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THE RESEARCH ON INNOVATION ABILITY OF TOURISM INDUSTRY CLUSTER IN LIAONING PROVINCE BASED ON FUZZY COMPREHENSIVE EVALUATION MODEL

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Abstract. *Tourism industry cluster itself is a regional innovation system. Innovation is the internal driving force for the development of tourism industry cluster. The innovation ability of cluster is the key to judge its development level and sustainable development ability, which is of great significance to the development of cluster itself and the development of regional economy. This paper constructs an evaluation index system of the innovation ability of tourism industry clusters, uses the analytic hierarchy process to calculate the weight of each evaluation index, and uses the fuzzy comprehensive evaluation model to calculate the innovation ability of tourism industry clusters in Liaoning Province, so as to reflect the innovation ability of tourism industry clusters in Liaoning Province.*

Keywords: Tourism industry cluster, Innovation ability, Analytic hierarchy process, Fuzzy comprehensive evaluation model

1. **Introduction.** The phenomenon of industrial cluster is the product of the development of market economy to a certain stage, the theory of industrial cluster often pays attention to innovation to promote regional development. Therefore, industrial cluster itself is a regional innovation system. In recent years, with the development of tourism industry and the continuous improvement of industrial chain, there has been a phenomenon of tourism industry cluster. Tourism industry cluster is a regional innovation system formed by the geographical agglomeration of tourism core attractions, tourism enterprises and related enterprises and departments in a certain region and the establishment of close ties. Innovation, as the internal driving force of the development of tourism industry cluster, is of great significance to the development of the cluster itself and the development of regional economy.

This paper takes the innovation of tourism industry cluster as the key word, searches on the HowNet, and collects 42 relevant literature. Finally, 20 studies about innovation of tourism industry cluster are screened out, including a literature review.

As for the innovation of tourism industry cluster, the current research mainly focuses on the innovation system, innovation approaches, innovation subjects and the evaluation of innovation ability. In terms of innovation system, we refer readers to [1-3] and the references therein. In [1], the concept of cluster innovation system is first put forward. In [2], in general, the innovation cluster is an organizational and economic form of implementation of the innovation system in the economy of any level and it serves as a catalyst for innovation in each specific sector of economy and region. [3] holds that the innovation

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system of tourism industry cluster consists of core elements, auxiliary elements and environmental elements. Tourism enterprises and administrative departments belong to the core elements and play a leading role in the development of the cluster system. In terms of innovation approaches, we refer readers to [4-6] and the references therein. [4] holds that the innovation of tourism industry clusters includes ideological innovation and activity innovation. [5] proposes three ways to innovate tourism industry clusters, namely, cultivating the innovation ability of stakeholder groups, introducing innovation sources and establishing innovation funds. [6] believes that the innovation channels of tourism enterprises include innovation in mechanism, technology, marketing, management and service. In terms of innovation subjects, [7] believes that tourism enterprises are the most important innovation subjects and the most direct actors participating in innovation and realizing innovation value-added. [8] believes that the innovation subject is the tourism enterprises, tourism scientific research planning organizations, various intermediary institutions and local governments in the cluster. In [9], the government occupies the most important position in the cluster. In terms of innovation ability evaluation, [9] evaluates the innovation ability of sports tourism industry cluster and believes that the government is the leading factor in the innovation evaluation of sports tourism industry cluster, so he constructs a government led evaluation system. [10] discusses the relationship among the social relationship network, resource acquisition ability and innovation performance of tourism industry cluster enterprises. When evaluating the innovation ability, they select the aspects of product innovation ability, service innovation ability and personnel quality. [11] studies the structural relationship between social capital, knowledge sharing, innovation and performance. The results reveal that social capital and knowledge sharing both have a significant and positive effect on performance through innovation. [12] designs an evaluation scale for the innovation performance of tourism enterprises, and studies the network structure, resource acquisition ability and innovation performance of tourism industry clusters.

This paper takes the innovation ability of tourism industry cluster as the research object. This paper is mainly divided into three parts. First, build an evaluation index system of the innovation ability of tourism industry clusters. Second, use the analytic hierarchy process to calculate the index weight. Finally, use the fuzzy comprehensive evaluation model to calculate the innovation ability of tourism industry clusters in Liaoning Province.

2. Construction of Research Methods and Index System.

2.1. Research method.

2.1.1. *Analytic hierarchy process.* This paper uses analytic hierarchy process to calculate the weight of each index of tourism industry cluster innovation ability evaluation. Analytic hierarchy process is a comprehensive evaluation method proposed by American operational research scientist sati [13]. At present, it is mainly used to calculate the weight of multiple indicators. Analytic hierarchy process decomposes complex problems into multiple elements from top to bottom, and forms an orderly level according to the logical relationship. By comparing each index in each level, the importance of each index is determined and sorted. Analytic hierarchy process is widely used and simple to operate.

2.1.2. *Fuzzy comprehensive evaluation method.* This paper uses the fuzzy comprehensive evaluation method to measure the innovation ability of tourism industry clusters. The fuzzy comprehensive evaluation method is a common method for fuzzy comprehensive evaluation. In the objective world, not all things are deterministic, but also some uncertain things. Because of this, the quantity studied in mathematics is divided into certainty and uncertainty, and the quantity of uncertainty is divided into randomness, gray and fuzziness. We usually use classical mathematics to study deterministic quantities, such as

geometry and algebra; use stochastic mathematics to study the quantity of randomness, such as probability theory and stochastic process; use the grey system theory to study the grey quantity, such as grey correlation analysis; fuzzy mathematics is used to study the quantity of fuzziness, such as fuzzy comprehensive evaluation.

2.2. **Evaluation index system of innovation ability of tourism industry cluster.** Tourism industry cluster is a complex system. Therefore, when establishing the evaluation index system of innovation ability of tourism industry cluster, we need to start from the overall situation. This paper summarizes and combs the 42 documents collected, and preliminarily establishes an evaluation index system of tourism industry cluster innovation ability, including 3 levels and 13 indicators. By further consulting data, collecting data and consulting experts, the index system is adjusted on the basis of following the principles of objectivity, scientificity and operability. Finally, the evaluation index system of tourism industry cluster innovation ability composed of 11 indexes is determined. The evaluation index system of innovation ability of tourism industry cluster is shown in the table below.

Table 1. Evaluation index system of innovation ability of tourism industry cluster

Evaluation index of innovation ability of tourism industry cluster (A)	Innovation subject (B_1)	Nucleus innovation subject (C_1)
		Auxiliary innovation subject (C_2)
	Innovation activities (B_2)	Independent innovation (C_3)
		Cooperative innovation (C_4)
	Innovation environment (B_3)	Infrastructure (C_5)
		Policy support (C_6)
		Knowledge environment (C_7)
	Innovation performance (B_4)	Economic performance (C_8)
		Social performance (C_9)
		Innovative achievements of tourism enterprises (C_{10})
		Growth benefits of cluster operation (C_{11})

3. **Empirical Research.** According to the model established above, the first step is to distribute the evaluation judgment matrix questionnaire of tourism industry cluster innovation ability to relevant experts and technicians, ask them to score and evaluate relevant indicators, recover 12 effective questionnaires, and then calculate the weight of each indicator according to the principles and steps of analytic hierarchy process. In the second step, 551 valid questionnaires were collected in Liaoning Province through field survey, questionnaire collection (for qualitative indicators) and reference to the statistical data of government departments (for quantitative indicators). Then, according to the principles and steps of fuzzy comprehensive evaluation model, an expert evaluation table was constructed and distributed to 30 relevant experts for evaluation. After collecting the data from the expert evaluation table, the fuzzy comprehensive evaluation of the innovation ability of tourism industry clusters in Liaoning Province is carried out.

3.1. **Calculation of index weight.** According to the principle and steps of analytic hierarchy process, the evaluation index system of innovation ability of tourism industry cluster is calculated. The specific process and steps are as follows.

1) Establish hierarchical structure model. According to the above, the evaluation index system of innovation ability of tourism industry cluster is divided into three levels.

2) Construct judgment matrix. In order to minimize the subjectivity of expert judgment results, the initial data of the tourism industry cluster innovation ability evaluation judgment matrix questionnaire are processed by the geometric average method to obtain the comprehensive judgment matrix as follows.

TABLE 2. Evaluation and judgment matrix of innovation ability of tourism industry cluster

A	B_1	B_2	B_3	B_4
B_1	1.0000	1.0595	1.3901	0.4871
B_2	0.9439	1.0000	2.1048	0.4883
B_3	0.7194	0.4751	1.0000	0.4943
B_4	2.0528	2.0480	2.0232	1.0000

B_1	C_1	C_2
C_1	1.0000	3.1881
C_2	0.3137	1.0000

B_2	C_3	C_4
C_3	1.0000	1.1501
C_4	0.8695	1.0000

B_3	C_5	C_6	C_7
C_5	1.0000	0.6808	0.8007
C_6	1.4688	1.0000	2.0301
C_7	1.2489	0.4926	1.0000

B_4	C_8	C_9	C_{10}	C_{11}
C_8	1.0000	1.9442	1.0064	0.6272
C_9	0.5144	1.0000	1.5379	0.8059
C_{10}	0.9936	0.6502	1.0000	1.2464
C_{11}	1.5945	1.2409	0.8023	1.0000

The figures in the table are the results of experts comparing the importance of indicators. For example, in the first table, the figures in the first row and second column are the results of B_1 compared with B_2. When the number in the table is greater than 1, it means that B_1 is more important than B_2. The larger the number, the more important the indicator. 1.0595 means that B_1 is more important than B_2, 1.3901 means that B_1 is more important than B_3, and 0.4871 means that B_1 is not as important as B_4, and so on. We can know the importance of each indicator.

3) Solve the judgment matrix and check the consistency. There are three methods to solve the judgment matrix, namely arithmetic average method, geometric average method and eigenvalue method. In previous studies, when using analytic hierarchy process to solve practical problems, one of them is used to calculate the weight, and different calculation methods may lead to the deviation of the results. In order to ensure the robustness of the results, this paper uses three methods to calculate the average value after calculating the weight respectively, so as to avoid the deviation caused by using a single method, and the conclusions are more comprehensive and effective. The calculation results of the three methods are shown in Table 3.

The figures in the table represent the weight of each index preliminarily calculated by three methods.

$$CI = (\lambda_{\max} - n)/(n-1),\ CR = CI/RI$$

According to the above formula, the consistency test is carried out. C.R.A = 0.0217 < 0.1; C.R.B_3 = 0.0319 < 0.1; C.R.B_4 = 0.0776 < 0.1. Matrices B_1 and B_2 are second-order matrices, which must pass the consistency test, so the judgment matrices pass the consistency test.

TABLE 3. The results of arithmetic average method, geometric average method and eigenvalue method

Index	Arithmetic average method	Geometric average method	Eigenvalue method
Innovation subject (B_1)	0.2134	0.0692	0.2138
Nucleus innovation subject	0.7612	0.9104	0.7612
Auxiliary innovation subject	0.2388	0.0896	0.2388
Innovation activities (B_2)	0.2347	0.0936	0.2342
Independent innovation	0.5349	0.5691	0.5349
Cooperative innovation	0.4651	0.4309	0.4651
Innovation environment (B_3)	0.1524	0.0163	0.1514
Infrastructure	0.2637	0.1316	0.2629
Policy support	0.4617	0.7199	0.4633
Knowledge environment	0.2745	0.1485	0.2738
Innovation performance (B_4)	0.3994	0.8208	0.4006
Economic performance	0.2620	0.2880	0.2639
Social results	0.2263	0.1497	0.2245
Innovative achievements of tourism enterprises	0.2364	0.1891	0.2348
Growth benefits of cluster operation	0.2754	0.3729	0.2768

4) Sort the hierarchical list. Hierarchical single sorting is a weight that measures the relative importance of each element in the same level relative to an element in the previous level.

5) Calculate the composite weight of each layer element on the system target and sort the total hierarchy. The final weight of each indicator is as Table 4.

The figures in the table represent the final weight of each indicator. For example, 0.1655, 01875, 0.1067 and 0.5403 represent the weights of B_1, B_2, B_3 and B_4, respectively, 0.1342 represents the weight of C_1 and 0.0313 represents the weight of C_2, and so on.

From the table, firstly, we can see that the weight of innovation performance is the highest in the primary index, indicating that it is the most important aspect. Secondly, the weight of growth benefits of cluster operation is the highest in the final result, indicating that it is the most important in all secondary index. Thirdly, the weights of infrastructure and knowledge environment are lower than other indexes; therefore, these two aspects have little impact on cluster innovation.

3.2. **Evaluation on innovation ability of tourism industry cluster in Liaoning Province.** According to the principle and steps of the fuzzy comprehensive evaluation model, this paper studies the evaluation of the innovation ability of tourism industry clusters in Liaoning Province. The specific process and steps are as follows.

1) Establish factor set U and evaluation set V for comprehensive evaluation. According to the above established evaluation index level of innovation ability of tourism industry clusters, the evaluation factor set of innovation ability of tourism industry clusters in Liaoning Province can be set as U, $U = \{U_1, U_2, U_3, \ldots, U_m\}$, which respectively represents the primary index level, namely innovation subject, innovation activity, innovation environment and innovation performance. Among them, U_m is composed of secondary indicators U_{mn}, namely core innovation subject, auxiliary innovation subject, independent innovation, cooperative innovation, infrastructure, policy support, knowledge environment, economic performance, social benefits, innovation achievements of tourism enterprises and growth benefits of cluster operation. The evaluation comment set of innovation

TABLE 4. Hierarchy total sequencing of innovation ability evaluation of tourism industry clusters

Primary index	Weight W_B	Secondary index	Weight W_C	Hierarchy total sorting W
Innovation subject (B_1)	0.1655	Nucleus innovation subject	0.8109	0.1342
		Auxiliary innovation subject	0.1891	0.0313
Innovation activities (B_2)	0.1875	Independent innovation	0.5463	0.1024
		Cooperative innovation	0.4537	0.0851
Innovation environment (B_3)	0.1067	Infrastructure	0.2194	0.0234
		Policy support	0.5483	0.0585
		Knowledge environment	0.2323	0.0248
Innovation performance (B_4)	0.5403	Economic performance	0.2713	0.1466
		Social results	0.2002	0.1082
		Innovative achievements of tourism enterprises	0.2201	0.1189
		Growth benefits of cluster operation	0.3084	0.1666

ability of tourism industry cluster is V, $V = \{V_1, V_2, V_3, V_4, V_5\}$, which is divided into five levels: very strong, strong, general, weak and very weak.

2) Determine the weight of each evaluation factor. The analytic hierarchy process has been used to calculate the weight of the evaluation index of the innovation ability of tourism industry cluster. It can be set that the set composed of the index weight of each dimension is W, and the weight matrix is $W_A = (0.1655, 0.1875, 0.1067, 0.5403)$, $W_{B_1} = (0.1342, 0.0313)$, $W_{B_2} = (0.1024, 0.0851)$, $W_{B_3} = (0.0234, 0.0585, 0.0248)$, $W_{B_4} = (0.1466, 0.1082, 0.1189, 0.1666)$.

3) Establish a single factor evaluation matrix. According to the established comprehensive evaluation factor set U and evaluation set V, aiming at the collected relevant data and data of tourism industry clusters in Liaoning Province, this paper constructs an expert evaluation table, which is distributed to 30 relevant experts for evaluation, normalizes the original data of the recovered expert evaluation table, and obtains a single factor evaluation matrix R, as shown in the following equations:

$$R_1 = \begin{bmatrix} 0.07 & 0.10 & 0.77 & 0.07 & 0 \\ 0 & 0.07 & 0.90 & 0.03 & 0 \end{bmatrix}$$

$$R_2 = \begin{bmatrix} 0 & 1 & 0 & 0 & 0 \\ 0 & 0.97 & 0.03 & 0 & 0 \end{bmatrix}$$

$$R_3 = \begin{bmatrix} 0 & 0.17 & 0.83 & 0 & 0 \\ 0 & 0.17 & 0.83 & 0 & 0 \\ 0 & 0.77 & 0.13 & 0.07 & 0.03 \end{bmatrix}$$

$$R_4 = \begin{bmatrix} 0.07 & 0.03 & 0.17 & 0.67 & 0.07 \\ 0 & 0.03 & 0.90 & 0.07 & 0 \\ 0 & 0.90 & 0.07 & 0 & 0.03 \\ 0.50 & 0.27 & 0.13 & 0.10 & 0 \end{bmatrix}$$

For example, the fuzzy evaluation matrix R_1 above belongs to innovation subject which means 7% of the experts in this judge thought the index C_1 of Liaoning Province is very strong, 1% thought it is strong, 77% thought it is general, 7% thought it is weak and 0% thought it is very weak, and so on. Evaluation vector of each index $C_2, C_3, C_4, \ldots, C_{10}$ can be obtained, respectively.

4) Establish a comprehensive evaluation model and calculate the system evaluation results. According to the single factor evaluation matrix R and the weight set w determined by analytic hierarchy process, the fuzzy comprehensive evaluation model $B = W * R$ and the operation method of multiplication bounded operator are used to obtain the comprehensive evaluation vector, as follows:

$$B_1 = W_{B_1} * R_1 = (0.0094, 0.0156, 0.1315, 0.0103, 0)$$
$$B_2 = W_{B_2} * R_2 = (0, 0.1849, 0.0026, 0, 0)$$
$$B_3 = W_{B_3} * R_3 = (0, 0.0330, 0.0712, 0.0017, 0.0007)$$
$$B_4 = W_{B_4} * R_4 = (0.0936, 0.1596, 0.1523, 0.1225, 0.0138)$$

After normalization, it is

$$R_B = \begin{bmatrix} 0.0564 & 0.0935 & 0.7884 & 0.0618 & 0 \\ 0 & 0.9861 & 0.0139 & 0 & 0 \\ 0 & 0.3096 & 0.6679 & 0.0159 & 0.0066 \\ 0.1728 & 0.2946 & 0.2811 & 0.2261 & 0.0255 \end{bmatrix}$$

The comprehensive evaluation results are as follows:

$$A = W_A * R_B = (0.1027, 0.3926, 0.3562, 0.1341, 0.0145)$$

The final evaluation result is determined by the scoring principle, which is to quantify the comment set, that is, use a group of appropriate numbers to represent the comment set, divide it into scientific and reasonable grades, and then weighted sum the evaluation indicators to get the conclusion. The comment set is $v = \{$very strong, strong, general, weak, very weak$\}$, which is quantified as $v = \{9, 7, 5, 3, 1\}$. Then, for the final result P, when $P \in [7, 9]$, $P \in [5, 7]$, $P \in [3, 5]$ and $P \in [1, 3]$, the corresponding final results are very strong, strong, general, weak and very weak, respectively.

$$P = \sum_{i}^{5} A_i \times V_i = 0.1027 * 9 + 0.3926 * 7 + 0.3562 * 5 + 0.1341 * 3 + 0.0145 * 1 = 5.8955$$

Therefore, the innovation ability of tourism industry cluster in Liaoning Province is "strong".

4. **Conclusion.** Firstly, this paper determines the elements of the evaluation of the innovation ability of tourism industry clusters. By combing the relevant literature at home and abroad and consulting experts, this paper determines four primary indicators: innovation subject, innovation activities, innovation environment and innovation performance. Each primary indicator is composed of corresponding secondary indicators. Secondly, this paper uses analytic hierarchy process to determine the weight of each index. According to the calculation results, innovation performance accounts for the highest proportion in the evaluation of innovation ability of tourism industry cluster, followed by innovation activities, then innovation subject and innovation environment. Finally, the fuzzy comprehensive evaluation model is used to calculate the innovation ability of tourism industry

clusters in Liaoning Province. The results show that the innovation ability of tourism industry clusters in Liaoning Province is "strong". The analysis process of this paper is simple and feasible, and the research results are scientific, reasonable and practical.

It is hoped that the future research can establish the evaluation index system from more aspects, and adopt methods other than questionnaire survey and fuzzy comprehensive evaluation to evaluate the innovation ability of industrial clusters, so as to make the research more scientific.

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REFERENCES

[1] J. Wei, Analysis of knowledge spillover effect of small enterprise cluster innovation network, *Science Research Management*, vol.24, no.4, pp.54-60, 2003.

[2] O. Orlova-Kurilova, I. Kuksa and I. Hnatenko, Specific signs of a synergistic effect in an innovation cluster, *Wielokierunkowosc Jako Gwarancja Postepu Naukowego*, Warszawa, Polska, pp.10-12, 2020.

[3] Y. H. Yao, *Research on Tourism Industry Cluster Network and Innovation Performance*, Ph.D. Thesis, China Agricultural University, 2015.

[4] T. Odinokova, Tourism cluster as a form of innovation activity, *Economics Ecology Socium*, vol.3, no.2, pp.1-11, 2019.

[5] Y. C. Wang, G. P. Gu and J. Wang, Tourism industry cluster planning and innovation countermeasures in Xiong'an New Area, *Economic Forum*, no.11, pp.12-18, 2020.

[6] X. H. Ma, Research on the innovation path of tourism industry in Enshi prefecture from the perspective of industrial cluster, *Industrial Innovation Research*, no.4, pp.20-22, 2019.

[7] O. K. Khamidov and R. J. Jalilovich, Implementing economic clustering in Uzbekistan's tourism industry, *Middle European Scientific Bulletin*, vol.12, pp.103-119, 2021.

[8] A. Kataya, Theoretic issues on the role of tourism clusters in regional development, *Review of International Comparative Management*, vol.22, no.3, pp.321-337, 2021.

[9] C. L. Zhang and W. H. Feng, Innovation of tourism industry cluster: Literature review and prospect, *Economic Forum*, no.7, pp.120-124, 2018.

[10] J. L. Xie, *Research on Collaborative Innovation Model of Sports Tourism Industry Cluster*, Ph.D. Thesis, Qufu Normal University, 2015.

[11] Y. M. Gao, W. H. Feng and C. Q. Ning, Research on the relationship between enterprise social relationship network, resource acquisition ability and innovation performance – Taking Wutai Mountain tourism industry cluster as an example, *Productivity Research*, no.2, pp.48-52, 2017.

[12] N. Kim and C. Shim, Social capital, knowledge sharing and innovation of small-and medium-sized enterprises in a tourism cluster, *International Journal of Contemporary Hospitality Management*, vol.30, no.6, pp.2417-2437, 2018.

[13] D. D. Shi, Cluster network structure, resource acquisition capability and enterprise technological innovation performance – An empirical study taking tourism industry as an example, *Enterprise Economy*, no.3, pp.130-133, 2014.

[14] H. K. Chan, X. Sun and S. H. Chung, When should fuzzy analytic hierarchy process be used instead of analytic hierarchy process?, *Decision Support Systems*, vol.125, pp.113-114, 2019.