Credit Risk Assessment of Listed Companies Based on Vector Angle Cosine

ZENG Xi

(College of Mathematics and Information, China West Normal University, Nanchong Sichuan 637009, China)

DOI: https://doi.org/10.56293/IJASR.2024.6019

IJASR 2024
VOLUME 7
ISSUE 4 JULY – AUGUST **ISSN: 2581-7876**

Abstract: A study is conducted on the credit risk assessment model of listed companies in China. Firstly, factor analysis is used to construct an indicator system from five dimensions: debt paying ability, development ability, operating ability, profitability, and cash flow. Then, the cosine method of vector angle is used to replace the subjective expert scoring method and assign weights to the indicators. Finally, based on the scoring model, the scores of 25 listed companies are calculated and their credit risk is evaluated.

Keywords: factor analysis; cosine of vector angle; listed companies: credit risk assessment

Introduction

Listed companies play an important role in Chinese economy, and conducting risk assessments on them is of great significance. Establishing a credit risk assessment model for listed companies can cultivate credit risk management talents, improve market systems, enhance the awareness of risk investors, and promote the orderly and healthy development of the capital market.

Yi Nan et al. used the entropy weight method to assign weights to indicators and constructed a credit risk assessment index system for listed companies[Error! Reference source not found.]; Li Chen et al. comprehensively used the Analytic Hierarchy Process and Entropy Weight Method to construct a composite index system for measuring Chinese aging population[Error! Reference source not found.]; Yan Jia et al. used CRITIC method to obtain weight coefficients and analyzed them using TOPSIS method to construct a comprehensive quality evaluation model for medicinal herbs[Error! Reference source not found.]; Hu Longwei et al. established a comprehensive benefit evaluation model for old residential areas based on the ideal solution grey correlation method[Error! Reference source not found.]; Yan Hong used ANP method to determine the weight of indicators and adopted the cosine method of vector angle to evaluate the quality of PC components[Error! Reference source not found.]; Zhang Caili et al. proposed an urban flood disaster evaluation method based on vector angle cosine and improved evidence theory[Error! Reference source not found.].

Select specific indicators based on the five criteria of debt paying ability, development ability, operating ability, profitability, and cash flow, use factor analysis to reduce dimensionality and screen indicators, and then combine the cosine method of vector angle to replace the subjective expert scoring method to determine indicator weights. The cosine method of vector angle can better handle the optimal and worst values of indicator data, weaken the adverse effects of extreme data on indicator weights, and overcome the subjectivity of expert scoring by utilizing the expressiveness of data itself. Construct a credit risk assessment index system for listed companies in China, and finally use a scoring model to calculate the scores of 25 listed companies and conduct credit risk assessment on them.

1. Selection of indicators

According to the principle of selecting risk assessment indicators that combine comprehensiveness, scientificity, and operability, 25 listed companies were selected from the csmar. Using the target stratification method, five criteria layers were selected: debt paying ability, development ability, operating ability, profitability, and cash flow. Fifteen corresponding indicators were initially selected under each criterion layer, as shown in Table 1.

Table 1. Financial Indicator System

category	indicators
debt paying ability	current ratio quick ratio asset liability ratio
development ability	total asset growth rate A net profit growth rate A operating income growth rate A
operating ability	accounts receivable turnover rate A current asset turnover rate A total asset turnover rate A
profitability	return on assets A operating profit margin ratio of profits to cost
cash flow	net cash content cash content operating income total cash recovery rate

Due to the possible correlation between indicators, using SPSS software, KMO>0.5 and Bartlett's sphericity test result<0.01 were obtained. Therefore, factor analysis was used to reduce the dimensionality of the indicators, and the maximum variance method was selected to rotate the factors. Five common factors were extracted, with a cumulative contribution rate of 82.029%; Through the Caesar normalization maximum variance method, the rotation converged after 6 iterations. Financial indicators are divided into five categories: the first category is operating profit margin, quick ratio, and current ratio; Category 2: return on assets A, current asset turnover A, total asset turnover A; Category 3: cash content of operating income, total cash recovery rate, accounts receivable turnover rate A; Category 4: operating income growth rate A; Category 5: Net profit growth rate A. To test whether this category is suitable for factor analysis, KMO and Bartlett's sphericity tests were performed for each major category. For the indicator categories with KMO>0.5 and Bartlett's sphericity test significance P<0.01, the category with the highest loading of the main factor was selected. The results show that the first, second, and third categories of indicators have passed the above tests, as shown in Table 2.

Table 2. Factor loading matrix for three types of indicators

Category 1		Category 2		Category 3	
operating profit margin	0.901	return on assets A	0.613	cash content of operating income	0.860
quick ratio	0.842	current asset turnover A	0.951	total cash recovery rate	0.832
current ratio	0.843	total asset turnover A	0.943	accounts receivable turnover rate A	0.584

The fourth and fifth categories only contain one indicator, so all indicators for these two categories are retained. In summary, after dimensionality reduction of the indicators, five indicators were obtained, namely operating profit margin, current asset turnover rate A, cash content of operating income, operating income growth rate A, and net profit growth rate A.

2. Vector cosine weighting of angle

The determination of indicator weights is crucial for credit risk assessment of listed companies and has a significant impact on the results of their risk assessment. The methods of indicator weighting can be roughly divided into two categories. One is subjective weighting methods, such as the common Analytic Hierarchy Process; One type is the objective weighting method, commonly known as entropy weighting method. The cosine method of vector angle is a multi-objective decision-making method that uses mathematical geometry to calculate and compare the degree of

closeness between the objective and the ideal objective to obtain the optimality of multi-objective selection. It plays an important role in the selection of multi-objective schemes[Error! Reference source not found.].

Assuming that O is selected as the starting point in the three-dimensional coordinate system XYZ, the eigenvectors formed by point O pointing to the ideal value, optimal value, and worst value are respectively referred to as the ideal vector V^*, optimal value vector V, and worst value vector v. By constructing the relative deviation matrix of the optimal value and worst value vectors. The specific steps are as follows:

（1）Let the optimal vector and the worst vector of the indicator be V and v, respectively:

$$V=(V_1,V_2,\cdots,V_m) \tag{1}$$

$$v=(v_1,v_2,\cdots,v_m) \tag{2}$$

$$V_i=\begin{cases}\max\limits_{1\le j\le n}\{a_{ij}\}, i\in I_1\\ \min\limits_{1\le j\le n}\{a_{ij}\}, i\in I_2\end{cases} \tag{3}$$

$$v_i=\begin{cases}\max\limits_{1\le j\le n}\{a_{ij}\}, i\in I_2\\ \min\limits_{1\le j\le n}\{a_{ij}\}, i\in I_1\end{cases} \tag{4}$$

V_i and v_i represent the best and worst evaluation values of the i, respectively, while m and n represent the indicator and the number of experts. I_1 and I_2 represent positive and negative indicators respectively, and a_{ij} represents the score of indicator i in expert j.

（2）Determine the relative deviation matrices R and G for evaluation objectives V and v, with the deviation matrix data being r_{ij} and g_{ij}:

$$R=(r_{ij})=\frac{|a_{ij}-V_i|}{\max\limits_{1\le j\le n}\{a_{ij}\}-\min\limits_{1\le j\le n}\{a_{ij}\}} \tag{5}$$

$$G=(g_{ij})=\frac{|a_{ij}-v_i|}{\max\limits_{1\le j\le n}\{a_{ij}\}-\min\limits_{1\le j\le n}\{a_{ij}\}} \tag{6}$$

（3）Calculate the cosine weight of the angle for indicator i:

$$w_i=\cos(r_i,g_i)=\frac{\sum\limits_{j=1}^{n}r_{ij}g_{ij}}{\sqrt{\sum\limits_{j=1}^{n}r_{ij}^{\,2}}\sqrt{\sum\limits_{j=1}^{n}g_{ij}^{\,2}}} \tag{7}$$

（4）Normalize the above formula to obtain indicator weights of θ_i:

$$\theta_i=\frac{w_i}{\sum\limits_{i=1}^{m}w_i} \tag{8}$$

3. Example Analysis

3.1 Data Processing

In order to eliminate the influence of dimensional differences between various indicators, reduce the differences between indicator data, and facilitate subsequent data analysis, this article adopts the maximum-minimum standardization method:

Standardization of positive indicators:

$$x_{ij}' = \frac{x_{ij} - \min\limits_{1\le i\le n}\left(x_{ij}\right)}{\max\limits_{1\le i\le n}\left(x_{ij}\right) - \min\limits_{1\le i\le n}\left(x_{ij}\right)} \tag{9}$$

Standardization of reverse indicators:

$$x_{ij}' = \frac{\max\limits_{1\le i\le n}\left(x_{ij}\right) - x_{ij}}{\max\limits_{1\le i\le n}\left(x_{ij}\right) - \min\limits_{1\le i\le n}\left(x_{ij}\right)} \tag{10}$$

3.2 Rating and Weighting

After conducting factor analysis on the data of the 25 selected listed companies, the component scores obtained from principal component analysis were used instead of expert scoring to weaken the influence of data subjectivity on the results. The scoring results are shown in Table 3.

Table 3. Component Scores

	F1	F2	F3	F4	F5
operating profit margin	0.049	-0.028	-0.032	-0.026	0.819
current asset turnover rate A	-0.06	0.07	-0.069	0.479	0.098
cash content of operating income	-0.024	0.367	-0.079	0.005	-0.057
operating income growth rate A	-0.135	-0.135	0.447	0.023	0.045
net profit growth rate A	0.277	-0.02	-0.135	-0.154	0.182

By using software to write programs and using the cosine weighting method of vector angles to weight the five indicators, it can be obtained that:

The optimal value vector $V = (0.819, 0.479, 0.367, 0.447, 0.277)$;

The worst vector $v = (-0.032, -0.069, -0.079, -0.135, -0.154)$;

The cosine weight of the angle of indicator i is $w_i = (0.05, 0.2237, 0.1644, 0.2194, 0.21)$;

Normalize and obtain indicator weights of $\theta_i = (0.0576, 0.2579, 0.1895, 0.2529, 0.2421)$。

3.3 Evaluation Results

Based on the weighted indicator system obtained above, combined with standardized data, the comprehensive scores of 25 listed companies can be obtained using the scoring model $S_k = \sum_{k=1}^{n} \theta_i \cdot x_{ik}$, where S_k is the

comprehensive score of the k, θ_i is the weight of the i, and x_{ik} is the standardized score of the k-th object for the i-th indicator. The results are shown in Tables 4 to 7.

Table 4. Ranking of Results (1)

Stock code	688005	688007	688001	688388	688009	688010
sort	25	24	23	22	21	20

Table 5. Ranking of Results (2)

Stock code	688122	688015	688006	688029	688018	688033
sort	19	18	17	16	15	14

Table 6. Ranking of Results (3)

Stock code	688012	688066	688028	688022	688019	688333
sort	13	12	11	10	9	8

Table 7. Ranking of Results (4)

Stock code	688003	688016	688088	688011	688020	688002	688008
sort	7	6	5	4	3	2	1

According to the scoring model, the scores of 25 listed companies are calculated. The lower the score, the lower the ranking, and the higher the credit risk; The higher the score, the higher the ranking, and the lower the credit risk level. In Tao Qiuyue'article[Error! Reference source not found.], the Logit and KMV models rated 688008 with a credit rating of A, indicating low risk, and only one of the 25 listed companies had an A rating. According to the results of this article, Lanqi Technology has the lowest score, ranks first, and has the lowest risk, which is consistent with the results in Tao Qiuyue's article.

4. Conclusions and Recommendations

A scientific and reasonable assessment of the credit risk of listed companies in China can provide reference for investors'decision-making and help listed companies adopt reasonable and effective measures to cope with risks. Using factor analysis to reduce the dimensionality of indicators, using component scores to represent expert ratings, and combining cosine angle method to assign weights to indicators, a scoring model was used to evaluate the credit risk of 25 listed companies. Considering the comprehensive low credit risk from three aspects: listed companies, financial institutions, and external environment, listed companies should strengthen their internal financial management and control capabilities; Financial institutions should establish a sound credit risk indicator system and credit evaluation quality verification mechanism; The government builds an information resource exchange platform and creates a trustworthy environment for listed companies.

Reference:

1. Ning Y N, Yang S, Li Y F. Construction of Credit Risk Assessment Index System for Listed Companies [JJ. Journal of Neijiang Normal University, 2017, 32 (12): 59-63.
2. Li C, Liu Z P, Li X. Construction and Application of a Composite Indicator System for Measuring Population Aging [J]. Statistics and Decision making, 2023, 39 (19): 59-64.
3. Yan J, Li R, Ji S G. CRITIC - Approximate Ideal Solution Ranking Method for Comprehensive Evaluation of the Quality of Puzzle Medicinal Materials [J]. West China Journal of Pharmacy, 2024, 39 (03): 299-302.
4. Hu L W, Wang J R, Xia S Y. Comprehensive Benefit Evaluation of Old Residential Area Renovation Based on Ideal Solution Grey Correlation Method [J]. Journal of Liaoning University of Technology (Natural Science Edition), 2022, 42 (04): 253-258

5. Yan H. Research on Quality Evaluation of PC Components in Prefabricated Buildings Based on Vector Angle Cosine Method [JJ. Journal of Engineering Management, 2019, 33 (03): 42-46.
6. Zhang C L, Niu F Y. Evaluation of urban waterlogging disasters based on vector angle cosine and improved evidence theory [J/OLJ. Journal of Wuhan University (Engineering Edition): 1-12.]
7. Wang L. Building Fire Risk Assessment Based on IOWA and Vector Angle Cosine [J]. Fire Science and Technology, 2021, 40 (09): 1355-1359.
8. Tao Q Y. Credit Risk Assessment of Listed Companies on China's Science and Technology Innovation Board: A Study Based on KMV Model and Ordered Logit Model [J]. Journal of Shanghai Lixin Institute of Accounting and Finance, 2020,32 (02): 27-38
9. Zhu T Y. Credit Risk Issues, Causes, and Countermeasures of Listed Enterprises in Shanxi Province [J]. Economic Research Guide, 2023 (23): 60-62.