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Chinese Transportation Industry and Performance Evaluation

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Abstract: Purpose to introduce the status quo of China's transportation development and performance evaluation of transportation industry and to construct an improved integrated evaluation model. Methodology The demonstration procedures and results are shown through the analysis of the most eminent transport corporations in the Chinese transportation industry. First, Analytic Hierarchy Process, Gray Relation Analysis and Factor Analysis are used in the model. After the test, an integrated evaluation model is conducted based on an Arithmetic Average Model, Borda Model and Copeland Model. The optimal model is selected based on the Spearman Rank Correlation coefficients. Findings The results showed that the benchmarking companies were Tielong Logistics in the railway transport, Beijing Media in the waterway transport and Channel Share in the road transport. The financial performances of the listed companies in road transport were the best. Originality We proposed an integrated evaluation method that improved the evaluation methodology and solved the problem of the one-sidedness in an individual evaluation method and the inconsistency in the multiple evaluation methods. The prior test and the back test of the integrated method indicated that the entire methodology was consistent.

Key words: Integrated evaluation, factor analysis, analytic hierarchy process, gray relation analysis, cluster analysis

INTRODUCTION

Transportation, as a basic part of the integrated economic system, plays a pivotal role in China's development. Since the reform and opening up, transportation productivity in China has undergone a sustainable and rapid growth, but the problem of the rough extensive development pattern has not been solved. Facing the future, we must accelerate the development and move towards a new stage of the modern transportation. As can be seen from China's transportation structure, the proportion of the road transportation and the aviation transportation is rising rapidly, which is closely related to China's economic development and industrial structure changes. With the economic development, the proportion of secondary and tertiary industries gradually increases in the industrial structure. The highly-qualified and highly-efficient passenger and freight transportation is in a higher demand. With its advantages of mobility, flexibility and "door-to-door" delivery service, the capacity of the road transportation must be in an inevitable growth under the premise of better road conditions and vehicle equipments. Aviation industry holds its own place in the rapid economic development because of its quick and safe transportation. This trend is in the accordance with the basic law of transportation development in more developed countries. Transportation, a basic industry in every nation, was badly beaten in the world financial crisis of 2008. Therefore, it has become important to improve the performance of listed transport companies. An empirical study of the financial performance of Chinese transportation companies can contribute to the related research worldwide.

LITERATURE REVIEW

The stock market is the "barometer" of the economy. Therefore, the sound and orderly development of listed companies is an important topic in economics. Currently, an evaluation study of the following 26 listed companies is divided into three categories. The first category concerns the evaluation index system; the second category concerns the evaluation of specific management issues, such as: performance evaluation (Tao and Chen, 2009; Zhao *et al*., 2009), evaluation of social responsibility, profit quality evaluation (Zang *et al*., 2008), evaluation of corporate management and evaluation of

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growth (Chen *et al*., 2006); the third category concerns method, the most important aspect in the evaluation, because method always focuses on the common issues instead of a specific aspect in the management. Due to different focal points of methods, it is no doubt one-sided to evaluate in any single method. Some scholars have tried to integrate different methods to evaluate the listed companies, such as Factor Analysis (FA), Super-Efficiency-Data Envelopment Analysis (SE-DEA) (Sun and Zhao, 2010), sequence analysis, relationship between entropy method (Mi and Huang, 2008), FA and Backpropagation Neural Network (BPNN) (Wang *et al*., 2010), Stochastic Frontier Analysis-Data Envelopment Analysis (SFA-DEA) (Qi *et al*., 2008). Wang *et al*. (2009) built an improved integrated evaluation model based on Analytical Hierarchy Process (AHP), FA, Gray Relation Analysis (GRA), etc. However, most of these methods haven't taken into the consideration the inconsistency of different methods in an integrated evaluation model.

METHODOLOGY

The evaluation index system on the financial performance of the listed Chinese transportation companies was built on the principles of scientific feasibility and completeness, hierarchy and association, independence and complementarity, comparability and quantifiability, simplicity and availability, etc., This multi-level multi-angle and multi-aspect system includes 4 indexes, namely, solvency, profitability, operation and the asset management and 10 individual indicators (X_1~X_{10}), namely, Quick ratio, Asset-liability ratio, Profit rate to net worth, Return on equity, Earning per share, Growth rate of revenue, Growth rate of operating income, Inventory turnover, Accounts receivable turnover and Total asset turnover.

Improvement of the integrated evaluation model: The prior test with Kendall's W method: Kendall's W, used for assessing agreement.

Among raters, was used to examine the consistency of the evaluation results of N objects from M methods. (Kendall and Smith, 1939):

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

where, m denotes the number of the evaluation methods, n that of the objects and H_1 the sum of the rankings of these objects. Hypothesis H_0 denotes the inconsistency of the rankings and H_1 the consistency. Test if the statistic $\chi^2 = m(n-1)W$ approximates $\chi^2_{\alpha/2}(n-1)$ in a large sample. When $\chi^2 \geq \chi^2_{\alpha/2}$, reject H_0 of the consistency among m rankings.

Binary comprehensive evaluation model:

Integrated evaluation model based on arithmetic average model: Let r_{ik} be the rankings of program y_i in the k-th method, i = 1, 2,..., n; k = 1, 2,..., m.

Convert the ranking of each method into an integer in the rate-scoring method, namely, n for No. 1, 1 for No. N and n-k+1 for No. K. If the rankings are the same, the mean of these rankings will be taken and calculated by the following formula:

$$\bar{R}_i = \frac{1}{m}\sum_{k=1}^{m} R_{ik} \tag{2}$$

Reorder these rankings m by average scores. If two $\overline{R_i} = \overline{R_j}$ are in the two programs, calculate the standard deviations of the scores of different methods with the formula:

$$\sigma = \sqrt{\frac{1}{2}\sum_{k=1}^{m}\left(R_{ik} - \bar{R}_i\right)^2} \tag{3}$$

where those with smaller standard deviations are better.

Integrated evaluation model based on Borda: The Borda count is a single-winner election method in which voters rank candidates in order of preference. Because it sometimes elects broadly acceptable candidates, rather than those preferred by the majority, the Borda count is often described as a consensus-based electoral system, rather than a majoritarian one. In the evaluation, if the number that y_i is superior to y_j is greater than the number that y_i is superior to y_j, then $y_i \prec y_j$. If the two numbers are equal, then $y_i = y_j$. The Borda matrix is defined as $B = \{b_{ij}\}_{m\times n}$:

$$b_{ij} = \begin{Bmatrix} 1, & y_i \succ y_j \\ 0, & \text{otherwise} \end{Bmatrix} \tag{4}$$

Define the score of y_i as:

$$b_{ij} = \sum_{j=1}^{n} b_{ij}$$

i.e., the number that y_i is superior to. Rank y_i based on the values of b_i. If $b_i = b_j$, calculate the standard deviations of different methods. The one with the smaller standard deviation is more superior.

Integrated evaluation model based on Copeland: Copeland's method or Copeland's pairwise aggregation method is a Condorcet method in which candidates are ordered by the number of pairwise victories, minus the number of pairwise defeats. Define:

$$c_{ij} = \begin{cases} 1, & y_i \succ y_j \\ 0, & \text{otherwise} \\ -1, & y_i \succ y_j \end{cases} \tag{5}$$

Define the score of y_i as:

$$c_{ij} = \sum_{j=1}^{n} c_{ij}$$

and rank t_i based on the values of c_i If $c_i = c_j$ calculate the standard deviations of different methods. The one with the smaller standard deviation is superior.

Back consistency test based on Spearman rank correlation coefficients: The purpose of a back test in an integrated evaluation is to test the correlation of the rankings from the integrated and individual evaluations. In addition, when there are multiple combinations of methods, the most reasonable combination of evaluations can be selected by the back test. The specific steps of the Spearman Rank Correlation Coefficients Method are as follows.

Convert the evaluation results into a ranking value. Assume that p combinations are conducted in the m initial methods. X_{ik} denotes the ranking of the i-th object with the k-th integrated method, $1 \le x_{ik} \le n$, (i = 1, 2, ..., n; k = 1, 2, ..., p).

Test hypothesis. Assume that H_0 denotes that the k-th integrated method is irrelative to the initial m evaluation methods and that H_1 denotes that the k-th integrated method is relative to the initial m evaluation methods. Construct statistics t_k ,which is subject to the t distribution, whose degree of freedom is n-2.

$$t_k = \rho_k \sqrt{\frac{n-2}{1-\rho_k^2}} \; (k=1,2...,p) \tag{6}$$

$$\rho_k = \frac{1}{2}\sum_{j=1}^{m} \rho_{ik} \tag{7}$$

where ρ_{ik} denotes the Spearman Rank Correlation coefficient of the k-th integrated method and the initial j-th method:

$$\rho_{jk} = 1 - \frac{6\sum_{i=1}^{n}\left(x_{ik} - x_{ij}\right)^2}{n\left(n^2-1\right)}, \; j=1,2...,m; k=1,2...,p \tag{8}$$

where, x_{ij} is the i-th value of the canonical result in the j-th method. x_{ik} is the i-th value of the canonical result in the k-th integrated method. n is the number of the objects. m is the number of the initial evaluation methods. p is the number of the integrated evaluation methods.

The final evaluation results: According to the values of the Spearman Rank Correlation coefficient, select the results of the most appropriate combination of evaluations as the final evaluation results, i.e., the largest t_k is the optimal integrated method. The purpose of the integrated evaluation method is not only to overcome the shortcomings of a single evaluation method, but also to take advantage of the various evaluation methods. Therefore, the results of the integrated evaluation methods are not identical to the results of the initial methods, but very close.

EMPIRICAL ANALYSIS

Factor analysis: Extract the factors using the Principal Component Method in SPSS14.0. 26 listed transport companies in China were taken as the research object in this paper. The eigenvalue and variance contribution rate of each factor were retrieved. According to the rule that the cumulative variance contribution rate should be over 85%, select factors F_1, F_2, F_3, F_4, and F_5 whose cumulative variance contribution rate was 87.09%.

Obtain the factor loading matrix using a Varimax matrix. Estimate the scores of the factors using the regression method. Take the ratio of the variance contribution rate of each factor in the cumulative variance contribution rate of the remaining four factors as the weight. Aggregate the weights and retrieve F, the composite score of each company:

$$F = \frac{F_1 * 38.37 + F_2 * 20.89 + F_4 * 9.91 + F_5 * 7.30}{87.09} \tag{9}$$

Analytical hierarchy process: In order to establish the pairwise judgment matrixes to determine the weights of the indexes, experts in the industry were surveyed to evaluate the financial performance of the listed transport companies by questionnaires in e-mails. 39 of the 45 questionnaires were recovered, among which 35 were valid. The comprehensive weights of the model are (0.06, 0.0828, 0.1285, 0.17, 0.13, 0.13, 0.1558, 0.04, 0.0529 and 0.05).

Grey relation analysis: Establish the reference sequence based on the maximum value of each indicator. Standardize the raw data. If a listed company's profitability is highly correlated to this reference sequence, the score of the company will be high. That is to say, the company

Table 1: The scores and the ranks of the listed companies based on AHP, GRA and FA

	AHP		GRA		FA	
Company	Score	Rank	Score	Rank	Score	Rank
Tielong logistics	63.25	2	0.555	3	0.76	2
Guangzhou-shenzhen railway	49.84	9	0.46	13	0.04	10
Datong-qinhuangdao railway	49.66	10	0.46	12	0.27	5
Kwok-hang rail	49.24	11	0.46	14	-0.08	19
China North locomotive and rolling stock industry	47.05	12	0.48	10	-0.02	14
Beijing media	61.89	3	0.56	2	0.25	6
Jiangxi changyun	55.39	4	0.505	6	0.25	7
China's medium-term	44.47	16	0.45	19	-0.03	15
Channel share	77.43	1	0.68	1	1.62	1
Yatong share	51.01	8	0.52	4	-0.01	13
Changjiang tanker	44.99	13	0.455	15	-0.04	16
Merchants transportation	44.64	15	0.45	17	0.21	9
COSCO shipping	44.24	17	0.45	18	0.01	12
China Shipping development	42.82	18	0.44	20	0.03	11
China shipping haisheng	40.64	20	0.43	21	-0.15	20
Ningbo marine	36.49	21	0.425	23	-0.17	21
China ocean shipping	27.4	24	0.41	25	-0.71	24
Tianjin marine shipping	23.69	25	0.515	5	-1.28	26
China shipping container lines	21.81	26	0.38	26	-0.91	25
Shandong airlines	53.26	5	0.505	7	0.32	3
Air China	53.1	6	0.505	8	0.32	4
CITIC offshore helicopter	51.57	7	0.47	11	0.22	8
China eastern airlines	44.79	14	0.495	9	-0.05	17
Hainan airlines	42.08	19	0.455	16	-0.07	18
Shanghai airlines	29.52	22	0.43	22	-0.5	23
China southern airlines	29.05	23	0.42	24	-0.26	22

has high profitability. Take the indicators of the 26 listed transport companies as the comparison sequence. Calculate the "corresponding difference list" of each comparison and reference sequence. The maximum corresponding difference is $\Delta\max = 0.989$ and the minimum $\Delta\min = 0$. To find 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 σ_i using the formula:

$$\delta_i(k) = \frac{\Delta\min + \xi\Delta\max}{\Delta_{0i}(k) + \xi\Delta\max} \quad (10)$$

$$\sigma_i = \frac{i}{N}\sum_{k=1}^{N}\delta_i(k) \quad (11)$$

where, N is the number of the indicators.

Rank the companies based on the correlation degrees. For the Scores and the Ranks in AHP, GRA and FA, Table 1.

The prior test with KENDALL-W: Apply Eq. 1 to the ranks in Table 1 and obtain χ^2 = 64.86. Take the significance level as α = 0.001 and retrieve the critical level of $\chi^2_{\alpha/2}(n-1)$ = 52.62 from Table 1. Obviously, χ^2>52.62 and H_0 is rejected, i.e., these three evaluation methods are consistent on the given significance level of α = 0.001. Apply the Arithmetic Average Method, Borda Method and Copeland Method to the integrated evaluation based on the ranks in AHP, GRA and FA.

The back test with Spearman rank correlation coefficient: Based on the ranks obtained from the individual evaluation methods and the integrated methods, Eq. 6 and 7 were applied to calculate the t-values of the Arithmetic Average Method, Borda Method and Copeland Method, expressed as t_a, t_b and t_c. t_a = 44.954, t_b = 45.021, t_c = 45.023. Take the significance level as α = 0.01 and retrieve the critical value of $t_{\alpha/2}(24)$ = 2.7696. Obviously, t_a, t_b, t_c are all larger than $t_{\alpha/2}(24)$. Therefore, the three integrated methods are closely correlated to the three individual methods. In addition, the t-value of Copeland Method is the largest and the ranks in this method are taken as the final ranks.

Clustering: Take the standard of the Copeland Method as the cluster index and cluster the 26 listed transport companies using the Euclidean Distance Method. According to the clustering dendrogram generated from SPSS 14.0, these companies can be divided into four groups (Table 2).

We got two basic results from Table 2. First, the benchmarking companies in railway, waterway and highway transportation were respectively Tielong Logistics, Beijing Media and Channel Share. Second, among the four kinds of listed transport companies, the financial performance of the railway companies was the

Table 2: Clustering results

Type	Company	Cluster scale
1	Channel Share, Tielong Logistics, Beijing Media	3
2	Jiangxi Changyun, Shandong Airlines, Air China, CITIC Offshore Helicopter, Yatong Share, Datong-Qinhuangdao Railway, Guangzhou-Shenzhen Railway, China North Locomotive and Rolling Stock Industry, Kwok-hang Rail, China Eastern Airlines	10
3	Changjiang Tanker, China's Medium-term, Merchants Transportation, COSCO Shipping, China Shipping Development, Hainan Airlines, China Shipping Haisheng, Ningbo Marine	8
4	Shanghai Airlines, China Southern Airlines, China Ocean Shipping, Tianjin Marine Shipping, China Shipping Container Lines	5

best, followed by highway. The financial performance of the waterway and the air listed transport companies was not as good as that of the railway and the highway.

CONCLUSIONS

The results were true that the financial performance of Tielong Logistics, Beijing Media and Channel Share were the best in the transport industry and that the performance of railways was better than the rest transports. In this research, we proposed an integrated evaluation method that improved the evaluation methodology and solved the problem of the one-sidedness in any individual evaluation method and the inconsistency in multiple evaluation methods. The prior test and the back test of the integrated method in this study made the results more convincible. In particular, the consistency of the Arithmetic Average Method, Borda Method and Copeland Method indicate that the entire methodology is consistent.

The introduction of the status quo of China's transportation development and performance evaluation of transportation industry is detailed and realistic and the results of the proposed model in this research are objective and reasonable.

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