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A Empirical Analysis on Performance Evaluation of the Tertiary Industry in Eastern Chinese Province Based on DEA

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Abstract: This paper comprehensively evaluated the performance of the tertiary industry in eastern Chinese province, using Data envelopment Analysis and the statistical section data of tertiary industry status investigation. The result figures out the provinces which are DEA efficient and which are not, in eastern Chinese province at 2009. According the result and discussion, imbalanced regional development exists in eastern. So, the adjustment direction and range are given based on the DEA evaluation, that the development of technology-intensive industry should be the key of tertiary industry.

Key words: Tertiary industry; DEA; Scale efficiency; Performance evaluation

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1. INTRODUCTION

The tertiary industry involves the provision of services to other businesses as well as final consumers, provides services to the general population and to businesses and the basic characteristic of this sector is the production of services instead of end products. It is one of the three economic sectors, the others being the secondary sector (approximately the same as manufacturing) and the primary sector (agriculture, fishing, and extraction). According to the provision of National Bureau of Statistics, Chinese tertiary industry is split into two main categories, the distribution and service, four levels: first, the circulation departments, such as transportation industry, post and communication, catering industry, wholesale and retail industry and warehousing; second, the departments serving the producing and life, such as financial industry, insurance industry, information consulting service, etc.; third, the departments serving for education, such as broadcast, television, physical, social welfare, etc.; forth, such as state organs, government agency, social organizations, police, military, etc, but it does not count as the factor in the third industrial output value or GDP [1]. In the national economic statistic, the tertiary industrial output value includes transport, storage and post, wholesale and retail trades, hotels and catering services, financial intermediation, real estate, leasing and business services, scientific research, technical services and geologic prospecting, management of water conservancy, environment and public facilities, services to households and other services, education, health, social security and social welfare, culture, sports and entertainment, public management and social organizations.

The level of tertiary industry is an important indicator of modernization and civilization of state or region. The development of tertiary industry can promote the growth of national economy, satisfy the increasing needs for material and cultural fulfillments and improve the level of social and professional service, but also be good for the development of market economy, the optimization of allocation resources and the enhancement of national economy efficiency and operating quality [2–5].

According to the zoning, eastern provinces include Beijing, Tianjin, Hebei, Shanxi, Shanghai, Jiangsu, Zhejiang, Anhui, Fujian, Jiangxi, Shandong, Henan, Hubei, Hunan, Guangdong, Guangxi, Hainan. They are active areas of economic activities. This study focuses more on the performance evaluation of tertiary industry of the seventeen provinces, with statistical data and DEA.

2. METHODOLOGY

As a non-parameter evaluation method, data envelopment analysis (DEA) is used to empirically measure productive efficiency of decision making units (or DMUs). These approaches have the benefit of not assuming a particular functional form/shape for the frontier. However, they do not provide a general relationship (equation) relating output and input. It has a widely group of user in so many fields, such as mathematics, operations research, mathematical economy, management, etc. [6–9].

This method was proposed by Charnes, Cooper and Rhodes at 1978, and used to assessing the performance efficiency of departments primarily. The first model of DEA is C^2R. It is an optimization approach, which takes advantage of mathematical programming model and sampling technology, for evaluating the performance of a set of peer entities called Decision Making Units (DMUs) which convert multiple inputs into multiple outputs. The definition of a DMU is generic and flexible, such as hospitals, cities, courts, countries, etc. [8]. Every DMU is viewed as an evaluation unit, and all DMUs consist of the population. Formally, DEA is a methodology directed to frontiers rather than central tendencies.

According to the relative position of DMU and frontiers, we can learn whether the DMU is efficient. If the DMU is efficient, it means the DMU is in the ideal state, that is, the output of science & technology matches economical input well. If not, we can analysis the reasons of inefficient or weak efficient, and figure out the direction and extent of improvement.

The main advantage to this method is its ability to accommodate a multiplicity of inputs and outputs, and no need to explicitly specify a mathematical form for the production function. It is also useful because it takes into consideration returns to scale in calculating efficiency, allowing for the concept of increasing or decreasing efficiency based on size and output levels [9,10]. A drawback of this technique is that model specification and inclusion/exclusion of variables can affect the result, and the inefficient units can be analyzed and quantified. However, Berg [11] indicates that there are some disadvantages of DEA. For example, the result are sensitive to the selection of inputs and outputs, cannot test for the best specification, and the number of efficient firms on the frontier tends to increase with the number of inputs and output variables.

According to Cooper's description [8], the C^2R is given by

$$(PC^2R)\begin{cases} \max u^T Y_0 \\ \omega^T X_j - \mu^T Y_j \geq 0,\ j = 1, 2, ...n \\ \omega^T X_0 = 1 \\ \omega \geq 0,\ \mu \geq 0 \end{cases} \tag{1}$$

BC^2 model was proposed by Banker, Charnes and Cooper at 1984, and it is given by

$$(PBC^2)\begin{cases} \max(u^T Y_0 - \mu_0) \\ \omega^T X_j - \mu^T Y_j + \mu_0 \geq 0,\ j = 1, 2, ...n \\ \omega^T X_0 = 1 \\ \omega \geq 0,\ \mu \geq 0,\ \mu_0 \in E^1 \end{cases} \tag{2}$$

And its dual programming model is given by

$$(DBC^2)\begin{cases} \min \theta \\ \sum_{j=1}^{n} X_j \lambda_j \leq \theta X_0 \\ \sum_{j=1}^{n} Y_j \lambda_j \geq Y_0 \\ \sum_{j=1}^{n} \lambda_j = 1 \\ \lambda_j \geq 0,\ j = 1, 2, ...n,\ \theta \in E^1 \end{cases} \tag{3}$$

It is one of the most popular classical models. Formally, the input and output data of each DMU are directly used for modeling and DEA efficiency is calculated based on the dual theorem of linear programming.

3. CASE STUDY AND DISCUSSION

3.1. The Selection of Variables

The tertiary industry is a great industrial group, including a wide range of businesses. There are so many factors to its performance, and its efficiency also expresses in so many aspects. Therefore, the input and output variable should be selected. After principal component analysis, three variables are checked.

Table 1
The Variables of DEA

Input indicators	Output indicators
X_1-the number of the tertiary industry corporationbody X_2-the number of the tertiary industry practitioners	Y_1-the amount of the added value of the tertiary industry

Table 2
The Statistical Data of Eastern China

ID	Region	X_1/(billion)	X_2	X_3/(10 thousand persons)
1	Beijing	9179.19	326070	925.6
2	Tianjin	3405.16	99464	220.2
3	Hebei	6068.31	214124	1201.4
4	Shanxi	2886.92	136363	544.5
5	Shanghai	8930.85	259954	534.2
6	Jiangsu	13629.07	386037	1608.4
7	Zhejiang	9918.78	328369	1370.4
8	Anhui	3662.15	150844	1068.4
9	Fujian	5048.49	178045	754.6
10	Jiangxi	2637.07	113261	726.4
11	Shandong	11768.18	441614	1714.1
12	Henan	5700.91	241904	1509.2
13	Hubei	5127.12	241083	1219.7
14	Hunan	5402.81	194537	1216.3
15	Guangdong	18052.59	459624	2183.9
16	Guangxi	2919.13	147604	719.3
17	Hainan	748.59	25822	156.1
	Average	6769.725	232042	1040

3.2. The Analysis of Performance Evaluation of Input-Output Efficiency

The seventeen provinces of eastern China, that is, seventeen DMUs participate in the DEA analysis. The raw data is from the statistical yearbook and statistics bulletin (2009). Table 2 shows the statistical data of input and output variables for DEA procedure. And the DEAP 2.1 software is used, which is written to conduct data envelopment analyses.

3.2.1. The Efficiency Analysis

In Table 3, **crste**, comprehensive efficiency, the technological efficiency regardless of returns to scale; **vrste**, pure technical efficiency, the technological efficiency considering returns to scale; **scale**, scale efficiency, the scale efficiency considering the returns to scale; **irs**, increasing returns to scale; **crs**, constant returns to scale; **drs**, decreasing returns to scale.

Table 3
The Performance Evaluation Index of Seventeen Provinces

Firm	Crste	Vrste	Scale	
DMU1	0.787	0.787	0.999	irs
DMU2	0.988	1.000	0.988	irs
DMU3	0.722	0.743	0.971	irs
DMU4	0.559	0.599	0.932	irs
DMU5	1.000	1.000	1.000	crs
DMU6	0.924	0.924	0.999	irs
DMU7	0.790	0.792	0.998	irs
DMU8	0.618	0.655	0.943	irs
DMU9	0.740	0.764	0.968	irs
DMU10	0.593	0.646	0.918	irs
DMU11	0.707	0.708	0.999	irs
DMU12	0.600	0.620	0.968	irs
DMU13	0.541	0.562	0.963	irs
DMU14	0.707	0.733	0.965	irs
DMU15	1.000	1.000	1.000	crs
DMU16	0.504	0.547	0.921	irs
DMU17	0.738	1.000	0.738	irs
Average	0.736	0.769	0.957	

The Table 3 presents that the average of the pure technical efficiency of input-output in seventeen provinces is 0.769, and the average of scale efficiency is 0.957, at a moderate level in general. Among the seventeen provinces, there are two DEA effective DUMs (Shanghai and Guangdong), about 11.8% in total, and their scale efficiency index is 1. It means that these two DUMs (Tianjin and Hainan), have reached the best output level in the existing investment. Two cities, firm 2 and 17 whose scale efficiency index is less than 1 and pure technical efficiency index is 1, are weak DEA efficiency, about 11.8% in total. Thirteen provinces, whose scale efficiency index is less than 1, are inefficient, about 76.4% in total. These weak DEA efficient cities do not have the optimized relationship of input-output. Increasing output or reducing invest can adjust the allocation of technical resources, to realize the optimal combination of input and output. Table 3 also shows that fifteen provinces are increasing returns to scale, and they can increase the output to reach the balance (except the inefficient DMUs). Two provinces are decreasing returns to scale, and they can reduce the investment appropriately. In general, most provinces do not have the reasonable and optimal configuration, and there is great adjusting space in the optimization and utilization of the tertiary industry.

3.2.2. Projection

According to the result of the software DEAP 2.1, we record the redundant input and the lack of output for every DMU.

In Table 4, among the inefficient cities, for example, DMU 3, the scale efficiency index is 0.971, this is, 97.1% of investment can support current output level. So, the waste of resource and ineffective utilization exist in this province. This DMU will achieve relative optimum of input-output ratio under the condition that decreasing investment by 54,939 corporationbodies or 4,220,000 employees. The others are similar.

Table 4
The Input and Output of DMUs

DMU	Scale efficiency	Ideal condition of DMUs: Ideal output	Ideal input 1	Ideal input 2	The lack of output (s^{+})	The excess of input(s^{-}): Number of corporationbody	Number of practitioners
DMU1	0.999	9179.190	256753.061	728.833	0	-69316.939	-196.767
DMU2	0.988	3405.160	99464.000	220.200	0	0	0
DMU3	0.971	6068.310	159184.527	779.501	0	-54939.473	-421.9
DMU4	0.932	2886.920	81718.812	326.305	0	-54644.188	-218.195
DMU5	1.000	8930.850	259954.000	534.200	0	0	0
DMU6	0.999	13629.070	356857.460	1486.825	0	-29179.540	-121.575
DMU7	0.998	9918.780	260086.970	1085.435	0	-68282.030	-284.965
DMU8	0.943	3662.150	98863.387	497.531	0	-51980.613	-570.869
DMU9	0.968	5048.490	135999.691	576.401	0	-42045.309	-178.199
DMU10	0.918	2637.070	73165.181	377.405	0	-40095.819	-348.955
DMU11	0.999	11768.180	312506.556	1212.977	0	-129107.444	-501.123
DMU12	0.968	5700.910	149974.007	736.446	0	-91929.993	-772.753
DMU13	0.963	5127.120	135589.399	669.206	0	-105493.601	-550.494
DMU14	0.965	5402.810	142500.799	701.513	0	-52036.201	-514.787
DMU15	1.000	18052.590	459624.000	2183.900	0	0	0
DMU16	0.921	2919.130	80722.935	393.377	0	-66881.065	-325.923
DMU17	0.738	748.590	25822.000	156.100	0	0	0

This result also suggests that, most provinces make big investment owing to the recognition of the tertiary industry's importance to national economy growth, and the scale efficiency is almost 1. However, the average of pure technical efficiency is 0.769. This figure means that there is 23.1% for expanding. So, the development of technology is tertiary industry's direction. We should constantly develop and improve the conventional industries of tertiary industry, such as real estate; and speed up the burgeoning industry, like finical and insurance industry; also be active in expanding the technical service, electronic industry, internet digital industry, especially pay attention on the industrialization, commercialization and export-orientation of skill and knowledge intensive industry, to promote a rapid development of tertiary industry.

4. CONCLUSIONS

From above we can see that Shanghai and Guangdong province are DEA efficient, with the optimal match of the input and output. Tianjin and Hainan are weak efficient, whose technical efficiency is 1 but scale efficiency is less than one, and they can achieve relative optimum of input-output ratio by decreasing input or increasing output. The rankings of performance evaluation are as follows: Shanghai, Guangdong, Jiangsu, Beijing, Shandong, Zhejiang, Tianjin, Hebei, Fujian, Henan, Hunan, Hubei, Anhui, Shanxi, Guangxi, Jiangxi and Hainan. In general, the eastern provinces belong to upper-middle class.

However, there is some shortcoming. There is an imbalance between regions, for example, the big gap in the absolute amount of input, a waste of resources, insufficient output. Therefore, we should keep the advantage, make up the deficiency to enhance the proportion of tertiary industry accounted for national economic development further.

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