An Alternative Approach for Determining Regional Competitive Relationships and Pressures in the Tourism Sector Based on Game Cross-Efficiency DEA

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Abstract—Economic relationships between business units based on geographic location is an interesting topic that is worthy of deeper consideration. By using game cross-efficiency DEA, this paper proposes an alternative approach to determining competitive relationships and introduces a Tourism Competition Index (TCI) to quantify competitive pressure. A practical example from China is introduced to highlight the applicability of the assessment method, and illustrate how it can be used to evaluate the competitive position.

Keywords-regional competitive relationship; tourism efficiency; tourism competition index; game cross-efficiency DEA

1 INTRODUCTION

Studying relationships between places is very important for governments wanting to cooperate with others in developing local industry, however, there is generally a paucity of methodological literature about it. The most widely used approaches are a statistical interpretation of the gravity model used by Wilson [1] and the core-periphery model as used by Friedmann [2]. Both of these models, however, mostly discuss the spatial interactions of places. Wen proposed a method to directly evaluate competitive relationships, based on the judgement of similarity in economic resources [3]. Although Wen's work provided a way to evaluate the competition relationship, it's still seldom to be applied to the study in tourism. This paper proposes an integrated model that can reveal the relationships between places in the tourism sector, showing clearly whether they are competitors or not. Meanwhile, in order to study the influences of all relations, the paper introduces the notion of a Tourism Competition Index (TCI), that is able to quantify the pressure brought to bear on destinations. There are five steps and 4 assessment measures in this methodology. Finally, an example of China illustrates how the evaluation method works and highlights the potential of this approach.

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2 MODELS AND METHODOLOGY

2.1 Steps and Models

There are 5 steps in this competition relation assessment method, namely:

1） Calculate the Tourism Efficiency.

2） Calculate the Tourism Competition Index, based on a Game cross-efficiency matrix.

3） Determine the competitive relationship through a multivariate statistical analysis of variables, specifically the number of scenic spots (X) in a place, the total employment wages in Urban Units (Y) and Tourism Efficiency (Z). All values of X, Y, Z should be standardized by Z-score.

The variable X represents the tourism resources of a place. Since an attraction can often contain multiple scenic spots, it is likely to contain multiple numbers and types of tourism resources; as it is not possible to exactly calculate the difference in these tourism resources, the number of scenic spots can be used as a proxy measure instead to reflect similar positions with respect to tourism resources. Scenic spots include a variety of different tourism resources, and the closer they are clustered together, the higher the likelihood that they have similar resources.

Y represents the level of Human Resources. The tourism sector involves a number of industries, eliminating the need to confine the wages to just the travel or the commercial accommodation industries. Agricultural labor, however, should be excluded, even though tourism can be active in rural areas, where the service providers are often the local farmers and their families. These farmers however, often are contracted to, or own the land, so they are unlikely to leave just for a higher income in a different employment sector.

Z represents tourism efficiency. The evaluation criterion for the utilization of resource capacity is tourism efficiency, which is an input-output ratio reflecting the ability to utilize tourism resources with a value range of 0 to 1. A higher value means greater efficiency. Usually, capital and labor will flow from less efficient to more efficient places.

4） Euclidean distance is used to calculate the spatial distribution of the target place to other places.

5） The relationships with other areas are categorized according to the distance between them. The article follows the division method of Wen, and the resultant competition relations are shown in Table 1.

Table 1. Types of Relationships

Relationship	**Value of Distance**
Strongly cooperative	$1 \leq D \leq +\infty$
Weakly cooperative	$0.5 \leq D \leq 1$
No obvious type	$-0.5 \leq D \leq 0.5$

Weakly competitive	-1$\le D \le -0.5$
Strongly competitive	$-\infty \le D \le -1$

2.2 Game Cross-Efficiency Models

Data Envelopment Analysis (DEA) is a method of efficiency evaluation that was first introduced in 1978 and was known as the CCR model, so named after the founders Charnes, Cooper and Rhodes. It proposes that there are n Decision Making Units (DMUs), with m inputs and s outputs, while xij (i = 1..., m) are the input values and yrj (r = 1, . . ., s) the output values of DMUj (j = 1, . . ., n). E_{dd} is the efficiency of unit d.

$$\max E_{dd} \sum_{r=1}^{s} \mu_{rd}\, y_{rd}$$
$$S.t. \quad \sum_{i=1}^{m} \omega_{id} x_{id} = 1$$
$$\sum_{r=1}^{s} \mu_{rd} y_{rj} - \sum_{i=1}^{m} \omega_{id} x_{ij} \le 0, \; j = 1, \dots n$$
$$\omega_{id} \ge 0, , i = 1,2, \dots . m$$
$$\mu_{rd} \ge 0, , r = 1,2, \dots . s \qquad (1)$$

Cross-Efficiency Evaluation, as an extension to DEA, was introduced by Sexton et al.,[4] and further developed by Doyle and Green [5]. That solved a particular problem with the CCR model where there may be more than one DMU on the production frontier, and where they cannot be discriminated any further. It evaluates the overall efficiencies of the DMUs through both self-evaluation and peer appraisal, so the model and weights become more refined. Sexton recommended the use of both aggressive and benevolent formulations, where the aggressive model minimizes the average efficiency of other DMUs, and the benevolent model maximizes it.

Besides aggressive and benevolent cross-efficiency models, a game cross-efficiency model was proposed by Liang et. al [6], as follows:

$$\max \quad \sum_{r=1}^{s} \mu_{r_j}^{d}\, y_{rj}$$
$$S.t. \quad \sum_{i=1}^{m} w_{ij}^{d} x_{il} - \sum_{r=1}^{s} \mu_{r_j}^{d} y_{rl} \ge 0, l = 1, \dots n$$
$$\sum_{i=1}^{m} w_{ij}^{d} x_{il} = 1$$

$$a_d \sum_{i=1}^{m} w_{ij}^{d} x_{id} - \sum_{r=1}^{s} \mu_{r_j}^{d} y_{rd} \le 0$$
$$w_{ij}^{d} \ge 0, \; i = 1,2, \ldots . m$$
$$\mu_{r_j}^{d} \ge 0, , r = 1,2, \ldots . s \quad (2)$$

It proposes that there are n DMUs with m inputs and s outputs, while xij (i = 1, . . ., m) are the input values and yrj (r = 1, . . ., s) are the output values of DMUj (j = 1, . . ., n). Here, wi and ur (r = 1, . . ., s) are input and output weights respectively. Through the self-evaluation, and based on the formula (1) and (2), the result of game cross-efficiency DEA comes as a matrix. It assumes that DMUs are competing with each other, and in such a non-cooperative position, a player had an efficiency score which cannot be decreased when another player tries to maximize its own efficiency.

2.3 Tourism Competition Index (TCI)

This index is calculated on the basis of matrix of game cross-efficiency. F_d represents DMU d's Tourism Competition Index where: N is the total number of places; $\overline{\theta_1}$ is the average of evaluation values that are equal to or higher than d's self-evaluation; N_1 is the number of those DMUs. $\overline{\theta_2}$ is the average of evaluation values that are lower than d's self-evaluation. N_2 is the number of those places. The denominator is the number of all DMUs except d, so it becomes N-1.

$$F_d = \frac{\overline{\theta_1} \times N_1 - \overline{\theta_2} \times N_2}{N-1} \quad (3)$$

Based on self-evaluation, it is possible to see the deviation of evaluations to the target DMU. If the deviation value is negative, the DMU will be in a competitive environment, where the smaller the value, the greater the competitive pressure. If the deviation value is positive, the DMU will be in a cooperative environment; the greater the deviation value, the more cooperation and the lighter competitive pressure it is likely to have.

2.4 Selection of Variables

The approach here uses the number of hotels and employees in the tertiary sector and the length of highways as input variables. The reason for selecting those is the consideration that tourism is a hospitality industry; the number of hotels determines how many visitors can remain overnight, while employee numbers are related to how many visitors can be served. The length of the highways is related to how many visits can be made, because most cities in Sichuan do not have airports and only a few have rail connections. Domestic tourism receipts and visitor arrivals are used as output variables because Sichuan is an interior province and does not yet have a well-developed international tourism sector. The details are as shown below:

Table 2. Variables and explanations

Inputs:	X_1	Number of hotels
	X_2	Length of roads

	X_3	Number of Local Tourism Agencies
	X_4	Number employees in the tertiary sector
Outputs:	Y_1	Annual domestic visitor arrivals
	Y_2	Domestic tourism receipts

3 CASE STUDY OF CHINA

This example illustrates how this enhanced model and the TCI can be applied to the analysis of competitive situations by using data from 31 provinces, province-level municipalities and autonomous regions (hereafter provinces) in China. Following the integration of the Ministry of Culture with the National Tourism Administration in 2018, only one section in the Statistics of China Culture and Tourism reports refers to tourism since then. Therefore, with a lack of national data after 2018, the article uses data from the China Tourism Statistics report for 2018 (calendar year 2017).

Table 3. Tourism Efficiencies and TCIS in 31 Provinces of China in the Year of 2017

Province	Tourism Efficiency	TCI
Beijing	0.677	0.098
Tianjiang	1.000	-0.475
Hebei	0.639	0.232
Shanxi	1.000	-0.433
Neimenggu	0.713H	-0.005
Liaoning	0.478	0.535
Jilin	1.000	-0.399
Heilongjiang	0.316	0.565
Shanghai	0.705	0.047
Jiangsu	1.000	-0.350
Zhejiang	0.699	0.034
Anhui	1.000	-0.351
Fujian	0.559	0.389
Jiangxi	0.872	-0.266
Shandong	0.776	-0.112
Henan	0.814	-0.150
Hubei	0.674	0.049
Hunan	0.700	0.131
Guangdong	0.696	0.132
Guangxi	0.624	0.128
Hainan	0.211	0.567
Chongqing	0.896	-0.263
Sichuan	1.000	-0.356
Guizhou	1.000	-0.263
Yunnan	0.863	-0.199
Tibet	0.519	0.113
Shaanxi	0.544	0.429

Gansu	0.401	0.540
Qinghai	0.133	0.633
Ningxia	0.194	0.593
Xinjiang	0.292	0.597

As Tab.3 shows, Tourism Efficiency and the TCI have negative correlations. The evidence of China suggests that competition can also improve efficiency. Under the pressure of competition, governments have to optimize resource allocations, increase development levels and improve tourist yields, all of which are helpful to improve local tourism efficiency. For those provinces in a less competitive environment, there may be fewer motivations to act in a similar fashion, so their tourism efficiency is likely to remain at a relatively low level.

From Tab.4, it can be seen that Southwest China has not only a negative TCI but also the lowest score, making it the most competitive region. Here, Tibet is the only province with a positive TCI, and as such is in a cooperative environment. Those of Sichuan, Chongqing, Yunnan and Guizhou are all in a competitive environment as defined by their respective negative TCIs. The article therefore selected those as examples for a further analysis of the competition relationships they have with other provinces by continuing with steps 3, 4 and 5 as outlined above. The results are shown in Table 5.

Table 4. Relationships of Four Southwestern Provinces with other provinces of China

	Sichuan	**Chongqing**	**Guizhou**	**Yunnan**
TCI	-0.356	-0.263	-0.263	-0.199
Strong cooperative partners	Beijing, Shanghai, Shandong, Hainan, Qinghai, Ningxia, Tibet	Beijing, Shanghai Shandong, Hainan, Qinghai, Ningxia	Beijing, Shanghai Shandong, Hainan, Qinghai, Ningxia	Beijing, Shanghai Shandong, Tibet, Qinghai,
Weak cooperative partner	Xinjiang, Heilongjiang	Heilongjiang, Zhejiang, Tibet Xinjiang	Heilongjiang, Tibet, Xinjiang	Heilongjiang, Zhejiang, Hainan, Ningxia, Xinjiang
Weak competitive opponent	Hebei, Neimenggu, Jilin, Henan, Hubei, Hunan, Guangxi, Chongqing Guizhou, Yunan	Neimenggu, Henan, Hubei, Hunan, Guangdong, Sichuan	Tianjing, Neimenggu, Henan, Hubei, Hunan, Sichuan Guangdong,	Hebei, Neimenggu, Fujian, Henan, Hubei, Hunan, Guangdong

Strong competitive opponents	Jiangsu, Anhui, Jiangxi	Shanxi, Jilin, Jiangxi, Guizhou Yunnan	Shanxi, Jilin, Jiangxi, Yunan Chongqing	Shanxi, Jilin, Jiangxi, Guizhou Chongqing

It also can be seen that for Sichuan, Chongqing, Guizhou and Yunnan, each has a somewhat varied relationship with other provinces, showing that their positions are quite different. The main competitors come from three directions: North, Central, and inside Southwest China. Relationships with North and Central China should certainly not be ignored. The aim can be converting those relationships from weak competition to weak cooperation, so they will be helpful in bringing more tourists into southwest China, benefitting all of provinces in Southwest China. As for the competition inside Southwest China, since there is no sign of cooperation among the four provinces, regional cooperation policy may not work out because their interests are different and at the most time are against each other.

In terms of cooperators, the four provinces all have strong cooperative relations with Beijing and Shanghai. This is mainly because Beijing and Shanghai are the main tourist source markets, generating significant numbers of visitors to the southwest provinces every year. Thus, in the future promotion of their tourism economies, they should firstly continue their cooperative relationships with Beijing and Shanghai to ensure the flow of tourists from these two source markets. Additionally, Sichuan, Chongqing, Guizhou and Yunnan have a different level of cooperation with the provinces in the Northwest, based on which, relationships with Qinghai and Ningxia should be strengthened.

4 CONCLUSIONS

This article raised the concept of a Tourism Competition Index, and provides an enhanced methodology for calculating it enables a more specific analysis of tourism competition by delivering a number of quantifiable conclusions.

Firstly, benign competition can improve tourism efficiency, so governments don't need to intervene in it. The example of 31 provinces in China suggests that competition does not always increase costs but may spur governments to optimize resource allocation, which then helps to maintain tourism efficiency at a high level.

Secondly, it would be more effective to embrace cooperative partners rather than competitive ones. After classifying their relationships with other places, local governments would be able to be more precise when making policies or allocating resources. It would be better, for example, if Sichuan cooperated with Hainan before Jiangsu, because it already has a strong cooperative relationship with the former and this would allow both sides to benefit. Jiangsu, on the other hand, is already a strong competitor to Sichuan, so cooperative policies may require time, energy and resources to come about.

Thirdly, making regional cooperation policy should not only consider geographic location but also the existing competitive-cooperative relationships. In terms of geography for example, Sichuan, Chongqing, Yunnan and Guizhou are contiguous so it's easy to consider that they should work together to attract more tourists. However, since there's no cooperative relationship among them, a regional cooperative policy end in failure very likely due to the lack of common interests.

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