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Analysis on the Business Efficiency of Star-rated Hotels in Hubei Province Based on DEA-Malmquist Model*

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***Abstract*—This paper has constructed DEA-Malmquist index model and empirically analyzed the business efficiency of star-rated hotels in Hubei Province from 2010 to 2017. The conclusions are as follows: the DEA of star-rated hotels in Wuhan City and Qianjiang City is effective, and their star-rated hotels operate best; the investment scale of star-rated hotels in Hubei Province is basically moderate; but in order to improve the comprehensive efficiency, it is needed to attach importance to enhancing the management level and innovating the management system; the total factor productivity index in all cities (autonomous prefectures) fluctuates significantly, which is mainly affected by the technological progress change index. Therefore, the application of high and new technology should be vigorously promoted.**

Keywords—star-rated hotels; business efficiency; DEA; Malmquist index

I. INTRODUCTION

With the implementation of strategies of "rise central China" and "Yangtze River Economic Zone" and the consolidation of transportation hubs, the tourism attraction of Hubei Province has been increasing. As an important part of the tourism industry, star-rated hotels represent the tourism reception capacity and reflect the level of tourism development. The number of star-rated hotels in Hubei Province decreased from 455 in 2010 to 364 in 2017, with overall losses and generally low development quality. Therefore, we should construct a DEA model to measure the business efficiency of star-rated hotels from the perspective of input and output and explore its evolution rules, which will cast an important practical significance for improving the development quality of star-rated hotels, promoting the business efficiency of regional tourism enterprises, changing the development mode of tourism industry and heightening the tourism competitiveness of Hubei Province.

II. RESEARCH METHODS

Efficiency research methods mainly include stochastic frontier analysis (SFA) and data envelopment analysis (DEA). SFA method is a parametric model, which generally requires the determination of the functional relationship between variables in advance. The DEA method belongs to non-parametric model, and there is no need to set the functional relationship between input and output indicators in advance, which not only can avoid the mistakes caused by subjective factors but also decompose the efficiency. Therefore, this paper chooses the DEA method.

The DEA (Data Envelopment Analysis, DEA for short) method was used to evaluate the relative effectiveness between departments proposed by famous operational research experts A.Charnes, W.W.Cooper and E.Rhodes in 1978. It mainly includes CCR model with constant returns to scale and BCC model with variable returns to scale. Considering that the analysis of pure technical efficiency and scale efficiency is more conducive to the analysis of the specific reasons for the inefficiency of DEA, this paper adopts the BCC model.

Min θ, θ is unconstrained.

$$s.t\begin{cases}\sum_{j=1}^{n}\lambda x_{ij}+S_i^-=\theta x_{i0}\\ \sum_{j=1}^{n}\lambda_j y_{rj}-S_r^+=y_{r0}\\ \lambda_j\geq 0,\ j=1,2,\cdots n,\ S_i^-\geq 0,\ S_r^+\geq 0\end{cases}$$

In the formula, the i type of input in the jth decision-making unit, DMUj, is xij; the r type of output in the jth decision-making unit is yrj; xi0 and yr0 are the input and output values corresponding to the DMUj0; θ is the target value; λj is decision-making unit; S_i^- and S_i^+ are the relaxation variables of the input and output respectively.

Among it, when $\theta \in [0, 1]$, and $\theta=1$, and $S_i^+=0$ and $S_i^-=0$, DMU is relatively effective; when $\theta=1$, $S_i^+\neq 0$ or $S_i^-\neq 0$, DMU is weakly effective; when $\theta<1$, DMU is non-effective.

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Due to the fact that the BCC model can only measure cross section data, Caves, et al, put forward the Malmquist productivity index in 1982 to measure panel data. In order to compare the changes of DMU productivity in different periods, Fare, et al, combined it with DEA in 1994 to measure the growth changes of total factor productivity (Tfp). The total factor productivity (Tfp) index can be decomposed into technology efficiency change (Eff) index and technology progress (Tech) index. Technology efficiency change (Eff) index can be divided into pure technology efficiency change (Pe) and scale efficiency change (Se) index.

$$m_{v,0}(y_{t+1}, x_{t+1}, y_t, x_t) = \frac{d_v^{t+1}(x_{t+1}, y_{t+1})}{d_v^t(x_t, y_t)} \times \left[\frac{d_v^t(x_t, y_t)}{d_0^t(x_t, y_t)} / \frac{d_v^{t+1}(x_{t+1}, y_{t+1})}{d_0^t(x_{t+1}, y_{t+1})} \right] \times \left[\frac{d_0^t(x_{t+1}, y_{t+1})}{d_0^{t+1}(x_{t+1}, y_{t+1})} \times \frac{d_0^t(x_t, y_t)}{d_0^{t+1}(x_t, y_t)} \right]^{1/2}$$

$$Tfp = Eff \times Tech = Pe \times Se \times Tech$$

If the Tfp index is greater than 1, it indicates that the level of total factor productivity increases; if the Tfp index is less than 1, it shows that the total factor productivity decreases. A change rate that constitutes the index is greater than 1, which shows that it is the root of the improvement of production efficiency level; a change rate that constitutes the index is less than 1, which shows that it is the root cause of the decrease of production efficiency.

III. EMPIRICAL ANALYSIS

A. Index System and Data Sources

The measurement of business efficiency of star-rated hotels based on the DEA model requires scientific and reasonable input and output indexes. The original value of fixed assets can better reflect the capital investment of star-rated hotels; the number of employees at the end of the year can preferably show the human capital investment of star-rated hotels; the number of hotel rooms can better reveal the construction scale investment of star-rated hotels; The business income of star-rated hotels is composed of room income, catering income and other income, which can indicate the income of star-rated hotels better. The average occupancy rate is the percentage of the number of rooms rented to the total number of rooms available for rent, which can better reflect the rental situation of star-rated hotels. Learning from the existing literature on the business efficiency of star-rated hotels, and in light of model requirements and data availability, this paper selects the original value of fixed assets, the number of employees at the end of the year and the number of hotel rooms as input indexes, and business income and average occupancy rate of star-rated hotels as output indexes, and finally determines the input-output index system.

Considering the continuity and completeness of data, this paper chooses 15 cities (autonomous prefectures) in Hubei Province (except Xiantao City and Tianmen City) as decision-making unit (DMU), which meets the requirement that the number of decision-making units should be more than twice the sum (product) of the number of input and output indexes. This paper mainly studies the business efficiency of star-rated hotels in Hubei Province from 2010 to 2017. All the data are from Hubei Provincial Department of Culture and Tourism.

B. Results and Analysis

1) Overall evaluation of business efficiency of star-rated hotels in Hubei Province: As can be seen from "Fig. 1", scale efficiency was basically stable and close to 1 in 2010-2017. The trend of comprehensive efficiency is basically consistent with that of pure technical efficiency, showing that the scale of investment of star-rated hotels in Hubei Province has been relatively optimized in the past eight years. In order to promote the comprehensive efficiency, we must lay stress on the improvement of pure technical efficiency, as well as the upgrading of management level and the innovation of management system.

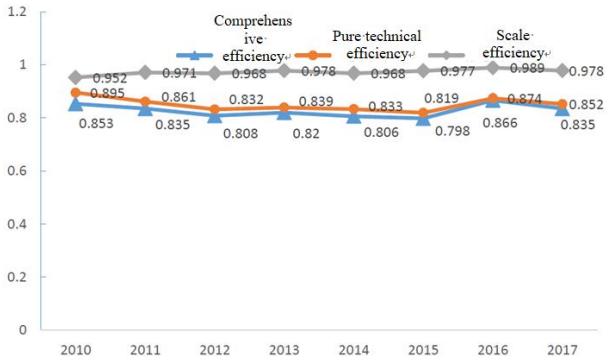

Fig. 1. Evolution of annual mean value of comprehensive efficiency of star-rated hotels in Hubei Province.

From “Table I”, it can be seen that all efficiency values of Wuhan and Qianjiang are 1, and DEA is effective and returns to scale is unchanged, which indicates that the management level, system innovation and investment scale of star-rated hotels in these two cities have reached the optimization condition, and the business effect is the best. All efficiency values of Shiyan City, Ezhou City and Shennongjia in 2017 were 1, and increased quickly compared with those in 2010. In 2017, cities with increasing returns to scale included Yichang City, Jingmen City, Jingzhou City, Xianning City and Suizhou City, and the DEA of these cities was non-effective. They can improve their business efficiency by expanding the scale; cities with diminishing returns to scale include Huangshi City, Xiangyang City, Xiaogan City, Huanggang City and Enshi Tujia and Miao Autonomous Prefecture. The scale efficiency of these cities is above 0.93, which indicates that the marginal effect of expanding scale to improve business efficiency is decreasing, and technological innovation should be paid attention to. In the three years, the DEA in Huangshi City, Xiangyang City and Suizhou City in 2013 was effective but in 2010 and 2017 was non-effective. Large fluctuation of pure technical efficiency leads to the same effect of comprehensive efficiency. Therefore, these three cities should pay attention to technological innovation, and

emphasize the promotion of management level and innovation of management system.

TABLE I. EFFICIENCY VALUES OF STAR-RATED HOTELS IN CITIES (AUTONOMOUS PREFECTURES) OF HUBEI PROVINCE

	2010				2013				2017			
	Comprehensive efficiency	***Pure technical efficiency***	***Scale efficiency***	***Trend***	***Comprehensive efficiency***	***Pure technical efficiency***	***Scale efficiency***	***Trend***	***Comprehensive efficiency***	***Pure technical efficiency***	***Scale efficiency***	***Trend***
	crste	vrste	scale		crste	vrste	scale		crste	vrste	scale	
Wuhan City	1.000	1.000	1.000	-	1.000	1.000	1.000	-	1.000	1.000	1.000	-
Huangshi City	0.814	0.814	1.000	-	1.000	1.000	1.000	-	0.890	0.948	0.938	drs
Shiyan City	0.752	1.000	0.752	drs	0.852	0.861	0.989	drs	1.000	1.000	1.000	-
Yichang City	0.861	0.861	1.000	-	0.769	0.794	0.969	drs	0.780	0.780	0.999	irs
Xiangyang City	0.722	0.726	0.993	drs	1.000	1.000	1.000	-	0.920	0.930	0.990	drs
Ezhou City	1.000	1.000	1.000	-	0.540	0.565	0.956	irs	1.000	1.000	1.000	-
Jingmen City	0.694	0.739	0.938	drs	0.549	0.552	0.995	irs	0.534	0.564	0.947	irs
Xiaogan City	0.735	0.740	0.994	drs	0.682	0.683	0.999	irs	0.665	0.691	0.963	drs
Jingzhou City	0.861	0.874	0.985	drs	0.771	0.771	1.000	-	0.648	0.658	0.985	irs
Huanggang City	0.916	0.916	1.000	-	0.750	0.752	0.998	irs	0.994	1.000	0.994	drs
Xianning City	0.872	0.953	0.915	drs	0.594	0.603	0.986	irs	0.571	0.590	0.967	irs
Enshi Tujia and Miao Autonomous Prefecture	1.000	1.000	1.000	-	1.000	1.000	1.000	-	0.938	1.000	0.938	drs
Suizhou City	0.566	0.804	0.704	drs	1.000	1.000	1.000	-	0.582	0.616	0.945	irs
Qianjiang City	1.000	1.000	1.000	-	1.000	1.000	1.000	-	1.000	1.000	1.000	-
Shennongjia	1.000	1.000	1.000	-	0.784	1.000	0.784	irs	1.000	1.000	1.000	-
mean	0.853	0.895	0.952	/	0.820	0.839	0.978	/	0.835	0.852	0.978	/

[a.] Note: "–" represents fixed returns to scale;"drs" represents diminishing returns to scale; "irs" represents increasing returns to scale.

2) Measurement and decomposition of Malmquist total factor productivity index of star-rated hotels in Hubei Province: As can be seen from the "Table II", the mean value of the total factor productivity index of all cities (autonomous prefectures) is 1.004, that is, the overall average annual growth is 0.4%. Except that the total factor productivity index of six cities (autonomous prefectures) including Ezhou City is less than 1, the indexes of other cities all show a growth trend of more than 1. Among them, Shiyan City has the fastest annual growth, which is 21.1%. Its growth is mainly due to technological progress. The change index of technical efficiency and scale efficiency of Suizhou Cityis is greater than 1. Its technical progress index is 0.920, which is the lowest in the province. Its pure technical efficiency is 0.963, which is basically close to the lowest level in the province. As a result, the total factor productivity index is 0.924, with an average annual decrease of 7.6%, which is the lowest in Hubei Province. All kinds of efficiency index in Wuhan are greater than or equal to 1, which indicates that DEA is effective in Wuhan. The total factor productivity index of other cities is mainly affected by technological progress index.

TABLE II. DECOMPOSITION RESULTS OF MALMQUIST TOTAL FACTOR PRODUCTIVITY INDEX OF STAR-RATED HOTELS IN HUBEI PROVINCE

firm	**eff**	**tech**	**pe**	**se**	**tfp**
Wuhan City	1.000	1.046	1.000	1.000	1.046
Huangshi City	1.013	1.010	1.022	0.991	1.023
Shiyan City	1.042	1.163	1.000	1.042	1.211
Yichang City	0.986	1.042	0.986	1.000	1.027
Xiangyang City	1.035	0.970	1.036	0.999	1.004
Ezhou City	1.000	0.926	1.000	1.000	0.926
Jingmen City	0.963	1.011	0.962	1.001	0.973
Xiaogan City	0.986	1.029	0.990	0.995	1.014
Jingzhou City	0.960	1.039	0.960	1.000	0.997
Huanggang City	1.012	1.023	1.013	0.999	1.035
Xianning City	0.941	1.022	0.934	1.008	0.962
Enshi Tujia and Miao Autonomous Prefecture	0.991	1.049	1.000	0.991	1.040
Suizhou City	1.004	0.920	0.963	1.043	0.924
Qianjiang City	1.000	0.941	1.000	1.000	0.941
Shennongjia	1.000	0.961	1.000	1.000	0.961
mean	0.995	1.008	0.991	1.005	1.004

As can be seen from the "Table III", the mean value of Malmquist total factor productivity index of star-rated hotels in Hubei Province is greater than 1. This shows that the business efficiency has been improved during 2010-2017; but the mean value of technical efficiency index is 0.995, which is less than 1; the scale efficiency is greater than 1,

and the scale does not need to be expanded, which is mainly caused by the low pure technical efficiency; besides, the technical progress index is 1.008 and greater than 1, indicating that the improvement of tfp mainly depends on technological innovation. The changes of tfp can be roughly divided into three stages. The first stage is from 2010 to 2012, and it's greater than 1; the second stage is from 2012 to 2015, and it's less than 1; the third stage is from 2015 to 2017, it's greater than 1. Through decomposition, it can be seen that the change direction of tfp is basically opposite to that of eff, but basically consistent with that of tech, that is, the Malmquist total factor productivity index is mainly affected by technological progress. Moreover, the lowest se is 0.989 and close to 1, showing that the investment scale of star-rated hotels in Hubei Province is basically close to the optimal. The eff is mainly restricted by the management level. Therefore, in order to improve tfp, we must pay attention to the innovation of management system.

TABLE III. DECOMPOSITION RESULTS OF MALMQUIST TOTAL FACTOR PRODUCTIVITY INDEX OF STAR-RATED HOTELS IN HUBEI PROVINCE IN EACH YEAR

year	eff	tech	pe	se	tfp
2010-2011	0.975	1.032	0.951	1.024	1.006
2011-2012	0.962	1.112	0.965	0.997	1.070
2012-2013	1.015	0.961	1.005	1.009	0.975
2013-2014	0.989	0.950	1.001	0.989	0.940
2014-2015	0.980	0.964	0.970	1.010	0.945
2015-2016	1.092	0.940	1.077	1.014	1.026
2016-2017	0.960	1.117	0.971	0.989	1.072
mean	0.995	1.008	0.991	1.005	1.004

IV. CONCLUSION AND SUGGESTION

A. Main Conclusion

By using the business data of star-rated hotels in 15 cities (autonomous prefectures) of Hubei Province from 2010 to 2017, the DEA — Malmquist model has been constructed to measure the comprehensive efficiency and total factor productivity of star hotels. The results show that:

The whole level of comprehensive efficiency of star-rated hotels is low. From 2010 to 2017, the mean value of comprehensive efficiency of star-rated hotels in Hubei Province was between 0.7 and 0.9, which was 0.866, the highest in 2016. The scale efficiency was close to 1. The investment scale is relatively reasonable. Pure technical efficiency is the main factor restricting the comprehensive efficiency. The comprehensive efficiency of Wuhan City, Enshi Tujia and Miao Autonomous Prefecture and Qianjiang City is relatively stable, while it fluctuates significantly in other cities (autonomous prefectures).

Malmquist total factor productivity index (tfp) of star-rated hotels fluctuates obviously. From 2010 to 2017, the tfp of star-rated hotels presented the fluctuation change of "V" style, which was basically opposite to the change direction of eff and consistent with that of tech. The change of TFP in each city (state) is basically in line with that of tech, and the se is basically effective, and the eff is mainly affected by pe.

B. Policy Suggestions

As an important pillar of green economy development, tourism industry plays an irreplaceable role in stabilizing growth and promoting employment. Star-rated hotels in Hubei province should seize the development opportunity of tourism industry and strive to improve business efficiency and improve development quality.

1) Moderately expanding the scale of development: The number of star-rated hotels in Hubei Province has decreased overall. Among them, the number of high-star hotels has continued to grow, however, the number of low-star hotels has continued to decrease, and the average annual scale efficiency has been less than 1. Therefore, we can reasonably expand the scale of development of star-rated hotels, especially the low-star hotels, pay attention to the needs of low-end and mid-end consumers, actively develop economic hotels and optimize the structure of star-rated hotels.

2) Paying attention to the Improvement and Development of Quality: The bu efficiency of star-rated hotels in Hubei Province is mainly affected by pure technical efficiency, that is, subject to management level and management system. Therefore, in the future, we should pay attention to reforming the existing management system, actively learning from and absorbing the advanced management experience of multinational hotels, improving business efficiency and improving economic efficiency.

3) Vigorously promoting the development of high and new technology: The main factor that restricts the productivity index of total factor is technical progress. At present, artificial intelligence develops rapidly. Star-rated hotels can reduce energy consumption and save the energy by integrating artificial intelligence and big data analysis, enrich product design, improve sales system, and innovate service content, cultivate excellent talents, and promote the wide application of high and new technology in star-rated hotels.

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