesses significant advantages in transportation, logistics, and the digital economy. As early as 2011, the city proposed a strategic plan to establish a general aviation pilot zone. In 2014, the Overall Plan for the Zhengzhou General Aviation Pilot Zone (2014–2030) was approved. In 2017, the Zhengzhou National General Aviation Industry Comprehensive Demonstration Zone was officially designated, becoming one of the first 26 national demonstration zones. By 2023, Zhengzhou had attracted 126 general aviation enterprises, and low-altitude tourism projects such as sightseeing flights from Shangjie Airport to the Yellow River area, "Aerial Views of Zhengzhou," and tours to Songshan Shaolin Scenic Area had been successively launched, laying a solid foundation for the sector. In 2024, Zhengzhou released the Action Plan for Accelerating the Innovation and Development of the Low-Altitude Economy Industry (2024–2026), providing policy support for low-altitude tourism. In 2025, the Measures to Support High-Quality Development of Low-Altitude Economy Industries in the Zhengzhou Airport Economic Comprehensive Experimental Zone were introduced, further improving infrastructure and providing fiscal subsidies. These measures indicate that Zhengzhou is leveraging its geographic location and industrial base to accelerate the integration of low-altitude tourism with related industries, significantly amplifying the sector's industrial linkage effects and contribution to regional economic growth.

4.2. Data sources

2015 city-level MRIO table published by CEADs; Henan Statistical Yearbook, Zhengzhou Statistical Yearbook, and Zhengzhou customs data;

Annual flight hours and per-hour flight rates of enterprises in Zhengzhou primarily engaged in low-altitude tourism (survey data);

Total annual flight hours of Zhengzhou general aviation sector (survey data).

4.3. Measurement of industrial linkages and economic contribution of low-altitude tourism in Zhengzhou

4.3.1. Construction of Zhengzhou's 2023 input–output table

First, the intermediate matrix for Zhengzhou was extracted from the 2015 city-level MRIO table published by CEADs, and supplemented with data from statistical yearbooks, customs, and other sources. Next, using the 2015 table as the baseline and 2023 as the target year, the RAS method was applied iteratively to generate a 2023 Zhengzhou input–output matrix that satisfies both row and column balancing constraints. Finally, the target-year input–output table was compiled by combining this matrix with the remaining data.

Table 2. Backward linkage coefficients of low-altitude tourism

Sector	Backward Linkage Coefficient	Proportion	Sector	Backward Linkage Coefficient	Proportion
Manuf. of non -metallic mineral products	0.0605	9.49%	Health care and social work	0.0084	1.32%
Construction	0.0537	8.42%	Education	0.0083	1.31%
Finance	0.0522	8.19%	Mining and washing of coal	0.0067	1.05%
Leasing and commercial services	0.0429	6.72%	Food and tobacco processing	0.0054	0.84%
Manufacture of communication equipment, computers and other electronic equipment	0.0406	6.37%	Administration of water, environment, and public facilities	0.0052	0.81%
Information transfer, software and information technology services	0.0338	5.31%	Manufacture of metal products	0.0043	0.68%
Scientific research and polytechnic services	0.0338	5.31%	Mining and processing of nonmetal and other ores	0.0031	0.48%

Production and distribution of electric power and heat power	0.0330	5.18%	Manufacture of electrical machinery and equipment	0.0024	0.37%
Public administration, social insurance, and social organizations	0.0312	4.89%	Agriculture, Forestry, Animal Husbandry and Fishery	0.0014	0.21%
Smelting and processing of metals	0.0309	4.84%	Processing of timber and furniture	0.0012	0.19%
Wholesale and retail trades	0.0257	4.03%	Production and distribution of tap water	0.0010	0.16%
Transport, storage, and postal services	0.0214	3.35%	Mining and processing of metal ores	0.0009	0.14%
Real estate	0.0210	3.29%	Manufacture of leather, fur, feather and related products	0.0007	0.11%
Manufacture of paper, printing and articles for culture, education and sport activity	0.0163	2.56%	Production and distribution of gas	0.0004	0.07%
Accommodation and catering	0.0162	2.54%	Processing of petroleum, coking, processing of nuclear fuel	0.0004	0.06%
Culture, sports, and entertainment	0.0142	2.23%	Manufacture of measuring instruments	0.0002	0.04%
Manufacture of transport equipment	0.0139	2.19%	Textile industry	0.0002	0.03%
Manufacture of general purpose machinery	0.0139	2.18%	Comprehensive use of waste resources	0.0001	0.01%
Manufacture of chemical products	0.0130	2.05%	Other manufacturing	0.0000	0.01%
Resident, repair and other services	0.0101	1.58%	Repair of metal products, machinery and equipment	0.0000	0.00%
Manufacture of special purpose machinery	0.0088	1.39%	Extraction of petroleum and natural gas	0.0000	0.00%

4.3.2. Measurement of industrial linkage coefficients for low-altitude tourism

Backward-linked industries of low-altitude tourism are measured using total consumption coefficients. Based on the industrial linkage coefficient measurement model, the 2023 total consumption coefficients of low-altitude tourism with various industries, sorted in descending order, are presented in Table 2.

Forward-linked industries of low-altitude tourism are measured using total allocation coefficients. According to the industrial linkage coefficient measurement model, the 2023 total allocation coefficients with various industries, sorted in descending order, are presented in Table 3.

Table 3. Forward linkage coefficients of low-altitude tourism

Sector	Forward Linkage Coefficient	Proportion	Sector	Forward Linkage Coefficient	Proportion
Finance	0.0972	15.24%	Smelting and processing of metals	0.0032	0.51%
Real estate	0.0674	10.58%	Public administration, social insurance, and social organizations	0.0030	0.47%
Accommodation and catering	0.0509	7.98%	Production and distribution of gas	0.0029	0.46%
Food and tobacco processing	0.0491	7.70%	Scientific research and polytechnic services	0.0027	0.42%
Manufacture of paper, printing and articles for culture, education and sport activity	0.0225	3.54%	Processing of petroleum, coking, processing of nuclear fuel	0.0024	0.37%
Leasing and commercial services	0.0204	3.20%	Manufacture of leather, fur, feather and related products	0.0023	0.36%
Transport, storage, and postal services	0.0187	2.93%	Manufacture of general purpose machinery	0.0017	0.27%

Wholesale and retail trades	0.0178	2.79%	Manufacture of electrical machinery and equipment	0.0012	0.19%
Production and distribution of electric power and heat power	0.0136	2.14%	Manufacture of metal products	0.0012	0.19%
Resident, repair and other services	0.0133	2.08%	Mining and processing of nonmetal and other ores	0.0009	0.14%
Information transfer, software and information technology services	0.0119	1.87%	Processing of timber and furniture	0.0007	0.12%
Culture, sports, and entertainment	0.0114	1.80%	Textile industry	0.0007	0.11%
Agriculture, Forestry, Animal Husbandry and Fishery	0.0114	1.78%	Manufacture of special purpose machinery	0.0005	0.08%
Manufacture of communication equipment, computers and other electronic equipment	0.0107	1.68%	Administration of water, environment, and public facilities	0.0004	0.07%
Manufacture of chemical products	0.0098	1.54%	Other manufacturing	0.0004	0.06%
Mining and washing of coal	0.0082	1.29%	Mining and processing of metal ores	0.0004	0.06%
Education	0.0052	0.81%	Manufacture of measuring instruments	0.0003	0.05%
Manuf. of non -metallic mineral products	0.0045	0.71%	Health care and social work	0.0001	0.01%
Production and distribution of tap water	0.0033	0.52%	Repair of metal products, machinery and equipment	0.0000	0.00%
Manufacture of transport equipment	0.0033	0.52%	Extraction of petroleum and natural gas	0.0000	0.00%
Construction	0.0033	0.52%	Comprehensive use of waste resources	0.0000	0.00%

4.3.3. Calculation of value added for Zhengzhou's low-altitude tourism sector

Based on survey data, three enterprises in Zhengzhou—A, B, and C—whose primary business is low-altitude tourism, were selected to estimate the value added of Zhengzhou's low-altitude tourism industry using the following steps:

First, using the total annual flight hours and the hourly flight rates of enterprises A, B, and C, their 2023 annual low-altitude tourism revenue was calculated to be 556 million yuan;

Second, since the total annual flight hours of A, B, and C account for 59.34% of the total annual low-altitude tourism flight hours in Zhengzhou, the industry's annual revenue in the city was estimated at 937 million yuan using the proportional method;

Finally, given that low-altitude tourism revenue accounts for 0.52% of Zhengzhou's total tourism revenue, and that the city's tourism value added is 38.209 billion yuan (as estimated in Zha J et al. [19]), the value added of Zhengzhou's low-altitude tourism industry was calculated at 199 million yuan using the proportional method.

4.3.4. Measurement of the economic contribution of low-altitude tourism

Using the above data and the previously established measurement model, the economic contribution of low-altitude tourism in Zhengzhou was calculated via the input–output method. The results are summarized in Table 4.

Table 4. Economic contribution of low-altitude tourism IO industries in Zhengzhou, 2023 (Unit: 100 million yuan)

Contribution IO Industry	Direct (1)	Forward (2)	Backward (3)	Indirect (4) = (2) + (3)	Induced (5)	Total (6) = (1) + (4) + (5)
Wholesale and Retail Trade	0.36	0.31	0.23	0.53	0.13	1.03
Transportation, Storage and Post	0.10	0.21	0.20	0.41	0.08	0.59
Accommodation and Catering	0.44	1.04	0.75	1.80	3.38	5.61
Leasing and Business Services	0.01	0.14	0.17	0.31	2.96	3.28

Water Conservancy, Environment and Public Facilities Management	0.02	0.00	0.02	0.02	0.01	0.05
Paper Printing and Stationery, Sports Goods	0.04	0.09	0.05	0.14	0.02	0.20
Information Transmission, Software and Information Technology Services	0.46	0.10	0.13	0.23	0.11	0.81
Finance	0.04	0.01	0.00	0.01	0.03	0.08
Resident Services, Repair and Other Services	0.10	0.06	0.06	0.12	0.10	0.32
Education	0.13	0.04	0.04	0.08	1.40	1.60
Culture, Sports and Entertainment	0.06	0.05	0.05	0.10	0.21	0.37
Public Administration, Social Security and Social Organizations	0.22	0.02	0.12	0.14	0.49	0.85
Total Contribution of Low-altitude Tourism Industry	1.99	2.07	1.82	3.89	8.91	14.79

4.4. Measurement conclusions

First, backward-linked industries of low-altitude tourism. The highest linkage coefficients are observed in non-metallic mineral products (0.0605), construction (0.0537), and finance and insurance (0.0522), collectively accounting for over one-quarter (26.1%). Modern service industries such as leasing and business services (6.72%) and telecommunications and other electronic equipment (6.37%) also exhibit strong linkages. Traditional core tourism industries, including accommodation and catering (2.54%) and culture, sports, and entertainment (2.23%), show relatively lower linkage. This distribution indicates that the economic demand pull of low-altitude tourism primarily manifests in infrastructure, equipment manufacturing, and supporting services, providing important quantitative evidence for precise industrial support policies.

Second, forward-linked industries of low-altitude tourism. Finance and insurance (0.0972, 15.24%) and real estate (0.0674, 10.58%) together account for over one-quarter of forward linkages. Accommodation and catering, as well as food and tobacco, have coefficients of approximately 0.05, together accounting for nearly 16%. Mid-level linkage industries include paper, printing, and educational and sporting goods (0.0225, 3.54%), leasing and business services (0.0204, 3.20%), and transportation, storage, and postal services (0.0187, 2.93%). Overall, low-altitude tourism primarily promotes the development of finance and insurance, real estate, and accommodation and catering, providing quantitative guidance for precise upstream supply chain planning and prioritizing improvements in aviation financial services and tourism consumption infrastructure.

Third, the total economic contribution of low-altitude tourism to Zhengzhou in 2023 was 1.479 billion yuan. The industrial leverage ratio reached 1:7.42, meaning that every unit of value added drives 7.42 units of total economic output. This demonstrates a substantial multiplier effect and industrial spillover, underscoring the sector's role as a new regional economic growth point.

Fourth, by industrial contribution, accommodation and catering make the largest contribution to Zhengzhou's economy. The top five industries are: accommodation and catering (561 million yuan), leasing and business services (328 million yuan), education (160 million yuan), wholesale and retail trade (103 million yuan), and public administration and social security (85 million yuan), collectively accounting for 83.66% of the total. This highlights the "service-intensive" nature of Zhengzhou's low-altitude tourism sector.

Fifth, by contribution structure, induced contribution dominates. Ranked from high to low: induced contribution (60.25%), forward contribution (13.98%), direct contribution (13.43%), and backward contribution (12.34%). This indicates that the core value of Zhengzhou's low-altitude tourism lies in its strong spillover effect, as indirect and induced contributions through industry chain linkages and resident consumption far exceed the sector's own output.

Sixth, overall analysis shows that the industry has formed a linkage network dominated by modern service industries. Leasing and business services demonstrate prominent backward (0.0429) and forward (0.0204) linkages, with a combined economic contribution of 328 million yuan, indicating strong industry chain integration. Accommodation and catering exhibit significant forward linkage (0.0509) and a total contribution of 561 million yuan, serving as a key carrier for extending the consumer chain. Finance and insurance show high backward (0.0522) and forward (0.0972) linkages, providing robust support for industry development. However, high-end manufacturing industries, such as transportation equipment and specialized machinery, have

relatively low linkage coefficients, suggesting room for improvement in technological integration and high-end factor aggregation.

Field surveys confirm that the study's conclusions align with the local context of Zhengzhou. Model outputs are consistent with multiple data sources, indicating that the methodology is scientifically sound, accurate, and applicable.

4.5. Policy recommendations

Based on the above findings and the practical development of low-altitude tourism in Zhengzhou, the following policy recommendations are proposed:

4.5.1. Industrial linkages

Based on backward linkage coefficients, efforts should strengthen integration with non-metallic mineral products, construction, finance and insurance, and leasing and business services. Specifically: Increase infrastructure investment, including general aviation airports and helicopter landing sites, upgrade small aircraft and helicopter manufacturing, and leverage finance, insurance, and business services to support operations through innovative financing and optimized service provision; Deepen the integration of information technology with low-altitude tourism to enhance technological intensity. By combining infrastructure, service innovation, and technology empowerment, promote cultural tourism consumption and the development of related industries.

Based on forward linkage coefficients, attention should focus on finance and insurance, real estate, accommodation and catering, and food and tobacco to activate supply-side effects. Improve aviation financial services and support cultural tourism real estate, develop high-quality food and lodging facilities to match consumption demand, and enrich experiential consumption scenarios such as "low-altitude + culture" or "low-altitude + entertainment." Through demand-side upgrading and scenario innovation, optimize related industry demand and create a mutually reinforcing supply-demand cycle.

4.5.2. Economic contribution

Based on economic contribution results, efforts should aim to amplify indirect and induced contributions. Data show that accommodation and catering, leasing and business services, and education contribute significantly through induced effects, reflecting strong local economic stimulation via secondary consumption driven by employees' income. Policies should go beyond simply expanding flight routes to construct a consumption ecosystem, encouraging local spending by tourists and employees, thereby enhancing spillovers to wholesale, retail, and resident services. Systematic policy support can position low-altitude tourism as a catalyst for regional economic circulation and an engine for upgrading service sector capabilities.

5. Conclusion

This study applied the RAS method to iteratively update city-level Multi-Regional Input–Output (MRIO) tables and construct a single-city input–output table for the target year. Combined with the proportional allocation method and input–output model, the study comprehensively measured the industrial linkage coefficients of low-altitude tourism in Zhengzhou and its direct, indirect, and induced contributions to the regional economy. The results indicate: First, the industrial linkage characteristics are prominent. In backward linkages, non-metallic mineral products and construction lead, highlighting the strong pull of infrastructure and supporting facilities. In forward linkages, finance and insurance and real estate stand out, reflecting the sector's role in enabling financial services and providing spatial support. Second, the economic contribution structure is distinct. In 2023, the total economic contribution of low-altitude tourism to Zhengzhou reached 1.479 billion yuan, with an industrial leverage ratio of 1:7.42. Accommodation and catering, leasing and business services together contributed over 60% of the total, demonstrating the "service-intensive" nature of the sector. The induced contribution (60.25%) far exceeded the direct contribution (13.43%), confirming the sector's strong spillover effect and economic radiative influence.

This study draws on research from the civil aviation and tourism industries to examine the industrial linkages and economic contributions of low-altitude tourism, achieving notable findings. However, certain limitations exist. The approach does not provide an intuitive analysis of the sector's economic development, and sample survey results may vary. Future research could expand data collection across more low-altitude tourism enterprises and employ more precise quantitative methods to fully assess the comprehensive economic impact of low-altitude tourism.

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