# Journal of Applied Sciences

ISSN 1812-5654

Journal of Applied Sciences 13 (9): 1443-1448, 2013
ISSN 1812-5654 / DOI: 10.3923/jas.2013.1443.1448


# Comprehensive Evaluation on Profitability of the Listed Airlines in China

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**Abstract:** An evaluation and analysis for improving the profitability of airlines has been a key issue since the aviation industry has developed slower since the financial crisis. Many scholars have evaluated the performance of the listed airlines in a single evaluation approach. As a result, these different methods come to different evaluation results for the same companies. Therefore, a comprehensive evaluation system is proposed in this study and applied towards the evaluation of 12 Chinese listed companies. This approach overcame the one-sidedness of a single method and obtained more comprehensive and objective evaluation results.

**Key words:** Evaluation on profitability, Chinese airlines, factor analysis, principal component analysis, correlation degree, cluster analysis

## INTRODUCTION

The economic development and gradual opening of China's aviation market has grown increasingly rapidly. The throughput continues to maintain its high growth. For example, the growth of China's air cargo has risen by 34.5% in the past 5 years; passenger throughput of Shanghai airlines will reach 100,000,000 in 2015. Meanwhile, with the impact of the positive factors, such as the stabilization in oil prices and the appreciation of Chinese currency (Renminbi, namely, RMB), the operating environment of the aviation industry is better than that in previous years. Therefore, an evaluation of the profitability of airlines has become the core of research. To acquire and retain customers in such a highly competitive market, it is of strategic importance for Chinese airlines to understand the critical factors affecting their profitability. The primary purpose of this study is to evaluate the profitability of Chinese listed airlines according to these critical factors.

Among the dozens of contemporary comprehensive evaluation methods worldwide, there are two general categories: subjective and objective weights-based evaluation methods. The former are mostly qualitative approaches, such as Analytic Hierarchy Process (AHP) (Isaai *et al*., 2011) and the fuzzy comprehensive evaluation method (Wang and Hu, 2000), where the weights are retrieved from the subjective judgments of experienced experts. In Grey Relation (Liou *et al*., 2011), Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) (Torlak *et al*., 2011) and Principal Component Analysis (PCA) (Shan *et al*., 2011), the indicator weights are determined either by the indicator correlations or by the variation coefficient of the indicators. However, when evaluating listed airlines as well as other social and economic henomena, most scholars only use one evaluation method, such as the Factor Analysis (FA), PCA, etc., (Yuan, 2013; Mao *et al*., 2013; Zhang, 2012; Shi *et al*., 2013; Qi *et al*., 2008).

Analytic Hierarchy Process (AHP) is a structured technique for dealing with complex decisions. Rather than prescribing a "correct" decision, AHP helps decision makers find one decision that best suits their goal and their understanding of the problem. That is a process of organizing decisions that people are contemplating. Cheng and Lu (2010) evaluated tourism resources exploration potential of Zhangdu Lake wetland using the evaluation index system based on AHP.

In enterprise profitability evaluation, the fuzziness of some factors makes them difficult to evaluate but a comprehensive evaluation method based on fuzzy mathematics can quantitatively evaluate the profitability of enterprises to make up for the disadvantage of AHP. Wang *et al*. (2011) built a set of environmental evaluation index system to develop the circular economy for the iron and steel industry based on the ideas and theories of circular economy.

In an incomplete and inaccurate profitability system, due to many complex factors or inadequate data, multilevel gray evaluation expands the information sources and improves the reliability of evaluation and analysis. In addition, Gray Relation Analysis (GRA) between these two factors can quantitatively analyze the correlation degree, which is more reasonable and more accurate. Lan and Kai (2009) used multilevel gray evaluation method to evaluate the innovation capability of hub-and-spoke enterprise clusters. They combined the advantages of the analytic hierarchy process and the grey clustering method. The result showed that their methodology was especially useful when there was partial information and/or qualitative variables were used.

Ustinovichius and Simanaviciene (2010) studied the sensitivity analysis for cooperative decision using TOPSIS. However, judging from the ranking decision-making steps of Technique for Order Preference by Similarity to Ideal Solution (TOPSIS), TOPSIS has some inevitable drawbacks, (a) In the real world, it is not practical to find the positive and the negative ideal solutions. But these two solutions are the necessary boundaries of the entire solution set, (b) In this method, the weight information is determined in advance and the weight values are usually subjective, resulting in a certain subjective arbitrary and (c) In the application, the new projects are likely to cause TOPSIS reverse. Therefore, a more specific in-depth analysis is always in need afterwards.

Principal Component Analysis (PCA) uses an orthogonal transformation to convert a set of observations of possibly correlated variables into a set of values of uncorrelated variables. PCA is mostly used as a tool in exploratory data analysis and for making predictive models (Shaw, 2003). However, principal components are guaranteed to be independent only if the data set is jointly normally distributed and if the PCA is sensitive to the relative scaling of the original variables. FA is an improvement over the PCA, in that it estimates how much of the variability is due to common factors. But Sternberg (1977) proposed that in FA, each orientation is equally acceptable mathematically. This means that all rotations represent different underlying processes but all rotations are equally valid outcomes of standard factor analysis optimization. Therefore, it is impossible to select the proper rotation using factor analysis alone. In addition, more than one interpretation can be made of the same data factored the same way; moreover, factor analysis cannot identify causality (Darlington *et al.*, 1973).

In summary, many mathematical methods can be applied in comprehensive evaluations but the different focal points of these methods and the choice of methods may lead to different evaluation results, even if they are based on the same data. Both the theory and methods to evaluate the profitability of the airlines need to be developed and improved. Therefore, the core issue is to study the profitability of airlines, discuss the mechanism of airline profitability, the evaluation system and the method used to enhance profitability. In order to evaluate airline management and performance, this study presents a new approach to evaluate the Chinese aviation industry, obtaining more comprehensive, objective and realistic results.

## METHODS

In order to evaluate and analyze the 12 listed airlines comprehensively and scientifically, an integrated approach was applied. First of all, FA, PCA and GRA were utilized to analyze and evaluate the profitability and three results were retrieved, respectively. Second, Kendall-W was used for the consistency test of these results. If they were consistent, the scores would be standardized and summed up. The final ranks would be based on the summation of the standard scores. If the results were not consistent, the three methods would be compared pair wisely. The consistent methods would be sorted together. Then, the sample data, the evaluation results and the nature of the methods would be analyzed specifically and the objective, realistic and consistent methods would be selected for the comprehensive evaluation. The followings are the detailed steps:

**Step 1:** Evaluate, respectively using FA, PCA and GRA
**Step 2:** Test the consistency of the results by Kendall-W
**Step 3:** Standardize the scores of each sample retrieved from each method and obtain the standard score $R_{ij}$. ($R_{ij}$ represents the standard score of the sample in the method)
**Step 4:** Calculate: $P_i = \sum R_{ij}$
**Step 5:** Rank according to the value of $P_i$

## RESULTS

**Data and the index:** The indicators were selected fully and scientifically according to the financial theory, data availability and the specific issue in this study. These indicators can reflect the profitability of the aviation industry objectively and systematically. The five indicators for the comprehensive evaluation and analysis of the 12 Chinese listed airlines were rate of return on sale ($X_1$), profit rate of sales cost ($X_2$), operating profit rate of cost ($X_3$), rate of return on total assets ($X_4$) and return on equity ($X_5$). SPSS14.0 MATLAB and EXCEL were the software tools for FA, PCA and GRA. The sources came from the Sohu Annual Reports of Financial Listed Companies in 2010 (Sohu, 2010).

### Comprehensive evaluation and analysis of the profitability

- **Factor analysis:** Standardize the raw data, adjust the mean of the indicators and the values of variance to 0 and 1, eliminate differences between the dimensions of variables and obtain the following data (Table 1)

Table 1: Standardized data of the profitability indicators of the listed airlines

| Airline | $X_1$[1] | $X_2$ | $X_3$ | $X_4$ | $X_5$ |
|---|---|---|---|---|---|
| Shanghai airlines | -0.91 | -0.85 | -1.02 | -1.31 | -3.08 |
| Hainan airlines | -0.98 | -0.80 | -0.44 | -0.55 | 0.14 |
| China southern airlines | -0.86 | -0.99 | -0.65 | -0.88 | -0.28 |
| Shenzhen airport | 0.65 | 1.45 | 0.56 | 0.47 | 0.40 |
| Xiamen airport | 1.51 | 1.57 | 1.37 | 1.52 | 0.51 |
| Shanghai airport | 1.23 | 0.87 | 0.45 | 0.54 | 0.42 |
| Baiyun airport | 0.63 | 1.07 | 0.57 | 0.56 | 0.43 |
| [2]COHC | 0.50 | 0.35 | 0.32 | 0.39 | 0.41 |
| Hainan airlines (B Share) | -0.98 | -0.80 | -1.08 | -0.58 | 0.14 |
| Air China | -1.39 | -0.73 | -1.69 | -1.62 | -0.07 |
| Sinotrans | 0.83 | -0.90 | 1.59 | 1.40 | 0.49 |
| Shandong air (B Share) | -0.24 | -0.23 | 0.02 | 0.06 | 0.49 |

- Retrieve the eigenvalue and the variance contribution rate of each factor with PCA in SPSS. According to the principle that the cumulative contribution rate should be over 85% and were selected as the factors whose cumulative were 89.43%
- Obtain the factor loading matrix with the Varimax orthogonal rotation matrix and then retrieve the scores of the factors by regression. Take the ratio of the variance contribution rate of each factor to the cumulative variance contribution rate of the remaining four factors as the weight. Aggregate the weights and retrieve, which is the composite score of each company:

$$F = \frac{F_1 \times 0.7601 + F_2 \times 0.13425}{0.89435} \tag{1}$$

**Principal component analyses:**

- Standardize the raw data using SPSS to establish the correlation matrix of variables R
- Calculate the eigenvalues and the corresponding contribution rates of R using SPSS (Table 2)

According to the principle that the cumulative contribution rate should be over 85%, the two factors and were extracted as:

$$Y_1 = 0.254*X_1' + 0.208*X_2' + 0.241*X_3' + 0.255*X_4' + 0.171*X_5' \tag{2}$$

$$Y_2 = -0.315*X_1' - 0.364*X_2' - 0.136*X_3' - 0.04*X_4' + 1.113*X_5' \tag{3}$$

Table 2: Eigenvalue and contribution rate of the principal components in PCA[3] for the profitability evaluation of Hainan airline

| Parameters | $Y_1$[4] | $Y_2$ | $Y_3$ | $Y_4$ | $Y_5$ |
|---|---|---|---|---|---|
| Eigenvalue | 3.80 | 0.671 | 0.478 | 0.037 | 0.014 |
| Contribution rate | 0.76 | 0.130 | 0.100 | 0.010 | 0.000 |
| Cumulative contribution rate | 0.76 | 0.890 | 0.990 | 0.990 | 1.000 |

where, $X_i'$ was the standardized $X_i$.

- Calculate F:

$$F = \frac{Y_1 \times 0.7601 + Y_2 \times 0.13425}{0.89435} \tag{4}$$

**Grey relational analysis**

- Establish the reference sequence based on the maximum value of each indicator. Standardize the raw data, that is, divide the maximum value of each index for each company through this index value. If the profitability of a listed company is highly correlated to this reference sequence, the score of the company will be high; that is to say, the company has high profitability
- Take the indicators of the 12 listed airlines as the comparison sequence. Calculate the "corresponding difference list" of each comparison and reference sequence. The maximum corresponding difference is $\Delta max = 1.57$ and the minimum $\Delta min = 0$
- According to the actual situation of the transport industry, assume that the discrimination coefficient is $\xi = 0.5$, calculate the correlation coefficient $\delta_i$ (k) and the correlation degree $\sigma_i$ of $x_i$, the comparison sequence and $x_0$ and the reference sequence, by using the equation:

$$\delta_i(k) = \frac{\Delta min + \xi \Delta max}{\Delta_{0i}(k) + \xi \Delta max} \tag{5}$$

and:

$$\sigma_i = \frac{1}{N} \sum_{k=1}^{N} \delta_i(k) \tag{6}$$

where, N is the number of indicators.

Specific calculation of the correlation degree is shown in Table 3. Hainan Airlines is used as the example. Four rank the companies based on their correlation degrees.

[1]Rate of return on sale ($X_1$), Profit rate of sales cost ($X_2$), Operating profit rate of cost ($X_3$), Rate of return on total assets ($X_4$) and Return on equity ($X_5$)
[2]China ocean helicopter corp
[3]Principal component analysis
[4]$Y_1$, $Y_2$,..., $Y_5$ are the five principal components in PCA based on the data from Hainan airlines

Table 3: Calculation of the correlation degree of Hainan Airlines

| Indicator | $X_1$[5] | $X_2$ | $X_3$ | $X_4$ | $X_5$ |
|---|---|---|---|---|---|
| Reference sequence | 30.2779 | 47.3408 | 16.6442 | 12.802 | 17.48 |
| Hainan Airlines | -10.51 | 4.8057 | -3.485 | -3.231 | -23.19 |
| **Standardization** | | | | | |
| $X_0$ | 1 | 1 | 1 | 1 | 1 |
| $X_1$ | -0.34713 | 0.101513 | -0.18256 | -0.25244 | -1.32666 |
| $\|X_0 (k)-X_i (k)\|$ | 1.347 | 0.898 | 1.182 | 1.252 | 2.326 |
| $\Delta_{0i}$ (k) | 134 | 487 | 56 | 437 | 659 |
| $\delta_i$ (k) | 0.368 | 0.350 | 0.446 | 0.432 | 0.828 |
| $\sigma_i$ | 0.4852 | | | | |

Table 4: Profitability Evaluation scores and ranks of the 12 listed airlines and airports based on PCA, GRA and FA

| | | PCA[6] | | GRA[7] | | FA[8] | | | |
|---|---|---|---|---|---|---|---|---|---|
| No. | Company | Score | Rank | Score | Rank | Score | Rank | Total score | Total rank |
| 1 | Shanghai airlines | -1.960 | 12 | -1.380 | 12 | -0.700 | 8 | -4.040 | 12 |
| 2 | Hainan airlines | -0.490 | 8 | -0.690 | 8 | -0.840 | 9 | -2.020 | 8 |
| 3 | China southern airlines | -0.770 | 10 | -0.910 | 10 | -0.940 | 10 | -2.620 | 10 |
| 4 | Shenzhen airport | 0.719 | 4 | 0.702 | 3 | 0.866 | 2 | 2.286 | 3 |
| 5 | Xiamen airport | 1.384 | 1 | 1.996 | 1 | 1.651 | 1 | 5.031 | 1 |
| 6 | Shanghai airport | 0.746 | 3 | 0.635 | 4 | 0.864 | 3 | 2.246 | 4 |
| 7 | Baiyun airport | 0.696 | 5 | 0.521 | 5 | 0.765 | 4 | 1.982 | 5 |
| 8 | [9]COHC | 0.463 | 6 | 0.148 | 6 | 0.392 | 6 | 1.003 | 6 |
| 9 | Hainan airlines (B Share) | -0.640 | 9 | -0.770 | 9 | -1.030 | 11 | -2.430 | 9 |
| 10 | Air China | -1.180 | 11 | -1.030 | 11 | -1.530 | 12 | -3.740 | 11 |
| 11 | Sinotrans | 0.912 | 2 | 0.966 | 2 | 0.710 | 5 | 2.588 | 2 |
| 12 | Shandong air (B Share) | 0.114 | 7 | -0.190 | 7 | -0.200 | 7 | -0.280 | 7 |

**Evaluation scores and ranks in PCA, GRA and FA:** The reason why the factor scores of a company were negative was that the original data were standardized and the average of the profitability indicators was addressed as zero. Therefore, the negative profitability scores of an airline just indicated that the profitability of the company was lower than the average performance. For the specific scores and ranks in the three methods (Table 4).

**Test of the evaluation results in Kendall-W:** Kendall's W that can be used for assessing agreement among raters was used to examine the consistency of the evaluation results of N objects from M methods. Kendall's W ranges from 0 (no agreement) to 1 (complete agreement) (Kendall and Smith, 1939):

$$W = \frac{12\sum_{i=1}^{n} R_i^2 - 3\ m^2 n\ (n+1)^2}{m^2 n\ (n^2-1)} \quad (7)$$

where, k denotes the number of evaluation methods, $R^2_0$ that of objects and $R^2_p$ the sum of the rankings of these objects.

The hypothesis was that $H_0$ denoted the inconsistency of the rankings and $H_1$ the consistency.

To test if the statistic $\chi^2$ = m (n-1)W approximated in a large sample, determine if; if so, reject $X^2_\alpha(n-1)$ and accept the hypothesis of the consistency among the $x^2 \geq x^2_\alpha$ rankings.

According to Nonparametric tests in SPSS, the coefficient of concordance was W = 0.954 and was approximate the significance probability of ASYMP, with sig = 0.000<0.05.

**Clustering analysis:** Take the standard scores in the three methods as the cluster indicators and cluster the 12 listed airlines with the Euclidean Distance Method. According to the clustering dendrogram generated from the SPSS 14.0 package, these airlines can be divided into three groups. The first group includes Xiamen Airport only. The second group includes 5 airlines, i.e., Baiyun Airport, Sinotrans, Shanghai Airport, COHC and Shenzhen Airport. And the third group includes 6 airlines, i.e., Hainan Airlines, Hainan Airlines (B Share), China Southern Airlines, Shandong Air (B Share), Air China and Shanghai Airlines.

Two results can be generated. First, the clustering results of the profitability were closely related to the main business of the airlines. It was obvious that the profitability of the airports and the auxiliary companies was better than that of the transport airlines.

[5]Rate of return on sale ($X_1$), Profit rate of sales cost ($X_2$), Operating profit rate of cost ($X_3$), Rate of return on total assets ($X_4$) and Return on equity ($X_5$)
[6]Principal component analysis
[7]Gray relation analysis
[8]Factor analysis
[9]China ocean helicopter corp

In type 1, Xiamen Airport was principally engaged in the service of terminal and ground facilities for domestic and international airlines. In the financial crisis, this company took efforts to promote transit operations, the implementation of the easily-accessed channel and *ad hoc* adherent technologies. All of these policies contributed to the development of the aviation market in Xiamen.

In type 2, the three major airports focused on transportation and the auxiliary business. Sinotrans was engaged in the import and export goods, as well as in the agency business of the transit of the international goods across the border. The main business of COHC was oil services.

In type 3, the airlines are all engaged in the passenger and cargo transportations. Their performance was poor in 2010 for the following reasons: (1) The global financial crisis reduced the demand, (2) Oil prices increased dramatically, (3) The tendency towards RMB appreciation slowed down and (4) A large purchase of aircraft also increased the airline's respective financial burdens and depreciation costs.

Secondly, in the poor financial condition, the profitability of the airlines is inversely proportional to the size of the company. In type 3, small companies, namely, Hainan Airlines (B Share), Shandong Air (B Share) and Hainan Airlines were rated better than large airlines such as China Southern Airlines, Air China and Shanghai Airlines. The reason why is believed to be that the big companies could not achieve similar economies of scale as compared to the small airlines, as well as the cost amortization of the fixed.

## CONCLUSION

As can be seen from the final evaluation results, the profitability of Xiamen Airport ranked first in the aviation industry, which is consistent with the actual condition. In this study, a comprehensive evaluation approach was proposed based on the previous evaluation methods. This improvement overcomes the one-sidedness of a single method and the disadvantages of other methods and eliminates the difference of various evaluation methods. This approach leads to the more objective, comprehensive and realistic evaluation results. In particular, the final evaluation scores can be clustered to obtain a more accurate classification. This model can offer some suggestions and reference to various evaluations of the listed companies. This way of choosing the benchmarking companies in the listed companies is also a helpful tool to study the benchmarking companies and propose the improvement policies for listed companies.

The proposed method can not only be a comprehensive analysis and evaluation of the profitability of the listed airlines but also help the investors to understand the status and the weak points of the listed Chinese airlines. The further research and discussion may include, (1) The study of the profitability evaluations of the airlines and airports from various countries, (2) The enrichment and the improvement of the evaluation theory and the methodology, (3) The selection and contributions of the non-financial indicators in the profitability evaluation and (4) The detailed recommendations and suggestions for the decision makers, policy makers and airline companies.

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