

## Using DEA Method to Measure and Evaluate Tourism Efficiency of Guangdong, Guangxi and Hainan Provinces in the South of China - A case of the Beibu Gulf Urban Agglomeration-

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### Abstract

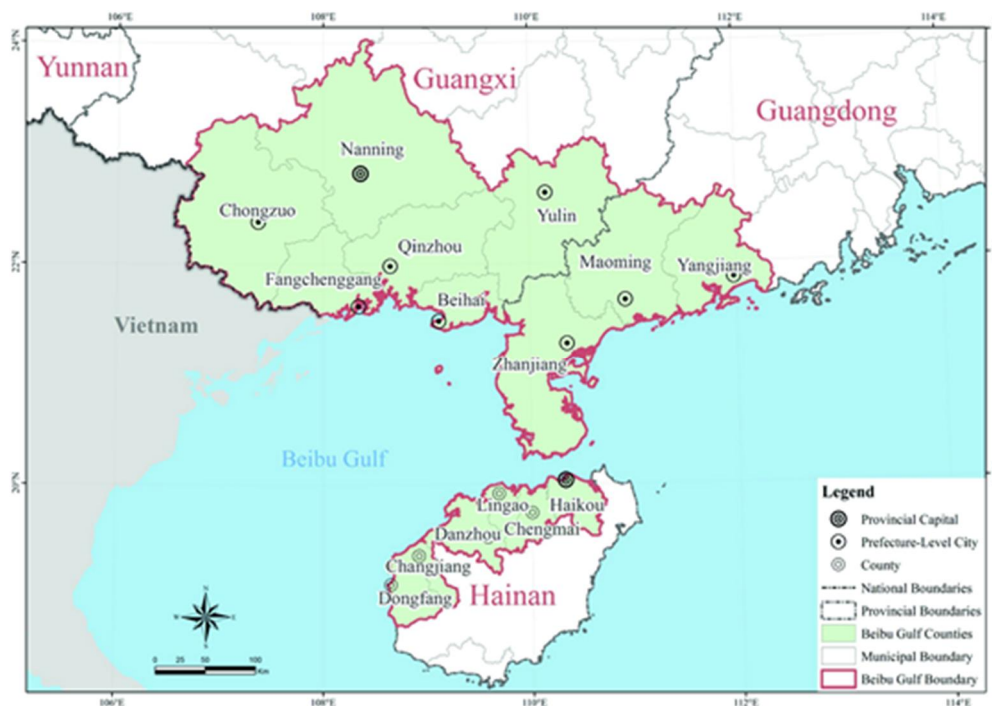
China's "One Belt and One Road" initiative has brought multiple opportunities to the development of tourism in Guangdong, Guangxi and Hainan provinces and the implementation of the Beibu Gulf Urban Agglomeration Development Plan has set clear goals for further accelerating the coordinated development, in-depth cooperation of the three. This study takes the Beibu Gulf Urban Agglomeration as the research object and utilized the data envelopment analysis (DEA) procedure to estimate the technical efficiency, pure technical efficiency, and scale efficiency scores for each city and Malmquist index was subsequently used to analyze dynamically, then tries to offer an adequate inclusion of sustainable factors in overall tourism development efficiency results through the detection and estimation of potential sources of efficiency. In order to complete the task, data collection was focused on Guangdong, Guangxi and Hainan provinces of China over the period from 2016 to 2018. The results in the first phase show relatively high efficiency scores, particularly in the case of the Beibu Gulf Urban Agglomeration and with room for improvement in the case of other cities of Guangdong, Guangxi and Hainan provinces. The second stage results present several aspects that should be carefully considered in order to analysis tourism efficiency of the Beibu Gulf Urban Agglomerations vertically according to the changes of the frontier.

**Key words:** Beibu Gulf Urban Agglomeration; Tourism efficiency; DEA method

### 1. Introduction

Guangdong, Guangxi and Hainan provinces are the cradleland of China's ancient Maritime Silk aRoad. It is not only the platform of trade between ancient people and southeast Asia and other coastal countries, but also a bridge for cultural exchange and tourism. Geographically, Guangdong, Guangxi and Hainan provinces are all located in the Beibu Gulf and the South China Sea, and they are economic and geographical units closely connected in their own systems. With an area of about 405,000 square kilometers, a coastline of more than 10,000 kilometers, and a population of 128 million, the three provinces and autonomous regions belong to

the south China region, which straddles the tropics and subtropics. With the implementation of China's "One Belt And One Road" strategy, it brings multiple opportunities for the economic and social development of Guangdong, Guangxi and Hainan provinces. The joint development of tourism in this three provinces will help to increase new economic growth points and enhance cultural cohesion, create a new normal of the economy and new forms of cultural business, enhance the visibility and reputation both at home and abroad, and bring material benefits and spiritual enjoyment to urban and rural residents. In February 2017, the National Development and Reform Commission issued the "Beibu Gulf Urban Agglomeration Development Plan" and clearly points out that the Beibu Gulf Urban Agglomeration (as shown in figure. 1) should "strengthen regional tourism cooperation, build a coordinated tourism development pattern of large, medium and small cities, and jointly build an international tourism and leisure destination". There would be a large amount of financial, human and material resources invested in the construction of Beibu Gulf Urban Agglomeration under this under such a policy, which not only brings a new development opportunity to the tourism industry, but also presents a severe challenge to the evaluation and improvement of tourism efficiency. On May 9, 2018, Guangdong, Guangxi and Hainan provinces signed an agreement to develop the Beibu Gulf Urban Agglomeration into a world-class tourist destination. Representatives of 15 cities and counties (Yangjiang, Maoming, Zhanjiang, Nanning, Qinzhou, Beihai, Fang Chenggang, Yuli, Chongzuo, Haikou, Danzhou, Lingao, Dongfang, Chengmai, Changjiang) from Guangdong, Guangxi, and Hainan signed the Beibu Gulf Urban Agglomeration Tourism Cooperation Agreement. According to the agreement, the 15 cities and counties will work together to develop the tourism brand of "Beautiful blue bay," as well as introduce more boutique travel routes to jointly establish a world-class tourist destination in the region.



**Figure 1. The location map of the Beibu Gulf Urban Agglomeration**

The main hypothesis of this research is the proper inclusion of sustainable factors in the results of tourism development efficiency according to the actual situation of the Beibu Gulf Urban Agglomeration development, and unlike most studies dealing with the evaluation of micro-level efficiency, this paper tries to use a scientific, reasonable, rigorous and feasible research methods to make a practical evaluation and in-depth research on the

tourism efficiency in the Beibu Gulf Urban Agglomeration which is of great significance to improve the resource utilization rate, realize tourism transformation and upgrading.

The remainder of this research is systematized as follows. Section 2 presents the results from previous relevant researches. Section 3 provides research methodology by explaining the basis of a data envelopment analysis (DEA) and the Malmquist index, as well as data collection procedure and descriptive statistics. Section 4 contains research results, including complete data analysis procedure. Finally, Section 5 concludes the empirical results while highlighting the potential advantages and limitations of such an analysis, along with recommendations for policymakers and other stakeholders.

## **2. Literature review**

Urban tourism efficiency refers to the nature of maximizing the output of unit factor input in a certain period of time and maximizing the total surplus of all stakeholders in the development of the tourism industry by taking the city as a tourism economic production unit. Overseas studies on the efficiency of the tourism industry have been carried out earlier. Morey utilized DEA method to evaluate and study the operating efficiency of some private chain hotels in the United States, and draw valuable conclusions about the efficiency of hotel management [1]. Kgksal used DEA model to evaluate the operating efficiency of local travel agencies, and the results showed that the operating efficiency of most travel agencies was not high [2]. Barros et al. and Medina et al. evaluated and compared the efficiency of the tourism industry in France, Spain and Portugal [3-4]. Hadad have indicated that great interest in evaluating productivity and efficiency in tourism industry is not a surprise, considering both the growing economic significance of tourism as a source of international employment and revenue, and increasing competition in the global tourist markets. Efficiency is the foundation of development, and tourism is an important part of a state's economy, so it is considered very important for both social and economic development of a certain state [5]. Toma proved in her paper that DEA model could evaluate the efficiency of the tourism sector at the regional level, which can provide additional information and indicate necessary decision making, so as to achieve an optimal scale of tourism market [6]. The main purpose of this study is to assess the efficiency of tourism at provincial or regional level, in order to obtain information that can be used as a reference for the government when making long-term decisions concerning the future development of tourism. Efficiency is generally the relationship between output and input parameters, and refers to the business performance of an enterprise (at micro level) or of a state (at macro level). The process that produces more outputs than inputs is more efficient. Optimum efficiency will be achieved if you can produce significantly more outputs than inputs. It is impossible to improve efficiency without the use of new technologies or the introduction of various changes [7]. In addition, some foreign researchers have carried on the evaluation research to the tourism traffic efficiency [8-9].

Domestic research on the efficiency of the tourism industry started relatively late. Tao Zhuomin took 31 provinces of China as examples, conducted empirical analysis on the efficiency of China's tourism industry, and drew the conclusion that the overall scale was not economic [10]. Ma Xiaolong took major Cities in China as research objects, analyzed regional differences in the efficiency of tourism industry, and believed that scale efficiency was the direct cause affecting technical efficiency [11]. Li Rui and Liu Jia explored the space-time characteristics and evolution rules of tourism industry efficiency by taking Bohai Rim region and coastal region as research areas respectively [12-13]. Besides, some researchers evaluated the efficiency of the tourism industry in Anhui and Jiangsu provinces [14-15].

According to the existing research results, most of the research on the efficiency of tourism industry focuses on the national level, regional level, provincial level and enterprise level, etc., while the research on the

comprehensive efficiency of the development of tourism industry in urban agglomeration is still insufficient. Taking the Beibu Gulf Urban Agglomeration as a case study, this paper analyzes the efficiency differences of the tourism industry in various cities and the reasons for their formation, so as to provide theoretical support for promoting the transformation of the tourism industry in the urban agglomeration from scale and speed expansion to quality and efficiency development.

### 3. Materials and Methods

#### 3.1. Research Methodology

Efficiency, as a relation between achieved outputs and used inputs, has been put forward by Farrell, who defines the term technical efficiency as the ability to achieve the maximal output for a given set of inputs [16]. Two decades later, Charnes, Cooper, and Rhodes developed the DEA method which is a commonly used mathematical technique to analyze the multi-input and multi-output of the decision-making units (DMU) and to compare their relative efficiency and benefit [17]. The researchers in various fields quickly admitted that DEA was excellent methodology to modelling operational process.

Charnes, Cooper and Rhodes proposed CCR DEA model which is the first DEA model in 1978. Suppose there are  $n$  DMUs, namely  $DMU_1, DMU_2, DMU_3, \dots, DMU_n$ . Each  $DMU_j$ , ( $j = 1, \dots, n$ ) use  $m$  inputs  $x_{ij}$  ( $i = 1, \dots, m$ ) and generates  $s$  outputs  $y_{rj}$  ( $r = 1, \dots, s$ ). Let the input weights  $v_i$  ( $i = 1, 2, \dots, m$ ) and the output weight  $u_r$  ( $r = 1, 2, \dots, s$ ) as variables. Let the  $DMU_j$  to be evaluated on any trial be designated as  $DMU_o$  ( $o = 1, 2, \dots, n$ ). Therefore, the efficiency of each  $DMU_o$ ,  $e_o$ , can be found by solving the following linear programming, which is called multiplier form in DEA [18].

$$\begin{aligned}
 e_o &= \max \sum_r u_r y_{ro} \\
 s.t. & \sum_r u_r y_{ro} - \sum_i v_i x_{io} \leq 0 \\
 & \sum_i v_i x_{io} = 1 \\
 & u_r, v_i \geq 0
 \end{aligned} \tag{1}$$

The model is run  $n$  times to identify the relative efficiency scores of all the DMUs. Each DMU selects a set of input weights  $v_i$  and output weights  $u_r$  to maximize its efficiency score. In general, a DMU is efficient when it obtains the maximum score of 1, otherwise a DMU is inefficient. The DEA model that implemented Variable Return to Scale (VRS) is called BCC model. In BCC model, VRS is assumed and the efficient frontier is formed by the convex hull of the existing DMUs. The envelopment form of BCC [18] is:

$$\begin{aligned}
 \min & \theta_o \\
 s.t. & \sum_j \lambda_j x_{ij} - \theta_o x_{io} \leq 0 \\
 & \sum_j \lambda_j y_{rj} - y_{ro} \geq 0 \\
 & \sum_j \lambda_j = 1 \\
 & \lambda_j \geq 0
 \end{aligned} \tag{2}$$

Note that BCC differs from CCR in that it has the additional convexity constraint,  $\sum_j \lambda_j = 1$ . A DMU is BCC

efficient if it has an optimal solution of  $\theta = 1$ ,  $\lambda = 1$ , and  $\lambda \neq 0$ .

The Malmquist index method is based on the Malmquist productivity index proposed by Cave et al. (1982) and the change value of total factor productivity (TFP) constructed by Fare et al. (1994), which can reflect the DMU production efficiency of decision-making units in different periods [19-20]. Fare et al. (1994) decomposed total factor productivity change rate (Malmquist productivity index) into technical efficiency change index (TECI) and technological progress change index (TCI) under the assumption of variable returns to scale [20]. The economic meaning of Malmquist index is that when Malmquist index  $m$  is greater than 1, it means that the overall production efficiency of decision-making unit increases from  $t$  to  $t + 1$ . If it is equal to or less than 1, it means that the overall production efficiency does not change and the overall production efficiency decreases. Technological progress change index (TCI) indicates the degree of technological innovation, which indicates the degree of change of DMU production technology between the two measured time points. If the index TCI is greater than 1, it means technological progress; other the change index of technical efficiency (TECI) reflects the change of production efficiency when the technical level is fixed. If TECI is greater than 1, it means the production efficiency is improved. Otherwise, it means the production efficiency is not changed or reduced.

### 3.2 Variable selection and data source

The DEA method has strict requirements on input and output indexes, and the quality of index selection is crucial to the evaluation results. If the input index and output index are not selected scientifically, the shape and position of the production frontier will change to a certain extent, thus affecting the accuracy of efficiency evaluation. Therefore, the author has a comprehensive understanding of the variables selected by domestic and foreign scholars for the research of tourism efficiency by using DEA method before studying, and summarizes the more representative indexes as shown in Table 1.

**Table 1. The summary of tourism efficiency evaluation index**

No.	Previous research	Input index	Output index
1	Ma Xiaolong et al. , 2010	Number of employees in the tertiary industry; Urban fixed-asset investment; Attraction of urban resources; The use of foreign capital amount	Income from starred hotels
2	Cao Fangdong et al. , 2012	Number of employees in the tertiary industry; Number of Tourist attractions; Number of starred hotels; Number of travel agencies	Number of tourist arrivals; Total tourism revenue
3	Gong Yan et al. 2014	Number of employees in the tertiary industry; Number of Tourist attractions; Number of starred hotels; Number of travel agencies; Grade highway density	Total tourism revenue; Number of tourist arrivals
4	Ivana Ilić & Ivana Petrevska, 2018	Tourism costs (in mil. Euro); Number of beds	Number of arrivals; Number of nights spent; Tourism revenue (in mil. Euro)

Tourism is a comprehensive industry with complex and diverse input and output indexes [21]. At present, researchers have not reached consensus on the choice of input and output indexes. In economics, land, labor and capital are the most basic factors of production, but the development of tourism is generally not limited by

land area [22]. Therefore, this paper does not take land as the input factors of tourism, but labor and capital have an important impact on the development of tourism industry. The quantity of tourism direct employment is an ideal indicator of labor factor input, but there is a lack of statistics on this data in the statistical yearbook of China, so the quantity of employment in catering and accommodation industry is chosen to replace this variable. In addition, the number of A-level national tourist attractions occupies a central position in the tourism capital investment and is an important factor to attract tourists, while the number of starred hotels and travel agencies reflects the tourism acceptance capacity of a region, so these elements are used as investment indexes in this paper. By observing Table 3-1, we can find that the number of tourist arrivals and tourism revenue are selected as the output indexes in most researches, and these two variables can reflect the development level and scale of the urban tourism industry to some extent. Therefore, the number of tourist arrivals and tourism revenue are also selected as the output indicators in this paper.

The research scope of this paper covers 53 cities and counties in Guangdong, Guangxi and Hainan provinces, and the panel data of tourism input and output indexes from 2016-2018 are taken as the research samples. All data are from statistical yearbooks of all provinces, China City Statistical Yearbook, China Regional Economic Statistical Yearbook, official websites of National Tourism Administration, official websites of provincial and municipal tourism bureaus, and statistical bulletins of national economic and social development of all regions.

#### 4. Research Results

##### 4.1 Data Envelopment Analysis Results

The results obtained from the output-oriented DEA – BCC model with MAXDEA 8 PRO software to estimate the static efficiency of tourism in 53 cities of Guangdong, Guangxi and Hainan provinces, including 15 cities in the Beibu Gulf Urban Agglomeration from 2016 to 2018, and obtains the technical efficiency, pure technical efficiency and scale efficiency.

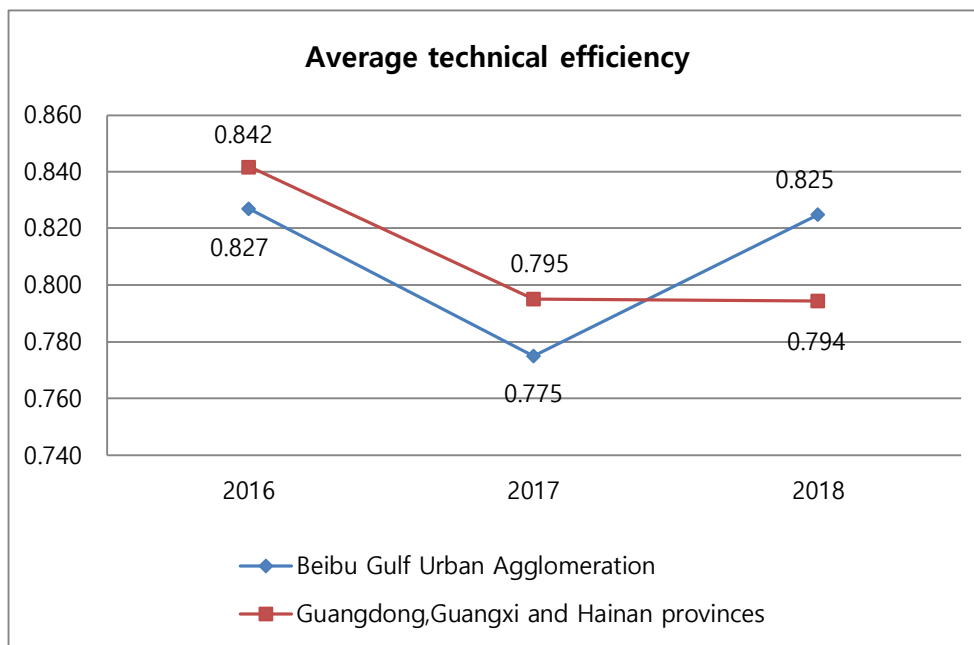
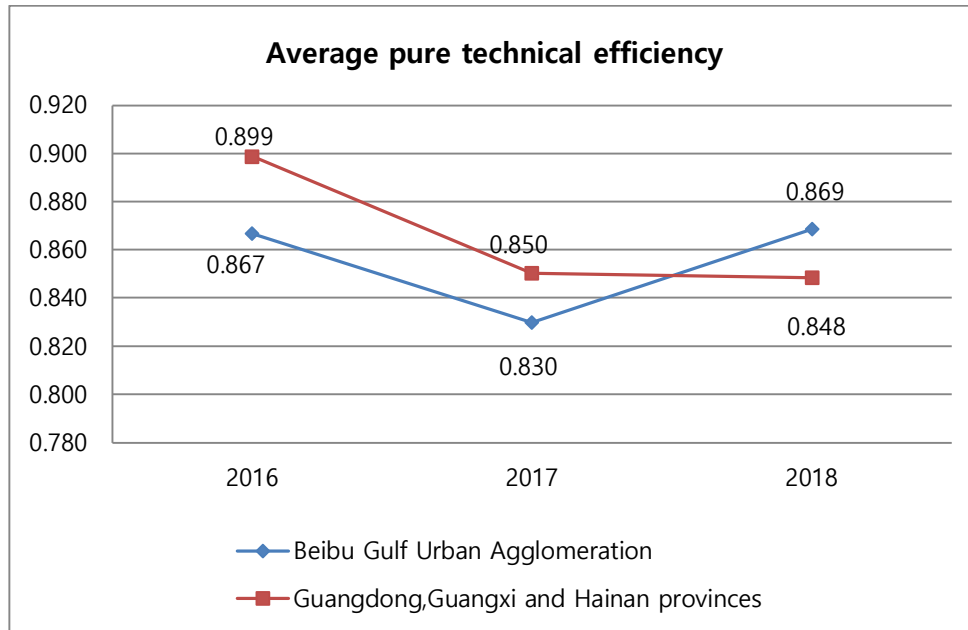


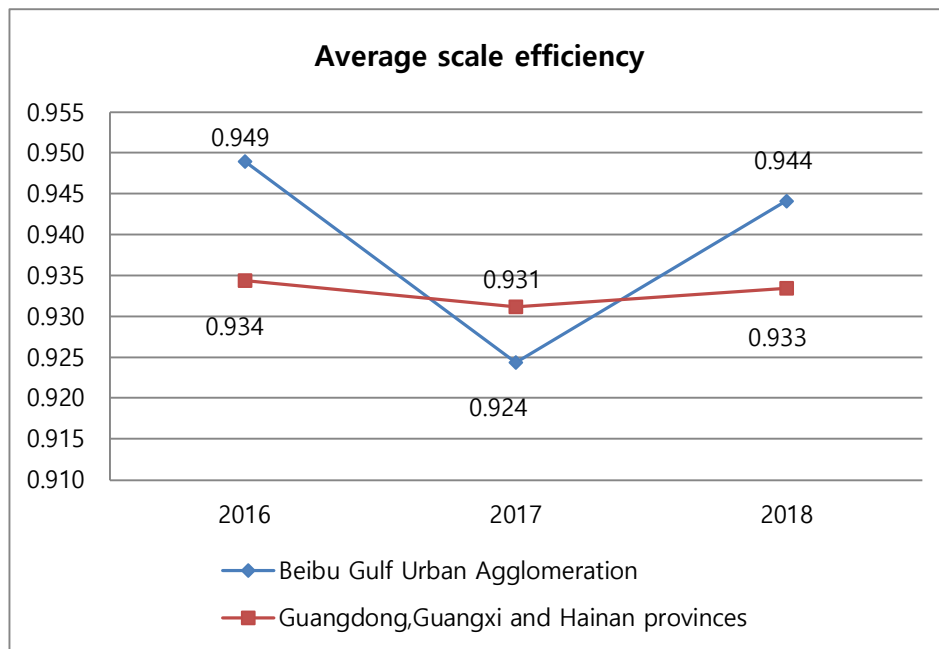
Figure 2. Average efficiency scores in tourism industry of the Beibu Gulf Urban Agglomeration and Guangdong, Guangxi, Hainan provinces from 2016-2018

It can be found from Figure 2 that the overall average efficiency scores in tourism of the Beibu Gulf Urban Agglomeration and Guangdong, Guangxi, Hainan provinces shows a trend of decreasing first and then increasing from 2016-2018, and the average technical efficiency of the Beibu Gulf Urban Agglomeration is lower than that of Guangdong, Guangxi and Hainan provinces in 2016 and 2017. The average technical efficiency of the Beibu Gulf Urban Agglomeration reached 0.825, higher than 0.794 in Guangdong, Guangxi and Hainan provinces in 2018. In general, the development momentum of tourism in the Beibu Gulf Urban Agglomeration is overall good, higher than the regional average.



**Figure 3. Average pure technical efficiency scores in tourism industry of the Beibu Gulf Urban Agglomeration and Guangdong, Guangxi, Hainan provinces from 2016-2018**

Figure3 illustrates the estimation results of the average pure technical efficiency scores in tourism industry of the Beibu Gulf Urban Agglomeration and Guangdong, Guangxi, Hainan provinces is consistent with the technical efficiency, showing the tendency declining at the beginning and rising up in late from 2016-2018, and the average pure technical efficiency of the Beibu Gulf Urban Agglomeration is lower than that of Guangdong, Guangxi and Hainan provinces in 2016 and 2017. The average pure technical efficiency of the Beibu Gulf Urban Agglomeration reached 0.869, higher than 0.848 in Guangdong, Guangxi and Hainan provinces in 2018. Thus, it can be seen that the organizational management level, tourism technology and methods within the Beibu Gulf Urban Agglomeration have been greatly improved, higher than the regional average level.



**Figure 4. Average scale efficiency scores in tourism industry of the Beibu Gulf Urban Agglomeration and Guangdong, Guangxi, Hainan provinces from 2016-2018**

Figure 4 shows that different from the trend of technical efficiency and pure technical efficiency, although the average scale efficiency scores in tourism industry of the Beibu Gulf Urban Agglomeration and Guangdong, Guangxi, Hainan provinces from 2016-2018 takes on a downward and then upward tendency, the volatility of the Beibu Gulf Urban Agglomeration is relatively flat, and the average scale efficiency of the Beibu Gulf Urban Agglomeration is higher than that of Guangdong, Guangxi and Hainan provinces in 2016 and 2018, only in 2017, the average of scale efficiency is 0.924, lower than 0.931 of Guangdong, Guangxi and Hainan provinces. In general, the large-scale development of tourism in the 15 cities of the Beibu Gulf Urban Agglomeration is relatively smooth and has certain advantages of scale. The improvement of technical efficiency mainly comes from the improvement of technical level rather than the expansion of scale.

The three mean values of efficiency reflect the overall situation of tourism between the Beibu Gulf Urban Agglomeration and the 53 cities of Guangdong, Guangxi and Hainan, but in fact there are some differences in the development of tourism among the 15 cities of the Beibu Gulf Urban Agglomeration. To be specific, the tourism efficiency of each city needs to be analyzed according to the tourism efficiency value of each city.

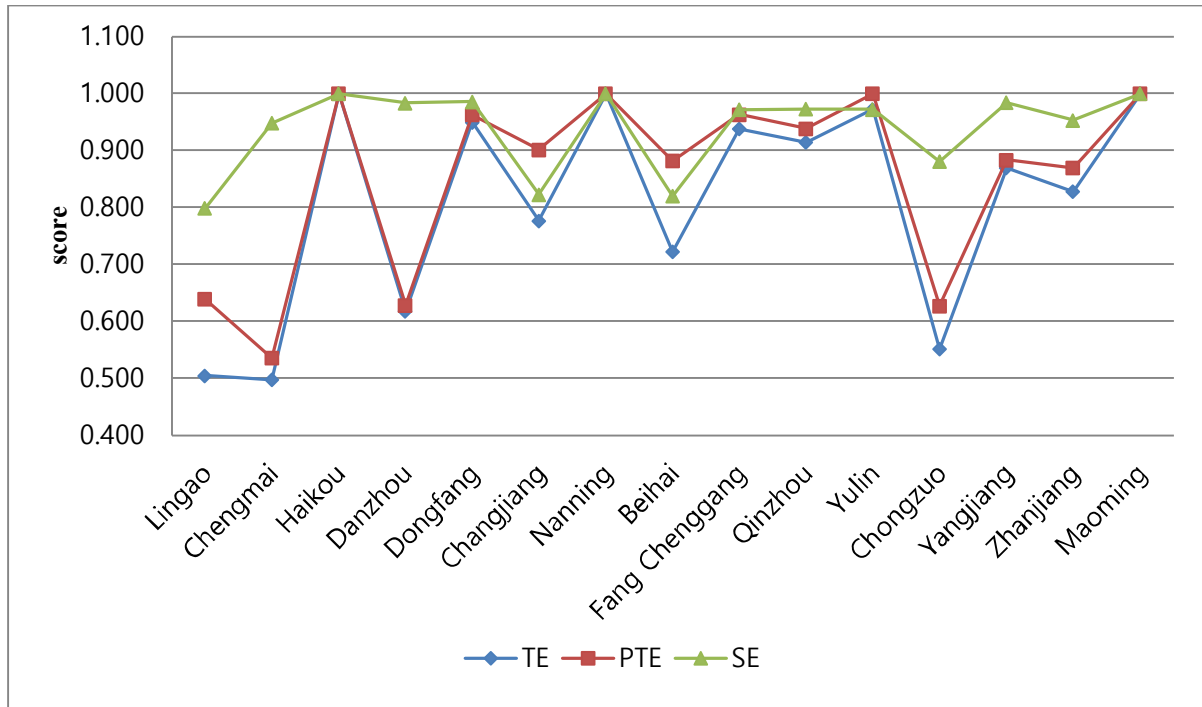
**Table 2 Three average efficiency scores in the 15cities’ tourism industry of the Beibu Gulf Urban Agglomeration**

DMU	TE	PTE	SE
Lingao	0.504	0.638	0.798
Chengmai	0.498	0.536	0.948
Haikou	1.000	1.000	1.000
Danzhou	0.617	0.628	0.983
Dongfang	0.949	0.962	0.985
Changjiang	0.776	0.901	0.822



Nanning	1.000	1.000	1.000
Beihai	0.721	0.882	0.819
Fang Chenggang	0.937	0.963	0.971
Qinzhou	0.914	0.938	0.972
Yulin	0.972	1.000	0.972
Chongzuo	0.551	0.627	0.880
Yangjiang	0.869	0.883	0.983
Zhanjiang	0.827	0.869	0.953
Maoming	1.000	1.000	1.000
AVE	0.809	0.855	0.939

Note: "DMU, TE, PTE, SE" respectively represent decision-making units, technical efficiency, pure technical efficiency and scale efficiency scores



**Figure 5. Comparison and variation trend of three average efficiency in the 15 cities' tourism industry of the Beibu Gulf Urban Agglomeration**

Table 2 and Figure 5 indicate that the average efficiency scores of tourism industry in Nanning, Maoming and Haikou is equal to 1 from 2016-2018, it means that these three cities are in the forefront of all 15 cities of the Beibu Gulf Urban Agglomeration in terms of organization, management, technical level and scale of tourism, and all the efficiencies reach the optimal level. In addition, the average efficiency of tourism in Dongfang, Fang Chenggang, Qinzhou and Yulin was all greater than 0.9, ranking in the second tier among 15 cities, among which Yulin reached 0.972, which was the closest to the forefront of efficiency. The average efficiency of tourism in other 8 cities is less than 0.9, among which Chengmai is the lowest with only 0.498.

From the perspective of pure technical efficiency, the average pure technical efficiency of Haikou, Nanning,

Maoming and Yulin from 2016 - 2018 is equal to 1, indicating that these cities are in the state of pure technical efficiency in terms of the technical level and management organization of tourism industry. In addition, the pure technical efficiency of Dongfang, Changjiang, Fang Chenggang and Qinzhou all exceeded 0.9, ranking in the second echelon of 15 cities of the Beibu Gulf Urban Agglomeration. Among them, Fang Chenggang's pure technical efficiency reached 0.963, which was the closest to the efficiency frontier. The average pure technical efficiency of tourism in other cities is less than 0.9, of which Chengmai is still the lowest with only 0.536.

The average scale efficiency in the 15 cities of the Beibu Gulf Urban Agglomeration is high overall, the average scale efficiency of Nanning, Maoming and Haikou is equal to 1, in a state of scale efficiency effective. Except that the average scale efficiency of Lingao, Changjiang, Beihai and Chongzuo is lower than 0.9, which shows that the scale efficiency of tourism is insufficient. The scale efficiency of other cities is between 0.9 and 1.0, among which Dongfang's scale efficiency is 0.985, which is the closest to scale efficiency.

#### 4.2 DEA-Malmquist analysis results

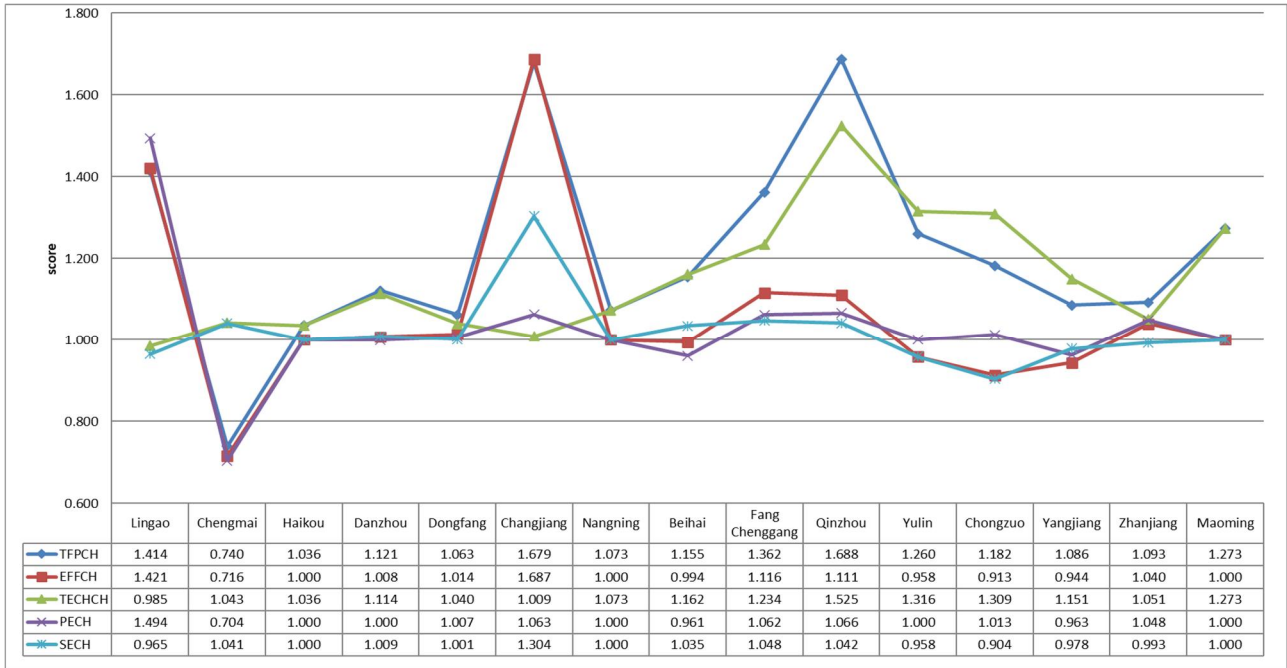
The previous part of the paper estimated the static efficiency of tourism in 53 cities of Guangdong, Guangxi and Hainan provinces, including 15 cities in the Beibu Gulf Urban Agglomeration from 2016 to 2018. In this part, the DEA-Malmquist index model is used to analyze the tourism efficiency according to the changes of the frontier from a dynamic perspective, so as to make the analysis more comprehensive and objective.

**Table 3 Annual Malmquist index of tourism efficiency in the Beibu Gulf Urban Agglomeration from 2016 to 2018**

Year	Tfpch	Effch	Techch	Pech	Sech
2016-2017	1.115	0.977	1.136	0.998	0.977
2017-2018	1.315	1.146	1.174	1.053	1.060
mean	1.215	1.061	1.155	1.025	1.019

Note: Tfpch represents total factor productivity change, Effch represents efficiency change, Techch represents technology change, Pech represents pure efficiency change, and Sech represents scale efficiency.

Based on the results in Table 3, the overall Tfpch value of tourism efficiency in the 15 cities of the Beibu Gulf Urban Agglomeration shows an increasing change from 2016 to 2018, with an increase of 11.5% from 2016 to 2017, and a higher growth rate of 31.5% from 2017 to 2018. But overall, the average growth rate in the three years reaches 21.5%. The Effch value increased at an average annual rate of 6.1%, and the Techch value increased at an average annual rate of 15.5%. Therefore, it can be concluded that technological progress is the main factor promoting the improvement of Tfpch value compared with the improvement of technical efficiency. For the overall efficiency of the tourism industry in the 15 cities of the Beibu Gulf Urban Agglomeration, it is the most urgent and critical work to improve the overall operation management level and organization level of the tourism industry.



**Figure 6. Individual Malmquist index of tourism efficiency in the Beibu Gulf Urban Agglomeration from 2016 to 2018**

Note: Tfpch represents total factor productivity change, Effch represents efficiency change, Techch represents technology change, Pech represents pure efficiency change, and Sech represents scale efficiency.

According to the data given in figure 6, it can be seen that except for the Tfpch value of Chengmai decreased by 26%, the other 14 cities showed an increasing trend (Tfpch>1) from 2016 to 2018, among which, Qinzhou experienced the largest increase, reaching 68.8%, and Lingao, Changjiang, Beihai, Fang Chenggang, Yulin, Chongzhi and Maoming all increased by more than 15%. In general, the dynamic changes of tourism efficiency vary greatly in the 15 cities of the Beibu Gulf Urban Agglomeration, but the overall growth rate is still very fast.

### 5. Conclusion

According to previously conducted analysis made by the output-oriented DEA-BBC model in the first stage and the DEA-Malmquist index in the second, the research assesses the sustainable tourism development efficiency in 53 cities of Guangdong, Guangxi and Hainan provinces, including 15 cities in the Beibu Gulf Urban Agglomeration over the period from 2016 to 2018. The main conclusions are as follows:

(1) The results in the first phase show relatively high efficiency scores, particularly in the case of the Beibu Gulf Urban Agglomeration and with room for improvement in the case of other cities of Guangdong, Guangxi and Hainan provinces. The average technical efficiency, pure technical efficiency, and scale efficiency scores of tourism efficiency in the Beibu Gulf Urban Agglomeration is higher than it in the three provinces, that means the overall level of organization and management within the tourism industry, as well as the technical means and methods of the Beibu Gulf Urban Agglomeration have been developing rapidly from 2016-2018 and still have some room for improvement.

(2) Although the overall efficiency of tourism in the Beibu Gulf Urban Agglomerations is comparatively higher, the urban tourism development is still unbalanced and different from each other among the 15 cities, the technical efficiency, pure technical efficiency and scale efficiency in Nanning during the three years are in a leading

position, which is related to its political position and the level of economic development. The tourism efficiency of Maoming and Lingao also achieves the optimal, shows that their organization and management of tourism, technology level and scale are in the forefront of the beibu gulf urban agglomeration. The average efficiency of Dongfang, Fang Chenggang, Qinzhou and Yulin are all greater than 0.9, ranking in the second echelon while the remaining 8 cities including Haikou, Danzhou, Changjiang, Beihai, Chongzuo, Zhanjiang, Yangjiang, Chengmai show a relatively low efficiency.

(3) The second stage results present several aspects that should be carefully considered in order to analysis tourism efficiency of the Beibu Gulf Urban Agglomerations vertically according to the changes of the frontier. The Tfpch value shows an overall upward trend from 2016 to 2018, which mainly due to the advance of technology. Although the growth rate of Tfpch value in most cities is relatively close, the causes in each city are not necessarily the same. Taking Qinzhou and Changjiang as examples, the dynamic efficiency increase based on the Techch rate increase of 52.5%, while in Changjiang is mainly based on the improvement of the value of Effch and Sech. Each city needs to take targeted measures to improve and optimize the tourism industry according to its own characteristics and the current situation of the industry, so as to better improve the efficiency of local tourism and promote the development of the industry.

(4) From the perspective of the division of provinces and regions, the tourism efficiency ranking of Maoming, Zhanjiang and Yangjiang in Guangdong province is relatively high, which reflects that Guangdong province has invested a lot in the development of urban tourism resources, tourism infrastructure and other tourism industry elements in recent years, and has achieved good results. In the six cities in Guangxi province, Nanning has been in a leading position due to its high political status and efficiency of economic development level of tourism, Yunlin, Qinzhou, Fang Chenggang, Beihai and Chongzuo are in the middle position, and shows obvious rising trend, that these cities have relatively strong social economic foundation strength, provide the strong support of the development of the tourism industry. Besides Haikou, the other cities and counties (Dongfang, Lingao, Danzhou, Chengmai and Changjiang) in Hainan province are all located along the beibu Gulf in the west, and belong to the regions with late tourism development, relatively low development level and administrative level. Therefore, all tourism efficiency is in the lower reaches. For cities of lower level and small scale, they should focus on regional cooperation to improve tourism efficiency in the future, strengthen cooperation with Haikou in resource development, route building, publicity and promotion, and sharing of tourists, and actively promote regional tourism integration construction, so as to achieve the overall enhancement of regional tourism competitiveness.

As so far, it should be noted that the results of the efficiency obtained by utilizing the DEA method are relative measurements and that there are other controlled and uncontrolled factors. For instance, due to the constraints of data availability, this paper selects the number of employment in catering and accommodation industry to replace the number of direct employment in tourism, which reduces the number of actual tourism practitioners. However, as tourism is a comprehensive industry with strong correlation, it can also explain the problem to some extent. In addition, only 3 years of panel data are used in this paper, which has a short time span and some limitations, so it needs further study and improvement.

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