Evaluation of Tourism Efficiency in Jiangsu Province Based on Three-stage DEA Model and Malmquist Index Model

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Abstract. This paper innovatively uses a three-stage DEA model in combination with the Malmquist index to assess the tourism development efficiency and situation of municipalities in Jiangsu Province from 2016-2019 in both a cross-sectional and vertical comparison perspective. The results showed that: all cities in Jiangsu Province are in the state of increasing scale payoff or efficiency frontier surface, total factor productivity is almost all greater than 1, the tourism industry as a whole is developing well, and management inefficiency is the main factor that restricts the further development of tourism. The tourism industry in southern Jiangsu [1] is in a highly de- veloped and mature stage, with high tourism efficiency, and tourism development is more closely related to technological progress; the tourism industry in central Jiangsu[2]and northern Jiangsu[3] is in a rapidly developing and rising stage, with low tourism efficiency but rapid development, and tourism development is more closely related to technological and management efficiency.

Keywords: Three-stage DEA model, Malmquist index model, tourism.

1. Introduction

Since the reform and opening up, China's economic take-off and the improvement of people's lives have led to the rapid development of tourism. Tourism is a key showcase for the external image of many cities and an important means of boosting the economy, and efficient tourism is closely associated with cities improving the visitor experience, optimizing resource scheduling, and saving inefficient resources. However, the development of local tourism is prone to inefficient and sloppy growth, which can lead to a waste of tourism resources. To avoid local tourism from falling into misconceptions and to achieve sustainable tourism development and efficiency, an evaluation of local tourism efficiency and development is needed.

Charnes, Cooper and Rhodes proposed a data envelopment analysis method to evaluate the relative effectiveness of multiple decision units in 1978; RolfFäre et al. combined the Malmquist index with DEA in 1994 to achieve a comparison of the efficiency of each of the same decision units in different years [1]; Fried proposed in 2002 a three-stage DEA approach to efficiency evaluation model, dividing the redundant part of inputs or outputs into three major parts: management inefficiency factors, environmental factors, and stochastic factors, pointing out that it should be necessary to consider management inefficiency factors and eliminate the influence of environmental and stochastic factors, and use the adjusted input or output DEA model to evaluate the relative efficiency [2].

After the introduction of the three-stage DEA model and the Malmquist index method to China, Chinese scholars used them to develop relevant results on tourism efficiency and obtained fruitful results. Yang Tunan et al. used the three-stage DEA model to analyze the innovation efficiency of 35 national high-tech zones in three major eastern city clusters in China in 2019 [3]; Li Qiong et al. used the three-stage DEA model to measure the efficiency of urban public transport operations in 36 central cities in China from 2016 to 2019 [4]. Liu Dan et al. combined the DEA model with Malmquist index to evaluate the cultural tourism industry in Sichuan Province from 2015-2019 [5]; Hou Jing used the

[1] Southern Jiangsu refers to the five cities of Nanjing, Wuxi, Changzhou, Suzhou and Wuxi, the same below
[2] Central Jiangsu refers to the three cities of Datong, Yangzhou and Taizhou, the same below
[3] North Jiangsu refers to the five cities of Xuzhou, Lianyungang, Huaian, Yancheng and Suqian, the same below

DEA-Malmquist index model to measure and evaluate the allocation efficiency of science and technology resources in prefecture-level cities in Hebei Province from 2015-2019 [6].

Jiangsu Province is one of the most economically active provinces in China and has the highest number of historical and cultural cities, towns and neighborhoods in the country. Tourism is an important economic pillar in Jiangsu Province, so there is a greater need for high quality and efficient tourism development. This paper uses a three-stage DEA model and combines it with the Malmquist index to evaluate the efficiency of municipalities in Jiangsu Province from 2016-2019 and dissect the reasons for changes in tourism efficiency in each municipality as a reference for decision-making by relevant government units.

2. Model preparation and variable selection

2.1. Three-stage DEA model foundation

The three-stage DEA model was proposed by Fried et al. in 2002 to find the regression relationship between input or output redundant components and environmental variables by means of the model idea and regression equation of SFA regression, and then to separate management inefficiency factors, environmental factors and random factors and remove the latter two in order to eliminate uncontrollable factors on efficiency evaluation [2]. The process of constructing the model and its rationale are described as follows.

First, the original inputs and outputs are substituted into the traditional DEA model to obtain the slack variables for each decision unit. In this paper, we focus on the efficiency evaluation of tourism in municipalities in Jiangsu province and choose the envelope-type input- oriented BCC model.

The DEA model in the first stage cannot eliminate the influence caused by environmental factors and random factors, so it is necessary to separate environmental factors and random factors in the second stage with the idea of SFA regression.

Suppose there are N decision units, each with M inputs, and a total of K environmental variables. Let K environmental variables be z1,... ,zK, and the input vector xn of the nth decision cell is (xn1, xn2, ..., xnM), the target input vector Xn is (Xn1, Xn2, ..., XnM), then its relaxation variable sn = xn $\bar{X}n\lambda$ is decomposed in the form: sni = fn(zi)+vni +uni, where vni is a random disturbance term obeying a normal distribution with mean 0, uni is a management inefficiency term obeying a half-normal distribution with mean 0 , the two are independent of each other, and fn is the environment-valued function.

In this paper, we choose t-values to test the regression relationship between slack variables and environmental factors and calculate the environmental factors, using the formula proposed by Jondrow et al. in 1982 to calculate the managerial inefficiency factors and subsequently obtain the stochastic factors. Next, assuming that all decision units are in the worst case among them after removing the uncontrollable factors, adjustments are made to each input term of each decision unit accordingly. The adjusted xni is the input that includes the management inefficiency factor but excludes the environmental factor and the random factor.

Finally, in the third stage, the adjusted xni is re-substituted into the DEA model used in the first stage, and the efficiency value estimated by the DEA method is then the efficiency after eliminating the environmental and random factors.

2.2. Malmquist Index Model Basis

The three-stage DEA model achieves cross-sectional comparison of the relative efficiency of different decision units at the same point in time with the exclusion of uncontrollable factors, but it does not enable vertical comparison of the same decision unit at different points in time. Therefore, in order to portray the dynamic changes of tourism efficiency in each city of Jiangsu province, the DEA-Malmquist index model [1] proposed by FareR. et al. in 1994 was chosen. The model is based on the following principle.

Suppose the input vector of a decision unit in period t is xt and the output vector is yt, and let $D^{t1}(x^{t2},y^{t2})$ be the distance between the input and output of this decision unit in period t1 and the frontier surface in period t2, then in the environment of period t and period t+1, the Malmquist index is defined as :

$$M^t = \frac{D^t(x^{t+1}, y^{t+1})}{D^t(x^t, y^t)} \tag{1}$$

$$M^{t+1} = \frac{D^{t+1}(x^{t+1}, y^{t+1})}{D^{t+1}(x^t, y^t)} \tag{2}$$

The definition uses the geometric mean of M^t and M^{t+1}, $M_0(x^t, y^t, x^{t+1}, y^{t+1})$, the total factor production index (Tfpch), reflecting the combined change in the efficiency of this decision unit in period t+1, relative to period t.

On the basis of equation (6), $M_0(x^t, y^t, x^{t+1}, y^{t+1})$ is decomposed into the following form.

$$M_0(x^t, y^t, x^{t+1}, y^{t+1}) = \frac{D^{t+1}(x^{t+1}, y^{t+1})}{D^t(x^t, y^t)} \times \sqrt{\frac{D^t(x^t, y^t)}{D^{t+1}(x^t, y^t)} \times \frac{D^t(x^{t+1}, y^{t+1})}{D^{t+1}(x^{t+1}, y^{t+1})}} \tag{3}$$

The first term on the right-hand side of the above equation reflects the distance of the decision unit from the production frontier in period t+1 compared to period t, i.e., the technical efficiency change index (Effch); the second term reflects the movement of the production frontier in period t+1 compared to period t, i.e., the technical progress change index (Tech). In addition, under the premise of variable returns to scale, Effch can be further decomposed into a pure technical efficiency change index (Pech) and a scale efficiency change index (Sech), which are combined to judge the components of Effch.

2.3. Data source and variable selection

The article considers the tourism industry of 13 municipalities in Jiangsu Province as the decision object, and the data sample interval is 2016-2019. Considering the accuracy and avail- ability of indicators, the data used in the article are from the statistical yearbook of Jiangsu Province from 2017-2021. The article explains the selection of each indicator as follows.

Revenue earned from tourism is a direct criterion to evaluate the effectiveness of regional tourism, so it is chosen as an indicator to portray the output of tourism. In addition, considering that the foreign exchange income generated by tourism is small and the exchange rate changes from time to time, foreign exchange income from tourism is not considered.

Labor, capital and land resources are important reference perspectives for selecting input variables, and the article selects input indicators [7][8] with these three major starting points. For labor, Jiangsu Provincial Bureau of Statistics does not count the number of people employed in tourism, so the number of travel agencies is chosen as a substitute; for land resources, the number of scenic spots can fully represent the tourism resources owned by the region, and the article refers to the quantification method proposed by Yang Chunmei (2014) et al. in their paper, assigning a score of 10 points to 5A scenic spots, 7 points to 4A scenic spots, and 5 points to 3A scenic spots, and using the scoring The cumulative results are involved in the model calculation; considering the fact that the development of tourism industry depends more on the cultural heritage and historical accumulation of the region, and it is difficult to change the status quo with capital investment in a short period of time, the article does not look for input indicators in terms of capital.

In order to ensure the full correlation between input and output indicators, MATLAB 2020a software is used and Spearman correlation test [9] is selected, and the results are shown in Table 1.

Table 1: Spearman's correlation test results

	tourism revenue	number of travel agencies	scenic spot ratings
Tourism revenue	1.0000	0.7918***	0.4167***
Number of travel agencies	0.7918***	1.0000	0.7197***
Scenic Area Rating	0.4167***	0.7197***	1.0000

notes:*** indicates that the p-value is significant at the 0.01 level of significance. The correlation coefffficients of input variables and output variables are positive and all pass the test at 0.01 significance level, indicating that the input-output index is consistent with the principle of "isotropy" and is reasonable.

The external environment of regional tourism mainly includes the endogenous tourism drive of the region and the external financial support [10]. On the one hand, residents' income is an important factor driving the development of regional tourism and tapping the potential tourism potential, and the article chooses residents' disposable income to measure it; on the other hand, government investment in cultural and tourism media and other aspects is the main source of external financial support. Jiangsu Provincial Bureau of Statistics does not have statistics on government expenditures on cultural tourism and media, so the article chooses government expenditures on cultural tourism sports and media for estimation.

3. Results and Analysis

3.1. Empirical results of three-stage DEA model

3.1.1. Stage one

Using DEAP2.1 software, the state of tourism efficiency level and scale payoffs in each city of Jiangsu Province from 2016-2019 were analyzed, and the results are shown in Table 2.

Table 2: stage 1 empirical test results

2016	Nanjing	Wuxi	Xuzhou	Changzhou	Suzhou	Nantong	Lianyungang	Huai'an	Yancheng	Yangzhou	Zhenjiang	Taizhou	Suqian	Average
hline crste	1	1	0.362	1	0.942	0.468	0.436	0.408	0.234	0.605	1	0.305	0.249	0.616
vrste	1	1	0.506	1	1	0.655	0.857	0.969	0.67	0.78	1	0.816	1	0.866
scale	1	1	0.716	1	0.942	0.715	0.509	0.421	0.347	0.776	1	0.374	0.249	0.696
	-	-	irs	-	drs	irs	irs	irs	irs	-	irs	irs		
2017	Nanjing	Wuxi	Xuzhou	Changzhou	Suzhou	Nantong	Lianyungang	Huai'an	Yancheng	Yangzhou	Zhenjiang	Taizhou	Suqian	Average
hline crste	1	1	0.387	0.968	0.933	0.482	0.493	0.414	0.26	0.649	0.326	0.281	0.630	0.387
vrste	1	1	0.5	0.969	1	0.655	0.863	0.975	0.659	0.74	1	0.861	1	0.863
scale	1	1	0.774	0.999	0.933	0.736	0.571	0.425	0.394	0.878	0.379	0.281	0.721	0.774
	-	-	irs	drs	drs	irs	irs	irs	irs	-	irs	irs		
2018	Nanjing	Wuxi	Xuzhou	Changzhou	Suzhou	Nantong	Lianyungang	Huai'an	Yancheng	Yangzhou	Zhenjiang	Taizhou	Suqian	Average
hline crste	1	1	0.423	0.973	0.913	0.472	0.526	0.431	0.31	0.664	1	0.342	0.288	0.642
vrste	1	1	0.508	0.975	1	0.632	0.874	0.964	0.683	0.705	1	0.849	1	0.861
scale	1	1	0.833	0.998	0.913	0.746	0.602	0.448	0.453	0.942	1	0.402	0.288	0.740
	-	-	irs	drs	drs	irs	irs	irs	irs	-	irs	irs		
2019	Nanjing	Wuxi	Xuzhou	Changzhou	Suzhou	Nantong	Lianyungang	Huai'an	Yancheng	Yangzhou	Zhenjiang	Taizhou	Suqian	Average
hline crste	1	1	0.991	0.477	0.946	0.862	0.461	0.585	0.484	0.345	0.707	0.37	0.33	0.658
vrste	1	1	1	0.539	0.951	1	0.611	0.89	0.916	0.68	0.715	0.861	1	0.861
scale	1	1	0.991	0.884	0.995	0.862	0.754	0.657	0.512	0.507	0.99	0.43	0.33	0.762
	-	drs	irs	drs	drs	irs	irs	irs	irs	-	irs	irs		

The results of the first stage of analysis show that the average value of pure technical efficiency for the four years from 2016-2019 increases year by year, and the average value of scale efficiency decreases slightly, the tourism industry in the southern part of Jiangsu Province is mature, close to or at the efficiency frontier surface, and the tourism industry in the central and northern part of Jiangsu Province is developing rapidly, all of which are in a state of increasing scale payoff. However, due to the interference of uncontrollable factors including environmental factors and random factors, this result cannot accurately respond to the tourism efficiency of each prefecture-level city and cannot be taken as the final evaluation result.

3.1.2. Second stage

The slack variables of each decision unit from 2016-2019 were derived in the first stage as the explained variables, and the two environmental variables were standardized as the explanatory variables, and the data of four years were combined and imported into Frontier 4.1 software for regression analysis, and the results are shown in Table 3.

Table 3: SFA regression results

	number of travel agents slack variable	scenic area rating slack variable
Constant term	-4.69	-10.84*
Resident income	39.17***	62.65***
Government input	-39.84***	-51.00***
δ^2	1481.45***	4273.43***
γ	1.00***	1.00***
LR	6.15**	5.95**

Note: ** indicates that the p-value is significant at 0.05 significant level, *** indicates that the p-value is

Significant at 0.01 significant level.

From the above table, it can be seen that all the variables have significant effects on the explanatory variables at the 0.01 significant level, except for the constant term which is less significant for the two slack variables, which indicates that there is a significant effect of external environmental variables on input redundancy in tourism. Meanwhile, the γ values of the two slack variables are very close to 1 and both pass the significance test, indicating the dominant influence of management inefficiency factors on input redundancy.

3.1.3 Third stage

According to the results calculated in the second stage, the input variables of each decision unit from 2016-2019 were adjusted, and the four-year pre-adjusted and adjusted inputs and raw outputs were combined back to the DEAp2.1 software to obtain the efficiency values and the payoff state of scale for each decision unit in the third stage and compared, and the results are shown in Table 4.

Table 4: stage 3 empirical test results

Before adjustment	Nanjing	Wuxi	Xuzhou	Changzhou	Suzhou	Nantong	Lianyungang	Huai'an	Yancheng	Yangzhou	Zhenjiang	Taizhou	Suqian	Average
hline crste	1	1	0.362	1	0.942	0.468	0.436	0.408	0.234	0.605	1	0.305	0.249	0.616
vrste	1	1	0.506	1	1	0.655	0.857	0.969	0.67	0.78	1	0.816	1	0.866
scale	1	1	0.716	1	0.942	0.715	0.509	0.421	0.347	0.776	1	0.374	0.249	0.696
Rank	1	1	4	1	2	5	6	7	9	3	1	8	10	
	-	-	irs	-	drs	irs	irs	irs	irs	-	irs	irs		
Adjusted	Nanjing	Wuxi	Xuzhou	Changzhou	Suzhou	Nantong	Lianyungang	Huai'an	Yancheng	Yangzhou	Zhenjiang	Taizhou	Suqian	Average
hline crste	1	1	0.386	0.883	1	0.479	0.456	0.405	0.253	0.626	0.925	0.299	0.275	0.614
vrste	1	1	0.55	0.951	1	0.7	0.871	1	0.704	0.825	1	0.819	1	0.878
scale	1	1	0.703	0.928	1	0.684	0.524	0.405	0.36	0.758	0.925	0.365	0.275	0.687
Rank	1	1	5	2	1	6	7	8	10	4	3	9	11	
	-	-	irs	irs	-	irs	irs	irs	irs	irs	irs	irs	irs	

Based on the results of data comparison, the following conclusions are obtained.

(1)From the perspective of the overall situation in Jiangsu Province, the ranking of tourism industry efficiency values in various cities in Jiangsu Province basically does not change, regard- less of before and after adjustment, and it is considered that the efficiency evaluation results obtained through the three-stage DEA model are relatively accurate and stable, and there is basically no problem of environmental over-exploitation and resource overuse in various cities, and the management inefficiency factor is the main factor that restricts the improvement of tourism industry efficiency.

(2)From the perspective of regional situation, the tourism industry efficiency in southern Jiangsu province is always in the top five and significantly higher than that in central and northern Jiangsu province before and after the adjustment, and it is believed that the tourism industry in southern

Jiangsu province is mature and relatively more efficient than that in central and northern Jiangsu province.

(3)From the perspective of city situation, Changzhou and Zhenjiang exit from the efficiency frontier after adjustment, and Xuzhou, Nantong, Huai'an, Yangzhou and Taizhou decrease in tourism efficiency after adjustment, indicating that the tourism efficiency of these cities is influenced by relatively favorable external environment and may have problems of rough growth and short-sighted development; Suzhou enters the efficiency frontier after adjustment, and Lianyungang, Yancheng and Suqian cities increase in tourism efficiency after adjustment. Tourism efficiency values rose, indicating that the external environment in which these cities are located is relatively poor. Nanjing and Wuxi are in the efficiency frontier plane before and after the adjustment, indicating that the external environment of Nanjing and Wuxi continues to be favorable and the tourism industry is mature.

(4)From the perspective of pure technical efficiency and scale technical efficiency, except Changzhou, the adjusted scale efficiency values of all cities in Jiangsu Province are not lower than those before the adjustment, and all cities in Jiangsu Province that are not on the efficiency frontier after the adjustment are in the state of increasing scale payoffs.

3.2. Empirical results of Malmquist index model

The adjusted input and output data obtained from the three-stage DWA model were substituted into the DEAP2.1 software, and the Malmquist index was calculated for the tourism-related data of cities in Jiangsu Province from 2016-2019, and the results are shown in Table 5.

Table 5: Empirical results of Malmquist index model

year=1	Nanjing	Wuxi	Xuzhou	Changzhou	Suzhou	Nantong	Lianyungang	Huai'an	Yancheng	Yangzhou	Zhenjiang	Taizhou	Suqian	Average
effch	1	1	1.094	0.97	1	1.017	1.118	1.029	1.101	1.064	1.002	1.079	1.069	1.041
tech	1.101	1.035	1.042	1.068	1.072	1.071	0.998	1.073	0.998	0.998	1.072	1.073	0.998	1.046
pech	1	1	1.031	0.97	1	1.024	1.027	1	0.992	0.961	1	1.051	1	1.004
sech	1	1	1.061	1.001	1	0.994	1.089	1.029	1.109	1.107	1.002	1.026	1.069	1.037
tfpch	1.101	1.035	1.14	1.037	1.072	1.09	1.116	1.103	1.099	1.062	1.074	1.158	1.067	1.088
year=2	Nanjing	Wuxi	Xuzhou	Changzhou	Suzhou	Nantong	Lianyungang	Huai'an	Yancheng	Yangzhou	Zhenjiang	Taizhou	Suqian	Average
effch	1	1	1.084	1.011	1	0.999	1.058	1.061	1.183	1.031	1.009	1.054	1.009	1.037
tech	1.055	1.059	1.036	1.083	1.091	1.082	1.036	1.052	1.036	1.036	1.082	1.037	1.036	1.055
pech	1	1	1.025	1.016	1	0.989	1.023	1	1.039	0.981	1	1.01	1	1.006
sech	1	1	1.058	0.995	1	1.01	1.034	1.061	1.139	1.051	1.009	1.044	1.009	1.031
tfpch	1.055	1.059	1.123	1.095	1.091	1.081	1.096	1.116	1.226	1.068	1.092	1.093	1.045	1.094
year=2	Nanjing	Wuxi	Xuzhou	Changzhou	Suzhou	Nantong	Lianyungang	Huai'an	Yancheng	Yangzhou	Zhenjiang	Taizhou	Suqian	Average
effch	1	1	1.146	1.02	1	1.064	1.135	1.127	1.137	1.064	1.038	1.087	1.215	1.078
tech	1.017	1.003	0.974	1.01	0.999	1.025	0.974	0.974	0.974	0.974	0.974	1.024	0.974	0.992
pech	1	1	1.063	0.974	1	1.012	1.019	0.986	0.982	1.008	1	1.028	1	1.005
sech	1	1	1.079	1.047	1	1.052	1.114	1.142	1.158	1.056	1.038	1.058	1.215	1.072
tfpch	1.017	1.003	1.116	1.03	0.999	1.09	1.105	1.098	1.108	1.037	1.063	1.059	1.183	1.069

Based on the results of data comparison, the following conclusions are obtained.

from the perspective of total factor productivity, according to the data in the above table, from 2016-2019, the average value of tfpch of all cities in Jiangsu Province is 1.08366, and it is believed that tourism in Jiangsu Province maintains a positive development trend in general, growing at an average growth rate of 8.37%; the tfpch values of all cities in Jiangsu Province are almost all greater than 1, and it is believed that the tourism performance of all cities in Jiangsu Province continues to improve.

from the perspective of technical efficiency index and technical change index, from 2016- 2019, the average value of effech of cities in Jiangsu province is 1.052 and the effech value of cities is steadily higher than 1, and the average value of tech is 1.031 but fluctuates, and there is an anomaly of technical regression in 2018-2019, it is believed that the progress of technical efficiency and technical progress on Jiangsu province both have a better effect on the improvement of tourism industry efficiency, but the stable technical efficiency progress is the main factor to promote the improvement of tourism industry efficiency in Jiangsu province from 2016-2019.

In order to obtain the tourism development and influencing factors in southern, central and northern Jiangsu Province, the relevant indices from 2016-2019 are averaged and the collated data are shown in Table 6.

Table 6: Malmquist index of southern, central and northern Jiangsu regions

	effch	tech	pech	sech	tfpch
Sunan	1.015	1.045	1.003	1.011	1.060
Suzhou Central	1.032	1.040	0.997	1.035	1.073
	1.095	1.017	1.013	1.081	1.113

Based on the results of data comparison, the following conclusions are obtained.the lowest values of effech, sech and tfpch in southern Jiangsu, combined with the actual situation of developed economy and rich tourism resources in southern Jiangsu, it is believed that the tourism industry in southern Jiangsu has been gradually developed and matured, and the improvement of tourism technology and management efficiency is less helpful to the development of tourism; the highest value of tech is believed that the continued breakthrough of tourism in southern Jiangsu mainly relies on technological progress to achieve. Therefore, the southern Jiangsu region should continue to adhere to innovative technology and continue to break through the bottleneck of tourism development by virtue of technological progress, thus bringing greater income generation to the region.

The effch, tech, sech and tfpch values of the central Jiangsu region are in the middle of the range, and combined with the fact that the economic development and tourism resources of the central Jiangsu region are between those of the southern and northern Jiangsu regions, it is believed that the tourism industry in the central Jiangsu region is basically in the rising stage, and improving tourism technology and management efficiency or achieving technological progress can help the development of the tourism industry in the central Jiangsu region. Therefore, each prefecture-level city in the central Jiangsu region should make a choice taking into account the actual local situation.

The highest values of effch, sech, and tfpch in northern Jiangsu, combined with the actual situation of lower economic conditions and lower visibility in northern Jiangsu, suggest that tourism in northern Jiangsu is still in the rising stage of vigorous development, and that improving tourism technology and management efficiency can play a significant role in the con- tinued development of tourism; the lowest value of tech suggests that technological progress is a priority for tourism development in northern Jiangsu is low and its benefits are relatively insuf- ficient. In conclusion, the northern Jiangsu region should insist on optimizing the technical and management efficiency of tourism industry, and vigorously explore the local tourism potential to promote tourism development.

4. Summary

The article uses the three-stage DEA model and Malmquist index model, respectively, to analyze the tourism industry efficiency of 13 municipalities in Jiangsu Province from 2016 to 2019, both horizontally and vertically, and measure the relative efficiency and development of tourism in each municipality under the premise of excluding environmental factors and random factors. The results are summarized as follows.

2016-2019, the tourism industry efficiency in Jiangsu Province maintained a positive development trend in general, with insignificant changes in efficiency values and rankings before and after adjustment, a low tendency of sloppy growth and short-sighted development, and purely technical efficiency factors such as management inefficiency as the main factors limiting the improvement of tourism industry efficiency in Jiangsu Province.

2016-2019, the efficiency of tourism industry in Jiangsu cities depends on fluctuating pure technical efficiency values, and tourism development is mainly attributed to stable tech- nical efficiency progress. The tourism industry in the southern Jiangsu region is in a highly developed mature stage, the tourism industry is highly efficient and tends to be saturated, and technical progress

is its bottleneck to achieve further improvement in tourism efficiency; the central and northern Jiangsu regions are in a rapidly developing rising stage, the tourism industry is less efficient and developing rapidly, and both improving technical efficiency and achieving technical progress can promote further improvement in tourism efficiency.

2016-2019, Nanjing and Wuxi have continued favorable environmental factors and stable and relatively healthy tourism development; Changzhou, Zhenjiang, Xuzhou, Nantong, Huai'an, Yangzhou and Taizhou cities have excessively favorable environmental factors and may have problems such as rough growth; Suzhou, Lianyungang, Yancheng and Suqian cities have rela- tively unfavorable environmental factors and may have problems such as relatively insufficient degree of resource development and utilization.

The article evaluates the relative efficiency and development of tourism in various cities in Jiangsu Province from 2016-2019 through a three-stage DEA model and Malmquist index model, and draws informative and valid analytical conclusions for local governments at all levels to refer to when making development decisions and policy formulation.

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