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ITJ

ISSN 1812-5638

INFORMATION TECHNOLOGY JOURNAL

ANSInet
Asian Network for Scientific Information
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

Information Technology Journal 12 (16): 3749-3752, 2013
ISSN 1812-5638 / DOI: 10.3923/itj.2013.3749.3752

Study of the Fuzzy Evaluation of Sports Tourism Resources Based on Data Envelopment Analysis and Hierarchy Analysis

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Abstract: As an intersectional part of sports and tourism, sports tourism is a branch of social sports, also an important part of tourism. To overall understand Hebei value of sports tourism resources and potentials, this study, taking an example as Hebei, combining with hierarchy analysis and data envelopment analysis, on basis of factor of sports tourism resources, builds comprehensive Fuzzy evaluation system and conduct objective evaluation on Hebei sports tourism resources, so as to provide scientific data supports and references for developing sports tourism activities and sports tourism industry.

Key words: Data envelopment analysis, hierarchy analysis, fuzzy, sports tourism resources

INTRODUCTION

Sports tourism is for tourists to visit or experience in the resort, which fully makes use of nature, landform or national traditions. It is also social economic and cultural, meanwhile it is the important content of sports industrialization and commercialization. As national economy develops, it becomes more and more important for sports tourism to develop regional tourism economy and improve the economic and social values of sports.

As a birthplace of Chinese nation, the terrain of Hebei tilts from northwest to southeast. The northwest area includes hills, plateaus and mountains, where distribute basins and valley bottom. The broad plain is in the central and southeast. Hebei is the unique province with plateaus, hill, mountain, plain, lake and coast, which is also a big province with abundant tourism resources. According to statistics, there are more than 400 resorts in Hebei, including 3 world cultural heritages, 5 national-level historical and cultural cities, 4 Chinese outstanding tourism cities, 7 national scenic areas, 11 national forest parks, 5 national nature reserves, 3 forty-top national tourist resorts, 2 top-ten national scenic spots and 23 national 4A scenic spots (Zhao, 2009). Therefore, Hebei has abundant national landscape and cultural landscape. Likely, the sports tourism resources are abundant, especially the distinct ones. So, it is essential to quantitatively evaluate Hebei sports tourism resources and clear their qualities and potentials, which is basis for developing. Yang jing calculated quantitative evaluation values of 23 single sports tourism resources from Tangshan, by means of hierarchy analysis and Delphi methods, in the study "research on quantitative evaluation on Tangshan sports tourism resources based on AHP" (Yan, 2010). The result indicated its resources are adequate and valuable, but its developing projects are monotonous, of which most resources are not utilized. Liu ying, et al, in the study "research on evaluation on Henan sports tourism resources based on AHP and fuzzy mathematic", constructed a comprehensive fuzzy evaluation system through hierarchy analysis and fuzzy mathematic and apply such system to evaluate Henan sports tourism resources objectively (Liu *et al*., 2012).

Hierarchy analysis and fuzzy comprehensive evaluation are very effective on plan evaluation with subjective judgment. However because each plan has the same weight allocation, which refers to trying to confirm the prior weights of varied indexes, then consider the sum of weights of varied indexes as the sort references, the problems exist, which include difficult to confirm weights, subjective weights and unjust evaluation, etc. To such problems, this study, on basis of hierarchy analysis and fuzzy comprehensive evaluation, integrating data envelopment analysis, constructs comprehensive evaluation system for Hebei tourism resources. It extends model for Tangshan in Yangjing's study to Hebei Province, with better universality and the result is different.

EVALUATION MODEL FOR FUZZY DATA ENVELOPMENT ANALYSIS

Data envelopment analysis is to utilize mathematical programming models (including linear programming,

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multi-objective programming, etc.), to evaluate relative efficiency of multiple inputs, especially the decisive units between multiple outputs. It has advantages of accuracy of objective data. However, it is difficult to find accurate index factors in reality. So, it is fuzzy. This study complementary the accurate data envelopment analysis and fuzzy comprehensive evaluation, resulting in a fuzzy comprehensive evaluation model for data envelopment analysis. It is separated into three steps: Firstly, fuzzy calculate the non-quantitative index weights; secondly, accurately calculate quantitative index weights by analyzing data envelopment and fuzzy operates the results; finally, conduct the comprehensive evaluation to get final evaluation results.

If there are m evaluation units, (C+d) indexes, c quantitative indexes and d non-quantitative indexes.

Fuzzy operation for non-quantitative weights: If $C = (c_1, c_2,\ldots, c_q)$ is factor set and $V = (v_0, v_1,\ldots v_{p-1})$ is comment set, the comprehensive evaluation matrix is:

$$R_j = \begin{bmatrix} r_{j10} & r_{j11} & \cdots & r_{j1(p-1)} \\ r_{j20} & r_{j21} & \cdots & r_{j2(p-1)} \\ \cdots & \cdots & \cdots & \cdots \\ r_{jq0} & r_{jq1} & \cdots & r_{jq(p-1)} \end{bmatrix}$$

$A_j = (a_{j1}, a_{j2}, \ldots, a_{jq})$ is weight matrix. So, the non-quantitative index weight of jth decisive unit after fuzzy operating is:

$$B_j = A_j R_j = (a_{j1}, a_{j2}, \cdots, a_{jq}) \begin{bmatrix} r_{j10} & r_{j11} & \cdots & r_{j1(p-1)} \\ r_{j20} & r_{j21} & \cdots & r_{j2(p-1)} \\ \cdots & \cdots & \cdots & \cdots \\ r_{jq0} & r_{jq1} & \cdots & r_{jq(p-1)} \end{bmatrix}$$
$$= (b_{j1}, b_{j2}, \cdots, b_{jp})$$

Calculation for data envelopment with quantitative weights: Imagine $X_j = (x_{1j}, x_{2j}, \ldots, x_{nj})^T$ and $Y_j = (y_{1j}, y_{2j}, \ldots, y_{sj})^T$ as input vectors of ith evaluation unit DMU_i ($1<i<m$), of which j= 1, 2, …,m. Each vector coordinate is positive. If demonstrate weight vector of input and output as $v = (v_1, v_2,\ldots, v_n)^T$, $u = (u_1, u_2,\ldots, u_s)^T$, the linear programming model after Charnes-Cooper transforming is:

$$\begin{cases} \max \mu^T Y_{j0} \\ \text{s.t.} \quad \omega^T X_j - \mu^T Y_j \geq 0, j = 1, 2, \cdots, m \\ \omega^T X_{j0} = 1 \\ \omega \geq 0, \mu \geq 0 \end{cases}$$

Take data into this model and get the optimal solution B_j', which is the accurate quantitative index weight.

Although, these data are more objective and persuasive, the motional cognition like "outstanding, fine, qualified and disqualified" and membership of fuzzy comprehensive evaluation don't exist. Therefore, this study applies membership function to fuzzy results.

The operation results of data envelopment can be considered as the membership degree of comment set $V = (v_0, v_1,, v_{p-1})$. Imagine $r = (r_0, r_1,\ldots r_{p-1})$ as membership, then:

$$r_j = \begin{cases} \dfrac{x - (j-1)\frac{1}{p-1}}{\frac{1}{p-1}} & ,(j-1)\frac{1}{p-1} \leq x < j\frac{1}{p-1} \\ \dfrac{(j+1)\frac{1}{p-1} - x}{\frac{1}{p-1}} & ,j\frac{1}{p-1} \leq x < (j+1)\frac{1}{p-1} \\ 0 & \end{cases}$$

Take B_j' into the formula above and get membership as $B_j = (b_{j1}, b_{j2},\ldots, b_{jp})$.

Comprehensive evaluation: Conduct comprehensive evaluation on such results. The comprehensive evaluation matrix is:

$$R_j = \begin{bmatrix} B_{j1} \\ B_{j2} \\ \cdots \\ B_{jk} \end{bmatrix}, j = 1, 2, \cdots, m$$

Of which, k is the number of indexes (quantitative and non-quantitative). Imagine $A_j = (a_{j1}, a_{j2}, \ldots, a_{jk})$, j = 1, 2, …, m as weight, then B =A and:

$$R \Rightarrow B_j = (a_{j1}, a_{j2}, \cdots, a_{jk}) \begin{bmatrix} B_{j1} \\ B_{j2} \\ \cdots \\ B_{jk} \end{bmatrix} = (b_{j1}, b_{j2}, \cdots, b_{jp}), j = 1, 2, \cdots, m$$

Utilizing the principle of maximum membership degree, the final result is v_l in $(v_0, v_1,\ldots v_{p-1})$ correspond to maximum b_{ji} in $B_j = (b_{j1}, b_{j2},\ldots, b_{jp})$

MODEL FOR DATA ENVELOPMENT ANALYSIS BASED ON HIERARCHY ANALYSIS

According to characteristics of data envelopment analysis, the conclusion overall depends on objective index data of evaluation plan. The important degree of varied evaluation indexes may be different in fact. Hence, to consider the preferences of decision makers and get reasonable evaluation results, this study integrates the objection of data envelopment analysis and subject of hierarchy analysis and builds an evaluation model for data envelopment analysis based on hierarchy analysis.

Its basic principle is to decompose the complex problem into many components firstly, then form the orderly hierarchical structural structure after grouping and layering. Finally confirm the comparative importance of varied factors by comparing. Calculate the sort of single layer and total sort. Finally confirm the corresponding weights of varied factors on decision. Therefore there are 4 steps: build hierarchy structure model; construct factor judgment matrix; conduct hierarchy single sort and consistent test; confirm total sort and consistence test.

To n evaluation plans, at first, according to special backgrounds, consider the important degree of varied indexes of each plan. Combing the investigations and consultation from specialists, confirm K index weight allocation vectors through hierarchy analysis:

$$(w^t,\mu^t)^T = (w_1{}^t, w_2{}^t,\cdots,w_m{}^t;\mu_1{}^t,\mu_2{}^t,\cdots,\mu_s{}^t)^T,\quad t=1,2,\cdots,k$$

On basis of two weight components of input and output indexes, confirm the constraint value interval through ratio of the weights and other weights. The constraint value intervals of input and output weight can be solved as follows:

$$P=\{(w_1,w_2,\cdots,w_m)\,|\,A_i \le \frac{w_i}{w_m} \le B_i, i=1,2,\cdots,m\}$$

$$Q=\{(\mu_1,\mu_2,\cdots,\mu_s)\,|\,\alpha_r \le \frac{\mu_r}{\mu_s} \le \beta_r, r=1,2,\cdots,s\}$$

A_i, B_i are the upper limit and lower limit of constraint interval of input weight component respectively; α_r, β_r are the upper limit and lower limit of constraint interval of output weight component respectively. Integrating that with data envelopment based on decisive unit, the comprehensive integrated model based on weight area can be solved:

$$\mathrm{Max}\sum_{r=1}^{s}\mu_r y_{rj_0} = h_{j_0}$$

s.t.:

$$\begin{cases} \sum_{i=1}^{m} w_i x_{ij} - \sum_{i=1}^{m}\mu_r y_{rj} \ge 0 \\ j=1,2,\cdots,n+1; j\ne j_0 \\ \sum_{i=1}^{m} w_i x_{ij_0} = 1 \\ (w_1,w_2,\cdots,w_m)\in P \\ (\mu_1,\mu_2,\cdots,\mu_s)\in Q \\ w_i \ge 0, \mu_r \ge 0 \\ i=1,2,\cdots,m; r=1,2,\cdots,s \end{cases}$$

By solving the mathematical programming, the prior order of j_0 plan can be seen. That is the optimal value of objective function.

EVALUATION ON SPORTS TOURISM RESOURCES

This study gets relevant data from questionnaires. To make data more universal and typical, this study select seven typical resorts: Nagatoshi taijiquan, Zhengding table tennis base, Yesanpo, Wanlong ski resort, Mulan paddock, the great wall ridge ski resort and Qinhuangdao Olympic center. The objects are sports teachers in colleges and universities, students majoring sports, tourism teachers in colleges and universities, students majoring tourism, other students and sports lovers. There are 500 questionnaires. This study constructs evaluation system in the methods above, shown as Fig. 1.

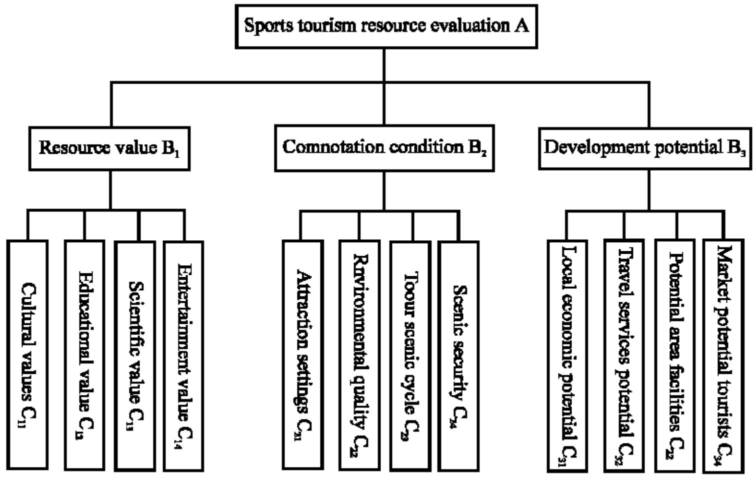

Fig. 1: Evaluation system

Table1: Weight of evaluation index

Object layer A	Principle layer B	Weight	Index layer C	weight	Total weight
Evaluation on Hebei sports tourism resources A	Resource value B_1	0.4941	Cultural value C_{11}	0.3161	0.1559
			Educational value C_{12}	0.1387	0.0688
			Scientific value C_{13}	0.2011	0.0993
			Entertainment value C_{14}	0.3429	0.1689
	Connotation condition B_2	0.3301	attractions settings C_{21}	0.2691	0.0882
			Environmental quality C_{22}	0.2059	0.0685
			Tour scenic cycle C_{23}	0.3009	0.0996
			Scenic security C_{24}	0.2238	0.00733
	Development potential B_3	0.1755	Local economic potential C_{31}	0.3799	0.0693
			Travel service potential C_{32}	0.1352	0.0241
			Potential area facilities C_{33}	0.2348	0.0423
			Market potential tourists C_{34}	0.2452	0.0429

Table 2: Evaluation set

Factor	Weight	Level				
Cultural value	0.1559	Extremely high	Higher	High	General	Low
Educational value	0.0691	Extremely high	Higher	High	General	Low
Scientific value	0.0993	Extremely high	Higher	High	General	Low
Entertainment value	0.1689	Extremely high	Higher	High	General	Low
Attractions settings	0.0887	excellent	Better	Good	General	Bad
Environmental quality	0.0683	excellent	Better	Good	General	Bad
Tour scenic cycle	0.0998	longest	Longer	Long	General	Short
Scenic security	0.0741	excellent	Better	Good	General	Bad
Local economic potential	0.0678	Extremely high	Higher	High	General	Low
Travel service potential	0.0241	Extremely high	Higher	High	General	Low
Potential area facilities	0.0426	Extremely high	Higher	High	General	Low
Market potential tourists	0.0439	Extremely high	Higher	High	General	Low

Table 3: Fuzzy comprehensive evaluation

		Single evaluation result			
Resort	Evaluation matrix	Resource value	Connotation condition	Development potential	Total result
Nagatoshi taijiquan	(0.124 0.307 0.333 0.087 0.147)	better	Better	general	better
Zhengding table tennis base	(0.195 0.306 0.375 0.078 0.061)	good	Better	better	better
Yesanpo	(0.185 0.323 0.357 0.101 0.031)	good	General	general	better
Wanlong ski resort	(0.236 0.363 0.285 0.088 0.023)	good	Good	better	good
Mulan paddock	(0.204 0.329 0.291 0.093 0.076)	good	Good	better	good
Great wall ridge ski resort	(0.117 0.163 0.338 0.366 0.022)	better	General	general	general
Qinhuangdao Olympic center	(0.244 0.382 0.268 0.089 0.013)	good	Good	good	good

Then, confirm the weights of indexes, shown as Table 1.

Then, confirm the evaluation set of sports tourism resources, shown as Table 2.

Finally conduct the fuzzy comprehensive evaluation on sports tourism resources and the result is shown as Table 3.

CONCLUSION

Hebei has abundant sports tourism resources, both national and emerging, which can satisfy different tourists, providing adequate resources for developing sports tourism. The results from fuzzy comprehensive evaluation shows, the total evaluation is general, good and better. It indicates the levels of qualities of sports tourism resources are different, with much space to improve. We should stress environmental qualities of resorts and developing potentials, integrating good and bad resources, to propel the sports tourism to a new level.

ACKNOWLEDGMENT

National Social Science Fund Project, Project No. (10CTY009).

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