Study on operational efficiency evaluation of civil aviation listing corporation

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***Abstract*— In recent years, civil aviation industry has great development, but the management of civil aviation enterprise is still extensive. So it restricts the further development of industry. The paper analyzes the operating efficiency of 10 listed companies of civil aviation between 2010 and 2014 by the data envelopment analysis (DEA). It measures and evaluates the technical efficiency, pure technical efficiency, scale efficiency and returns to scale of these listed companies. Based on the results, the paper also gives the corresponding recommendations, which will help civil aviation enterprise improve operating performance.**

***Index Terms*— civil aviation listed company; operating efficiency; DEA model**

I. INTRODUCTION

With the sustainable development of national economy, civil aviation industry enters into the rapid growth stage, but the management of civil aviation enterprise is still extensive. As a result, the operation efficiency of civil aviation enterprise did not appear to increase. Civil aviation industry needs to solve the problem of high input and low output. Therefore, by the DEA model, the paper tries to measure the operating efficiency of civil aviation enterprise, to find out the reason and adjustment method of the low efficiency, to improve the civil aviation enterprise management level and provide basis for decision making.

II. DEA METHOD

A. DEA Theory

Data envelopment analysis, referred to as DEA, is proposed by Charnes, Cooper, and Rhodes of the American famous strategists in 1978. This is a non parameter statistical method based on relatively evaluation of production efficiency. Keeping the input and output of the decision making unit (DMU) unchanged, the method builds a relative effective production frontier with the mathematical programming method. Then it make a projection of all DMU onto DEA production frontier. On this basis, by comparing the deviation degree of DMU from DEA frontier to get the relative efficiency between them.

Compared with other efficiency evaluation methods, the DEA method does not directly integrate data, so the optimal efficiency index of DMU is unrelated to dimension of input and output. Moreover, DEA does not need to find out the explicit expression of the relationship of input and output, and does not require any hypothesis of weight. Wth the actual data, DEA can directly find out optimal weights, so it has strong objectivity.

B. DEA Model

The typical models of DEA are C^2R model and B^2R model. C^2R model assumes that DMU is in state of constant returns to scale, while B^2R model assumes that DMU is in state of variable returns to scale.

Suppose that there are n DMU_j (j=1,2,... , n), each DMU has m input and s output, respectively represented as x_{ij}（i=1,2，…，m）and y_{rj}（r=1,2，…，s）,which is the input and output elements of DMU. x_{ij} denotes the i-th input of the j-th DMU. y_{rj} denotes the r-th output of the j-th DMU. The dual form of C^2R model can be expressed as follow:

$$\min\left[\theta-\varepsilon\left(\sum_{i=1}^{m}s_i^-+\sum_{r=1}^{s}s_r^+\right)\right]$$

$$\text{s.t.}\begin{cases}\sum_{j=1}^{n}\lambda_j x_{ij}+s_i^-=\theta x_{ij0}\\ \sum_{j=1}^{n}\lambda_j y_{rj}-s_r^+=y_{rj0}\\ \theta,\ \lambda_j,\ s_i^-,\ s_r^+\geq 0\end{cases}$$

Where θ is the index of the technical efficiency, s_i^- and s_r^+ is respectively variable of the input slack and the output slack, λ_j is an unknown weight of every DMU, ε is the non archimedes infinitesimal, and generally take the value of 10^{-7}.

The optimal solution of the C^2R model is assumed as θ^*，S^{*+}，S^{*-}，λ^*. Then, analysis of the technical efficiency, pure technical efficiency and scale efficiency can be carried on the DMU.

- Technical efficiency analysis

(a) If $\theta^*=1$，and ($S^{*+}\neq 0$ or $S^{*-}\neq 0$), then DMU is weak DEA efficient. It means that economic activity of the DMU is not optimal for both the technical efficiency and the scale efficiency.

(b) If $\theta^*=1$, and $S^{*+}=S^{*-}=0$, then DMU is DEA efficient, It means that economic activity of the DMU is optimal for both the technical efficiency and the scale efficiency. The DMU plays better in the current production scale and operation level.

(c) If $\theta^*<1$, then DMU is DEA invalid. The smaller θ^* is, the worse its relative efficiency is.

Scale efficiency analysis

λ^* can be used to analyze the scale efficiency of DMU. If $\sum\lambda_j^*=1$, it is constant returns to scale. If $\sum\lambda_j^*<1$, it is increasing returns to scale. If $\sum\lambda_j^*>1$, it is decreasing the returns to scale.

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- Pure technical efficiency analysis

Add 1 constraint condition as follow into the C^2R model:

$$\sum_{j=1}^{n} \lambda_j = 1$$

B^2R model can be got. It can calculate the pure technical efficiency, which reflects the ability to provide maximum output in a given input, or minimize the input in a given output. Therefore, the technical efficiency θ * is decomposed into two factors: the pure technical efficiency and the scale efficiency. Their relationship is expressed as: technical efficiency=pure technical efficiency × scale efficiency.

III. CIVIL AVIATION LISTED COMPANY OPERATING EFFICIENCY ANALYSIS

A. DMU and Indexes of the Input and Output

In this paper, DMU is 10 civil aviation listed companies, including Air China, China Southern Airlines, China Eastern Airlines, Hainan Airlines, Shandong Airlines, Beijing Capital Airport, Baiyun Airport, Shanghai Airport, Xiamen Airport, Shenzhen Airport.

Total assets, management costs and staff salaries are selected as the indexes of input. Total assets are assets which can bring all benefits to the enterprise. It is the basis of enterprise production activities. Management costs reflect the enterprise's management level, which affects the overall performance of enterprises. Staffs are the development power of enterprise. Staff salaries reflect the enterprise investment of labor.

Net profit and earnings per share are selected as the indexes of output. Net profit is the final result of enterprise business. It is the main index to measure the management efficiency of enterprise. Earnings per share are the ratio of the net profit and the total share capital. It is an important index of profit ability of the enterprise.

B. Data Source

In this paper, data came from the annual reports of 10 civil aviation listed companies. With the DEAP 2.1 software, using C^2R model and B^2R model, the paper firstly analyzes the average efficiency of 10 civil aviation listed company between 2010 and 2014.On this basis, the paper analyzes individual operational efficiency of the civil aviation listed company in 2014 and put forward the improvement direction.

C. Civil Aviation Listed Company Average Efficiency Analysis

In 2014, the total transportation turnover volume of Air China, China Southern Airlines, China Eastern Airlines, Hainan Airlines and Shandong Airlines is 686.3 billion ton kilometers, accounting for 91.7% of the transportation turnover volume of all airlines of China. The total passenger throughput of Beijing Capital Airport, Baiyun Airport, Shanghai Airport, Xiamen Airport and Shenzhen airport is 2.7 billion, accounting for 32.1% of the passenger throughput of all airports of China. The total cargo throughput of them is 7.88 million ton, accounting for 58.1% of the cargo throughput of all airports of china. Therefore, to some extent, the average efficiency of the 10 civil aviation listed companies can reflect the operational efficiency of civil aviation industry.

The paper divides the 10 civil aviation listed companies into two groups; these are airline group and airport group. The average efficiency calculated is shown in table 1.

2010~2014 civil aviation listed company average efficiency

group	average value	2010	2011	2012	2013	2014
airline	technical efficiency	0.678	0.5544	0.3156	0.2654	0.2694
airline	pure technical efficiency	0.8672	0.9672	0.9032	0.8314	0.7984
airline	scale efficiency	0.7586	0.5668	0.3382	0.311	0.3328
airport	technical efficiency	0.7832	0.8868	0.8774	0.878	0.8376
airport	pure technical efficiency	0.8686	0.9524	0.9654	0.9692	0.9078
airport	scale efficiency	0.8804	0.9152	0.8996	0.9006	0.9016

As can be seen in table 1, between 2010 and 2014, the average value of the technical efficiency of airport is close to 1, while the average value of the technical efficiency of airline is far less than 1. Figures also show that the average scale efficiency level of airline is significantly lower than the level of pure technical efficiency.

Analyzing the development situation of civil aviation industry between 2010 and 2014, the paper thinks that there are 3 main reasons for the above situation. First, the number of domestic airport is relatively less, in certain region often only 1 airport, so with the development of civil aviation, the utilization efficiency of the airport is improving. Second, oil price continues to rise so that airline fuel costs continue to increase and after 2011, the appreciation of RMB has narrowed so that airline exchange income decreases considerably. All of these directly weakened the airlines' performance. Third, scheduled aircrafts have been delivered and the transport power of airlines grows, but the market demand of passenger and cargo transportation was shunt by the High-speed Rail and the third party logistics company booming after 2010. The market demand cannot keep up with the airline resource input, so it restricts the scale efficiency of airlines and eventually leads to the inefficient operation efficiency of airlines.

D. Civil Aviation Listed Company Individual Efficiency Analysis

Through calculation, the paper gets the individual operation efficiency of the civil aviation listed companies of 2014. The result is shown in table 2.

As can be seen in table 2, in the technical efficiency, the value of Beijing Capital Airport, Baiyun Airport and Shanghai Airport are 1, so they are DEA efficient. The value of the rest companies are less than 1, so they are DEA invalid. That means that under the present management level and production scale, Beijing Capital Airport, Baiyun Airport and Shanghai Airport have achieved the best maximum yield and benefit, but other listed companies are not.

Analyzing the DEA invalid companies, Air China, China Southern Airlines, Hainan Airlines and Xiamen Airport are efficient in the pure technical efficiency, but invalid in the scale efficiency, which lead to their DEA invalid. Therefore, improving the scale efficiency, it can improve their technical efficiency. They are also in the stage of decreasing returns to scale. It reflects in the current technical level, too much input makes the scale of the four companies more than the optimal scale ,and redundant input is the bottleneck of scale efficiency improvement. Therefore, they must adjust the operation scale and optimize the input structure, such as airline closing high cost but small gains routes, grounding low guest rate flights, combining suitable routes etc. At the same time, they also need to develop the market demand so as to improve the scale efficiency.

2014 civil aviation listed company individual operation efficiency analysis

DMU	technical efficiency	pure technical efficiency	scale efficiency	returns to scale
Air China	0.175	1	0.175	decreasing
China Southern Airlines	0.095	0.512	0.185	decreasing
China Eastern Airlines	0.205	1	0.205	decreasing
Hainan Airlines	0.663	1	0.663	decreasing
Shandong Airlines	0.209	0.48	0.436	decreasing
Beijing Capital Airport	1	1	1	unchanged
Baiyun Airport	1	1	1	unchanged
Shanghai Airport	1	1	1	unchanged
Xiamen Airport	0.813	1	0.813	decreasing
Shenzhen Airport	0.375	0.539	0.695	increasing

As for China Southern Airlines, Shandong Airlines and Shenzhen Airport, both scale efficiency and pure technical efficiency are not high, so the enterprises need to use advanced management mode, improve the technical level and pay more attention to the coordination of technical progress and operation scale to improve the efficiency of resource use and management level.

CONCLUSION

The paper analyzes the operating efficiency of 10 civil aviation listed companies by the DEA method and gives the corresponding development recommendations. The research can help civil aviation enterprises improve their operating performance.

REFERENCES

[1] Distexhe.V,Perelman.S.,"technical eifficiency and productivity growth in an era of deregulatation:the case of airlines", Swiss Journal of Economics and Statistics, vol.130, Apr.1994, pp.669-689.

[2] Carlos Pestana Barros, Peter U.C. Dieke.,"performance evaluation of Italian airports: a data envelopment analysis," Journal of Air Transport Management, vol.13,Jul. 2007, pp.184-191.

[3]WANG Zhan bin,"an empirical study of chinese airports operational efficiency based on DEA,"Journal of Transportation Systems Engineering and Information Technology,vol.12,Dec.2012,pp. 186-191