Technological Efficiency of Hotel Industry in China and Its Influencing Factors

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***Abstract*—Based on regional panel data of China, this paper employ the two-stage stochastic frontier analysis (SFA) model to evaluate the technological efficiency of hotel industry during the period of 2002 to 2008. Second, the impact intensity of the industry structure, development of tourism industry and regional economy on the technological efficiency are measured. The results show that the generally trends are upward, and the increase of capital and labor inputs will continue to serve as the primary mean to develop regional hotel industry. Furthermore, the development of hotel industry is highly related to the booming of tourism industry and regional economy. Those state-owned hotels are evidently technological inefficient. Finally, policy implications and limitations are discussed.**

***Index Terms*—Hotel Industry, influencing factors, SFA, technological efficiency.**

I. Introduction

At the end of 2009, the Chinese government approved the Suggestions for Accelerating the Development of Tourism industry. Suggestion points out that the tourism industry is a strategic industry for its low resource consumption, large driving coefficient, more employment opportunities and excellent comprehensive benefits. Therefore, it requires cultivating the tourism industry into a strategic pillar industry of the national economy as well as the modern service industry people are more satisfied with. It shows that China has elevated the status of the tourism industry up to an unprecedented degree, and it has become an urgent task faced by the government and the tourist authorities how to balance and make sustainable development among elements of the tourism industry in order to welcome the arrival of the era of mass tourism. Only in this way can be the tourism industry makes its historic contribution to the economic reformation in terms of the change of development mode in the national economy.

The healthy and orderly development of the hotel industry not only meets the demand of the market where tourists grow fast at home and abroad so as to effectively promote the growth of tourist consumption, but also play a very important role in the transformation of economic development modes.

As the backbone and leading part of the hotel industry, the star-rating hotels, especially the LMs ones, are bound to affect the development trend of the whole hotel industry with their own progress no matter whether it is good or not. Therefore, how to optimize the resource allocation, improve efficiency of input-output, enhance competitiveness, and thus improve the economic benefit of star-rating hotels, becomes the important issue to be solved by the government departments in the current macro-control of the hotel industry. By the end of 2008, there had been 14,099 star-rating hotels in the whole country, of which 13,538 were the state-owned hotels (not invested by foreign enterprises, Hong Kong, Macao and Taiwan), and 561 were foreign invested hotels. Hotels with more than 200 rooms are classified as the LMs star-rating hotel. By the end of 2008, there had been 1,822 LMs star-rating hotels (of which 1568 were state-owned hotels and 254 were foreign invested hotels), which accounted for 12.9% of the total number of star-rating hotels in the country, and their operating income accounted for 53% of the total operating income of star-rating hotels in the country (*Yearbook of China Tourism Statistics, 2009*). Therefore, this paper selects the LMs star-rating hotels as the samples, which are the main part of China's hotel industry, to conduct the analysis of the technological efficiency in historical and spatial dimension.

In the section that follows, we provide an overview of the literature with regard to SFA and its application on tourism industry. In the third section, our methodology and data issues are elaborated, while the empirical analysis and some discussion are proposed in the fourth section. Finally, the conclusions are given at the end.

II. Literature Review

As for the measurement of technological efficiency, Farrell and Afriat who first proposed this concept argued that technological efficiency was correlated with the production possibility frontier [1, 2]. Technological efficiency was used to measure the distance between an enterprise's output and maximum output under the same amount of factor input. The greater the distance is, the lower the technological efficiency will be (Fig. 1).

There are usually two methods to measure the technological efficiency: one is the non-parameter method, such as the Data Envelopment Analysis (DEA). The other one is the parameter method, the representative of which is the Stochastic Frontier Analysis (SFA) method. The main advantage of DEA is to avoid setting errors, because the method does not need to set the functional forms or distributional assumptions [3], but its drawback is to take any condition that deviates from the efficient frontier as the inefficiency so that it cannot separate the stochastic errors. The DEA method requires accurate data, so it is tremendously influenced by the statistical errors. The main advantage of the SFA is to separate the pure statistical error

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from the inefficiency value, and its drawback is that it needs to set functional forms or distributional assumption of error terms in advance, which has a certain degree of subjectivity. Pires and Gatica's study shows that the SFA has a distinct advantage in the analysis of the growth of regional economy and the impact of the technological efficiency [4]. In the study of this paper, the impact of stochastic error terms on the technological efficiency cannot be ignored, and it is necessary to separate stochastic error terms and inefficient terms. Therefore, it will be helpful to acquire quantitative conclusion with a higher accuracy by measuring and calculating the technological efficiency and its changes of the regional LMs star-rating hotels with the SFA model.

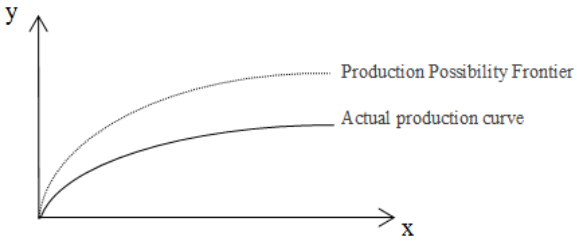

Fig.1. Diagram of technological efficiency

Frontier efficiency research has been widely conducted in banking and transportation industry in foreign countries [5], while the hotel industry is relatively ignored to a great extent [6, 7]. In the past, the ratio analysis, index of market performance, revenue performance and revenue management are mainly used for the research of the hotel industry's operation, until now, a significant development has been achieved in the evaluation of the efficiency of the hotel industry by using the SFA model in foreign countries in recent years. For example, Barros uses the stochastic frontier method to study the operating efficiency of the hotel industry in Portugal with the balanced panel data from 1999 to 2001 [8]; Wang, Lee and Wong uses one step stochastic frontier method to measure the related efficiency of 66 international tourist hotels in Taiwan between 1992 and 2002, and makes an investigation of the determinants of technological efficiency [9]; Chen uses the stochastic frontier analysis to analyze the cost efficiency of 55 international tourism hotel in Taiwan [10]. The SFA application started late in China, and the current studies about the industrial economy based on the application of SFA mainly center in the industrial departments and the specific trades in industrial departments [11]. For example, Liang researches the technological efficiency of the LMs industrial enterprises in Guangdong Province based on the stochastic frontier method [12]; Gu and Zhang analyze the efficiency of the tobacco enterprises in China with the stochastic frontier production function [13]. However, the stochastic frontier method has not yet been applied in the research of the hotel industry in China. The domestic researches of the hotel industry are mostly limited to the qualitative analyses with few quantitative analyses. There is a shortage of researches analyzing the development of regional hotel industries from the macroscopic perspectives, which is not conducive to the planning guidance and macro-control of the hotel industry and may result in the imbalance and disorder of the development of the star-rating hotel industry in various regions. Such situation will hold back the development process of the local tourism and slow down the development pace of the tourist economy.

Within this context, this paper aims to make an in depth understanding of development of hotel industry in China, and to specify the key elements affect the technological efficiency of hotel industry. Therefore, we evaluate the technological efficiency of each province and rank them in the stage 1, after that the analysis of impact factors is presented in the stage 2. In this progress, the two-stage SFA model and the software Frontier 4.1 are involved.

III. Methods and Data Issues

A. SFA Model

The initial stochastic frontier production function model was based on the cross-sectional data. This model divided error terms into two parts: the stochastic error term and the technological inefficiency term, which could be expressed as follows:

$$Y_i = x_i\beta + (V_i - U_i), i = 1, 2, ..., n \quad (1)$$

Of which: the explained variable Y_i is the output of the i_{th} sample, the explanatory variable vector x_i expressed the input vector of the i_{th} sample, β represent the vector of parameters to be estimated, V_i is a stochastic variable unrelated to U_i, $V_i \sim N(0, \sigma_v^2)$, and U_i is the non-negative stochastic variable, which was correlated with the technological inefficiency of the production, assuming $U_i \sim |\mathrm{N}(0, \sigma_u^2)|$. The impact caused by the technological inefficiency could be defined by the following equation:

$$U_i = Z_i\delta + W_i \quad (2)$$

Of which: Z_i is the explanatory variable vector associated with the technological inefficiency during the production, and δ means the vector of the parameter to be estimated, assuming that W_i complied with the truncated normal distribution $N(0, \sigma 2)$.Then the efficiency of the production technology of the i_{th} sample was defined as:

$$TE_i = E(-U_i) = E(-Z_i\delta - W_i) \quad (3)$$

As the above model was unable to deal with the column data, its application scope was therefore greatly restricted. In 1992, Battese and Coelli brought forward the stochastic frontier production function model aiming at the (unbalanced) panel data, which greatly expanded the application scope of the stochastic frontier production function model [14]. The model could be expressed as follows:

$$Y_{it} = x_{it}\beta + (V_{it} - U_{it}), i = 1, 2, ..., n; t = 1, 2, ..., T \quad (4)$$

Of which: the explained variable Y_{it} expressed the output of the i_{th} sample at the time of t, the explanatory variable vector x_{it} expressed the input vector of the i_{th} sample at the time of t, β expressed the vector of parameters to be estimated, V_{it} expressed the stochastic variable which was mutually independent to U_{it}, $V_{it} \sim \mathrm{N}(0, \sigma_v^2)$; $U_{it} = U_i \exp(-\eta(t - T))$, U_i expressed the non-negative stochastic variables, which were correlated with the technological inefficiency of production, assuming that it complied with the truncated normal distribution (truncated at the point of 0) $N(0, \sigma_u^2)$. η was the parameter to be estimated.

B. Data Source and Variable Specification

In order to better examine the regional differences in the technological efficiency of the LMs star-rating hotels in China, this paper conducts the analysis by using the traditional regional classification to divide the whole country into eastern, central and western regions on the basis of collecting the panel data of the 31 provinces and equivalents in China from 2002 to 2008. The eastern region includes 12 provinces which are Beijing, Tianjin, Hebei, Liaoning, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong, Guangxi, and Hainan; the central regions includes 9 provinces which are Shanxi, Inner Mongolia, Jilin, Heilongjiang, Anhui, Jiangxi, Henan, Hubei, and Hunan; the western region includes 10 provinces which are Chongqing, Sichuan, Guizhou, Yunnan, Tibet, Shaanxi, Gansu, Qinghai, Ningxia, and Xinjiang. The data are all from the *Yearbook of China's Tourism Statistics*, and the *Yearbook of China's Statistics* (from 2003 to 2009).

TABLE I: DESCRIPTIVE STATISTICS

	Min	Max	Mean	SD
Ln R	4.57	14.55	11.39	1.43
Ln K	6.11	11.30	9.09	1.08
Ln L	8.20	15.43	12.65	1.26
Ln SO	5.48	11.42	9.21	1.09
Ln TA	3.66	4.61	4.43	0.16
Ln GPC	8.02	17.45	13.71	1.55
Ln RV	8.06	11.20	9.53	0.63
Valid Samples	217			

Source: Author's own calculation.

This paper selects three input indicators: number of rooms (R), fixed assets (K), number of employees (L), one output indicators: Sales revenue of tourism industry (RV), and examines three influencing factors: the ratio of state-owned enterprises (SO), number of tourists arrivals (TA), and GDP per capita (GPC). The descriptive statistics about the variables are as shown in TABLE I.

IV. EMPIRICAL ANALYSIS

Based on the basic principles of the SFA model, this paper, by using the C-D logarithmic production function, measures the level of technological efficiency of China's LMs star-rating hotels and the impact strength of proportion of state-owned hotels, tourism industry and economic development on the efficiency. The specific form of the constructed model is:

$$\ln RV_{it} = \beta_0 + \beta_1 \cdot \ln F_{it} + \beta_2 \cdot \ln K_{it} + \beta_3 \cdot \ln L_{it} + (V_{it} - U_{it}) \quad (5)$$

$$M_{it} = \delta_0 + \delta_1 \cdot NF_{it} + \delta_2 \cdot RJ_{it} + \delta_3 \cdot PG_{it} + \varepsilon_{it} \quad (6)$$

$$TE_{it} = \exp(-U_{it}) \quad (7)$$

$$\gamma = \frac{\sigma_u^2}{\sigma_u^2 + \sigma_v^2} \quad (8)$$

RV_{it}, F_{it}, K_{it} and L_{it} respectively represent the sales revenue, number of rooms, fixed assets and number of employees of the i_{th} province in the t_{th} year. β_0 is a constant, β_1, β_2 and β_3 are parameters to be estimated, respectively expressed the output elasticity of the corresponding indicator; $V_{it} \sim N(0, \sigma_v^2)$ is independent to U_{it} , and U_{it} complies with the normal distribution of the positive half $N(M_{it}, \sigma_u^2)$. Variables F_{it}, RJ_{it} and PG_{it} mean the ratio of state-owned hotels, number of tourists arrivals, GDP per capita of the i_{th} province in the t_{th} year. We assume that the ratio of state-owned hotels, number of tourist arrivals, and GDP per capita are a group of factors influencing the technological efficiency of hotel industry. Through the estimation of parameter δ_i, we can obtain the relative impact of the influencing factors on technological efficiency. TE_{it} is the technological efficiency of the i_{th} region in the t_{th} year. $\gamma \in [0,1]$ is the parameter to be estimated too, reflecting the proportion of error term variation from U. It is necessary to inspect γ. If $\gamma=0$ is accepted, then U_{it} can be removed from the model, and the parameter estimation can be conducted by directly using the least square method rather than the stochastic frontier analysis model.

A. Estimation Results

Table II shows the annual average ranking of the input-output efficiency of the hotel industry in provinces and equivalents, reflecting the development of the hotel industry in different provinces and equivalents. It can be found that economically developed regions rank higher in terms of the development of LMs star-rating hotels, showing that the growing numbers of sightseeing and business tourists and relatively high level of per capita income in the economically developed regions stimulate the demand for the local high-grade hotels, which to a certain extent sets the pace to the development of the hotel industry. However, the LMs star-rating hotels in the well-known large tourism provinces such as Hainan and Yunnan rank lower, which is out of coordination with their tourism development, and has hampered the development of local tourism objectively. The low ranking of the two provinces is the result of the local backward in GDP per capita, and the low-grade tourism consumption owing to the fact that there are huge numbers of sightseeing tourists but few business travelers. The obvious peak and slack seasons of the local leisure products, poor management and lack of management talent are also related to the lower ranking.

Fig. 2 shows the transition of the annual average efficiency of hotel industry in the whole country as well as the eastern, central and western regions in the past seven years. It is clear that the overall efficiency level of the hotel industry in the whole country basically went upward year by year. However, in 2003, a certain degree of decline happened in various regions, which might be greatly related to the outbreak of SARS that year.

On the other hand, the construction of new hotels failed to meet the growing demand, which to some extent affected the development of hotel industry. The central region achieved a substantial increase in 2005, which might be the result of the strategy of Rise of Central China.

The investment in the central region increased, policies were relaxed, and good development prospects attracted investors to the hotel industry, all of which resulted in a significant development. In the same year, other regions, especially in the west, also showed varying degrees of

rebound. This trend not partly because of the market rebounded after SARS, but also closely related to the deepening implementation of the Great Western Development strategy.

TABLE II: RANKING OF AVERAGE EFFICIENCY

Ranking	Province	Average efficiency
1	Shanghai	0.95
2	Tianjin	0.93
3	Beijing	0.92
4	Zhejiang	0.91
5	Jiangsu	0.89
6	Liaoning	0.87
7	Chongqing	0.86
8	Guangdong	0.86
9	Henan	0.85
10	Jilin	0.84
11	Shandong	0.83
12	Shanxi1	0.82
13	Xinjiang	0.82
14	Anhui	0.80
15	Fujian	0.80
16	Qinghai	0.80
17	Hubei	0.79
18	Hunan	0.78
19	Neimenggu	0.77
20	Jiangxi	0.76
21	Guizhou	0.75
22	Hainan	0.74
23	Guangxi	0.72
24	Ningxia	0.71
25	Sichuan	0.71
26	Hebei	0.71
27	Yunnan	0.68
28	Heilongjiang	0.64
29	Shanxi2	0.63
30	Gansu	0.60
31	Xizang	0.47

Source: Author's own calculation.

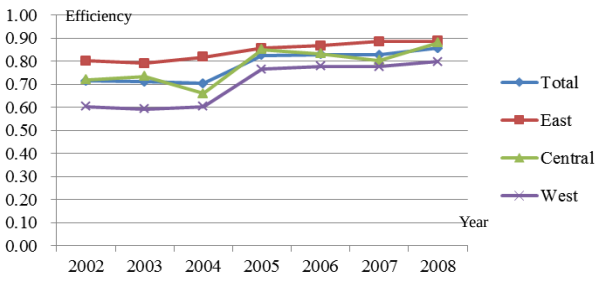

Fig. 2. Trends of annual average efficiency

In Fig.3, the variation coefficient is used to measure the degree of regional differentiation. It shows that the development levels of various regions have been gradually approaching the internal balance since 2004. The differentiation within the eastern regions changed little. The central region tended to reach balance from 2003 to 2005 while from 2005 the differentiation among regions increased again, which might be the result of the different implementations and operations in various regions about the initial strategy of *Central Rise*. As the policy increasingly matured, the development in various areas sped up, and the balance was approached to again in 2007. There was a big fluctuation rather than an obvious balance trend of development within the western regions, and the differentiation tended to go greater.

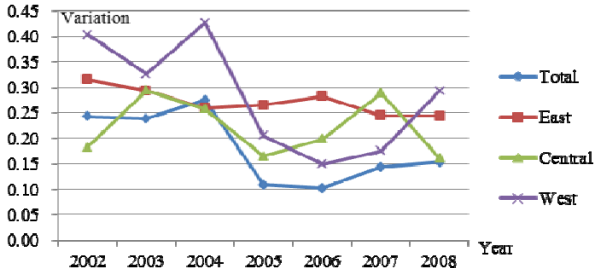

Fig. 3. Trends of variation coefficient of annual technological efficiency.

B. Parameter Analysis

The value of parameter estimation in the SFA model reflects the output elasticity of input indicators as well as the impact strength of various factors. Through the analysis of the value of parameter, we can better understand the weight of each indicator, and thus discover targeted recommendations for the policy. The analysis results are as shown in TABLE Ⅲ:

(a) The values of γ for the national, eastern, central and western regions are 0.94, 0.99, 0.92, and 0.98 respectively, and both the statistic t and the statistic LR have passed the significance test at the 1% level. Therefore, compared to the stochastic interference terms, all of the variations of the error terms basically come from the technological inefficiency U, showing that the technological inefficiency significantly exists. Thus, it is appropriate to use the SFA method to analyze the technological efficiency of the whole country and various regions from 2002 to 2008 while the production function derived from the traditional least square estimation cannot represent the efficient state.

(b) Through observing the coefficient of β_1, β_2, β_3, it can be found that:

The input of the fixed assets follows and occupies a rather important position.

Therefore, to increase capital and labor inputs will still serve as the primary means in the development of LMs star-rating hotels in China. The output elasticity of capital significantly surpasses that of labor in the eastern region, indicating that to start with increasing the capital input would lead to better effect in the eastern region, but the labor capital input in the eastern region cannot be ignored yet. Second, the output elasticity of the indicator room number is negative and remains a higher significance, showing that the marginal effect to expand the scale of the regional LMs star-rating hotels is negative, and the market has become saturated, which should be put into control.

TABLE III: PARAMETER ESTIMATION OF SFA MODEL

	Total			East			Central			West		
Variables	**ML**	**SD**	**t**	**ML**	**SD**	**t**	**ML**	**SD**	**t**	**ML**	**SD**	**t**
β0	0.10	0.23	0.42	0.40	0.51	0.79	1.52**	0.89	1.70	1.31**	0.58	2.24
β1	0.12**	0.08	1.54	-0.24	0.15	-1.59	0.17	0.16	1.05	0.21**	0.12	1.71
β2	0.41***	0.06	6.47	0.82***	0.12	6.77	0.14*	0.11	1.25	0.40***	0.14	2.81
β3	0.57***	0.09	6.04	0.39***	0.14	2.75	0.77***	0.26	2.96	0.36**	0.17	2.09
δ0	-0.51	9.63	-0.05	3.91***	1.04	3.75	5.14***	1.95	2.64	-2.55	2.94	-0.87
δ1	4.74***	1.88	2.52	-0.01	0.21	-0.03	-0.23	0.44	-0.51	10.26***	3.90	2.63
δ2	-0.07	0.09	-0.85	-0.11	0.05	-2.48	0.03	0.07	0.40	-0.30	0.13	-2.37
δ3	-2.12	0.10	-23.62	-0.17	0.03	-5.41	-0.43	0.17	-2.56	-4.64	1.68	-2.76
σ2	0.69***	0.10	6.71	0.08***	0.02	4.91	0.09***	0.02	3.87	0.95***	0.34	2.80
Γ	0.94***	0.02	62.11	1.00***	0.00	519.91	0.92***	0.13	7.02	0.98***	0.01	77.69
LR	112.39			21.82			13.21			68.91		
Mean efficiency	0.78											

Note: ***, ** and * represent significance at the level of 1%, 5% and 10%, respectively. LR is the likelihood ratio test statistic, and it conforms to the mixed Chi-square LR distribution here. The negative sign in inefficiency function means the positive effect of variable on the technological efficiency, and vice versa.

There is no significant correlation between the room number and the output in the central region. The output elasticity of the capital is significantly lower than other regions in the country, and it has no significant correlation with the output, showing that there is a big problem in the utilization efficiency of the capital in the central region, which should be taken seriously. The output elasticity of labor stays at the highest level in the country, significantly correlated with the output, which is closely connected with contradiction between the rapid development of the central region and the loss of human capital. Hence, it is imperative to start with resolving this contradiction and to put the construction of the personnel team for the hotel industry to a prominent position. The western region lags behind in the development, and the input-output elasticity is much similar to each other, maintaining at a relatively low level. Thus, in the coming period, the western region should attach emphasis to attracting enterprises and encouraging investment for the star-rating hotel projects, and increase the input of the government and the society. At the same time, pay attention to the introduction of the utilization efficiency of capital and the introduction of management talent. The simultaneous implementation of the three measures will promote the development pace of the high-grade star-rating hotel industry and improve the output efficiency of the hotel industry.

(c) The further conclusions can be obtained by analyzing the values of δ_1, δ_2, and δ_3:

The industry structure has a positive impact on the technological efficiency in the nationwide scope, and remains at a comparatively high level. It shows that the state-owned enterprises have a negative impact on the input-output conversion, indicating a large gap in the input-output efficiency between the state-owned hotels and the foreign invested hotels. The state-owned enterprises should look squarely at their own insufficiencies and further improve the level of input-output. The GDP per capita has a negative impact on the technological efficiency. An increase of one unit in the level of GDP per capita will reduce the level of technological efficiency by 2.12 units, indicating that the higher the GDP per capita, the higher the input-output efficiency in the local hotel industry will be. The number of tourist arrivals has no significant impact on the technological efficiency related to the level of the local tourism development. The reason that the state-owned enterprises have no direct and significant impact on the technological efficiency in the eastern region may lie in the higher input-output level of the state-owned hotels in the eastern region, which is as much as that of foreign invested hotels. Both the development of tourism industry and economy have negative impact on the technological efficiency, showing that the two indicators play significant roles in promoting the development of hotel industry, but the intensity is lower than that of other regions. The reason may lie in the fact that the economic development and the industrial level of the eastern region rank high in the country, which may thereby diminish the marginal effect. In the central region, the type of enterprise and the tourism development level have no significant impact on the technological efficiency. The GDP per capita is negatively correlated with the technological efficiency, well promoting the input-output efficiency with the intensity only next to that of the western region, which indicates that the economic development of the central region is still the top priority. The GDP per capita has a significant impact on the technological efficiency in the western region while the level of tourism development has a weak impact. The type of enterprise has a positive impact on the technological efficiency with high intensity, showing that there is a big problem in the operation of the state-owned hotels in the western region. There is a big gap in its input-output transformation level with the international level and that of the eastern region. Attention should be paid to the seriously ineffective consumption of resources.

V. CONCLUSION

This paper adopts the SFA model, based on the panel data

of 31 provinces and equivalents in China, to evaluate the technological efficiency of the LMs star-rating hotels in different region and examine the impact intensity of three impact factors. By doing this, we reflect the current development pattern of the hotel industry in China, and depict the history and the degree to what regions are different of the hotel industry in China in the past seven years.

The results show that it is appropriate to use the SFA method to analyze the technological efficiency of LMs star-rating hotels in China. In the nationwide scope, to increase the capital and labor input will continue to serve as the primary means in the development of the regional hotel industry. State-owned hotels lag behind the foreign invested hotels in the input-output conversion efficiency as a whole, for which state-owned hotels should find its insufficiency by comparison and improve the input-output efficiency. The eastern region should focus on the capital input as the hotel industry market approaches to saturation. There is a big problem in the capital utilization efficiency in the central region, and economic development remains as the top priority. The western region still remains at the low level, and inputs need to be enhanced in all aspects. The western state-owned hotels are significantly inefficient, to which attention should be paid. As a whole, both the development of the tourism industry and economy play a significant role in promoting the development of the hotel industry.

It should be noted that this paper does not make a comprehensive selection of indicators. Therefore, in the future researches output efficiency of more input elements and the impact of other factors on the hotel industry could be examined in greater details, which help to make an all-round understanding of the key points and effort-putting points of the industrial development, and provide a theoretical basis for the government's macroscopic industrial planning and regulation. On the other hand, based on the macroscopic analysis, several cases with specific characteristics can be researched profoundly so as to analyze the drawbacks and constraint factors in the development of the hotel industry from the macro- or micro-perspectives.

REFERENCES

[1] M. J. Farrell, "The measurement of productive efficiency," *Journal of the Royal Statistical Society*, vol. 120, no.3, pp. 253-290, 1957.

[2] S. N. Afriat, "Efficiency estimation of production functions," *International Economic Review,* vol. 13, no. 3, pp. 568-598, October 1972.

[3] A. Charnes, W. W. Cooper, and E. Rhodes, "Measuring the efficiency of decision making units," *European Journal of Operational Research*, vol. 2, pp. 429-444, 1978.

[4] J. O. Pires, and F. Gatica, "Productivity of nations: a stochastic frontier approach to TFP decomposition," *Z, Latin American Meetings*, December 2004.

[5] T. Mahmood, E. Ghani, and M. Din, "Efficiency of large scale manufacturing in Pakistan: A production frontier approach," *PIDE Working Papers*, 2007.

[6] R. I. Anderson, M. Fish, Y. Xia, and F. Mixhello, "Measuring efficiency in the hotel industry: A stochastic approach," *International journal of hospitality Management*, vol. 18, pp. 45-57, 1999.

[7] C. Pestana Barros, Peter U. C. Dieke. "Technical efficiency of African hotels. International," *Journal of Hospitality Management*, vol. 27, pp. 438-477, 2008.

[8] C. Pestana Barros, "Measuring efficiency in the hotel sector," *Annals of Tourism Research*, vol. 32, pp. 456-477, April 2005.

[9] Y. H. Wang, W. F. Lee, and C. C. Wong, "Productivity and efficiency analysis of international tourist hotels in Taiwan: an application of the stochastic frontier approach," *Taiwan Economic Review*, vol. 35, pp. 87-114, 2007.

[10] C-F Chen, "Applying the stochastic frontier approach to measure hotel managerial efficiency in Taiwan," *Tourism Management*, vol. 28, pp. 696-702, June 2007.

[11] O. Movshuk, "Restricting, productivity and technical efficiency in China's iron and steel industry, 1988-2000," *Journal of Asian Economics*, vol. 15, pp. 135-151, 2004.

[12] L. C. Lu, "Research on S and T activities efficiency of LMs manufacturing enterprises of Guangdong province: Based on stochastic frontier analysis," *Studies in Science of Science (in Chinese)*, vol. 3, pp. 75-80, 2009.

[13] J. G Gu and W. X Zhang, "The efficiency analysis of China's tobacco enterprises: Based on stochastic frontier production function," *Modern Economic Science (in Chinese),* vol. 4, pp. 88-92, 2007.

[14] G. E. Battese and T. J. Coelli, "Frontier production functions, technical efficiency and panel data: With application to paddy farmers in India," *Journal of Productivity Analysis,* vol. 3, pp. 153-169, 1992.

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