

Research on Credit Risk Evaluation of shipping Enterprises based on Fuzzy Comprehensive Evaluation Method

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Abstract

The outbreak of the novel coronavirus has dealt a huge blow to all walks of life in the world, and the shipping industry has also suffered a heavy impact. In the post-COVID-19 era, shipping enterprises should base on the current situation, face risks squarely and actively face the impact of the epidemic. Therefore, it is urgent to establish a set of credit risk evaluation model suitable for shipping enterprises to help them recover better. Based on this background, this paper starts from the current situation of shipping enterprises, combines qualitative and quantitative indicators, analyzes the existing risks and risk causes of shipping enterprises, and builds a multi-level credit risk evaluation system for shipping enterprises. Then, A representative shipping company of China A is selected as a case through the example analysis, which indicates that the multi-level fuzzy comprehensive evaluation method can comprehensively and effectively evaluate the credit risk of shipping enterprises.

Keywords

Credit Evaluation; Shipping Enterprises; Credit Risk.

1. Introduction

The ocean is the main channel of global trade, and more than 95% of the world's foreign trade imports and exports are completed through shipping. The development of the shipping industry will help promote the recovery of the trade economy[1], improve its international competitiveness and improve its international status. In recent years, many countries have paid more attention to the development of the shipping industry, actively promoted the healthy and orderly development of the shipping industry, and raised the development level of shipping trade to the national strategic level. In addition, with the proposal of the 21st Century Maritime Silk Road and the development of the Yangtze River Economic Belt, the economic and trade exchanges among countries have been promoted, the flow of resources has been accelerated, and the development of the world shipping industry has been provided with power and support. However, the problem of information asymmetry often exists between shipping enterprises and banks, coupled with the unique risk characteristics of shipping enterprises, which makes banks have greater operational risks when dealing with the credit business of shipping enterprises. Therefore, establishing a set of credit risk evaluation methods suitable for shipping enterprises is of great significance. Credit risk assessment [2] enables enterprises to take measures to control credit risk, which is the key to solving the current financing problems of shipping enterprises, so that enterprises can develop better and establish a good corporate image. There are many types of credit risk assessment. The existing research uses weighted least square method, mixed integration method, nearest subspace method and improved genetic algorithm [3]. However, a single algorithm has its own defects. Therefore, this paper uses multi-level fuzzy comprehensive evaluation method [8]to conduct a comprehensive analysis and evaluation of the credit risk of shipping enterprises, and constructs a multi-level

evaluation index system combining qualitative and quantitative indicators. Moreover, AHP [8] is used to determine the weight of each evaluation index, realizing the effective combination of evaluation index and evaluation method.

2. Construction of Credit Risk Evaluation Model for Shipping Enterprises

2.1. Design of Evaluation Index System

In the evaluation of credit risk, this paper cites a more scientific evaluation index. On the one hand, credit evaluators can make subjective evaluation; on the other hand, they can make comprehensive, objective and fair evaluation based on the specific situation of the enterprise itself. Based on the existing research results, this paper combines the construction principles of credit risk and credit risk evaluation index system, and puts forward five criterion levels, which are market risk, operation and management risk, ship investment and charter risk, political risk and credit risk, and establishes two indexes for each criterion level index. In practice, in order to ensure the scientificity, validity and operability of the evaluation, shipping companies can make corresponding adjustments to it. The specific credit risk evaluation index system of shipping enterprises is shown in Table 1.

Table 1. Credit risk evaluation index system of shipping enterprises

Target layer	Criterion layer	Index layer	Index type
Credit risk assessment of shipping enterprises	Market risk	Risk of changes in market demand	qualitative
		Rate variation	quantitative
		Risk of changes in capacity	qualitative
		The intensity of the competition	qualitative
	Operation and management risk	The likelihood of an accident	qualitative
		State of ship safety management	qualitative
		Fuel price fluctuation range	quantitative
		Fuel price fluctuation range	qualitative
	Ship investment and charter risk	Return on investment	quantitative
		Income-rent ratio	quantitative
	Political risk	Corporate affinity for shipping policies	qualitative
		The possibility of social instability such as strikes and unrest	qualitative
	Credit risk	Tax record	quantitative
		Social reputation	qualitative

2.2. Determine the Evaluation Factor Set

The whole set of credit risk evaluation indicators of shipping enterprises is defined as $u_i = \{u_1, u_2, u_3, u_4, u_5\}$, $u = u_1 + u_2 + u_3 + u_4 + u_5 = 1$. Among them $u_i (i = 1, 2, 3, 4, 5)$ is the index set of the criterion layer u_1, u_2, u_3, u_4, u_5 . In order: market risk, management risk, ship investment and leasing risk, political risk, credit risk. In the index layer, suppose $u_{ij} = \{u_{i1}, u_{i2}, u_{i3}, u_{i4}, u_{i5}\}$ among them $u_{ij} (i = 1, 2, 3, 4, 5; j = 1, 2, 3, \dots, n)$ is the evaluation index set. Thus, the credit risk evaluation index system of shipping enterprises is obtained, as shown in Table 2.

Table 2. Credit risk evaluation index system of shipping enterprises

Target layer	Criterion layer	Index layer
	Market risk	Risk of changes in market demand u_{11}

Credit risk assessment of shipping enterprises	u_1	Rate variation u_{12}
		Risk of changes in capacity u_{13}
		The intensity of the competition u_{14}
	Operation and management risk u_2	The likelihood of an accident u_{21}
		State of ship safety management u_{22}
		Fuel price fluctuation range u_{23}
		Freight safety level u_{24}
	Ship investment and charter risk u_3	Return on investment u_{31}
		Income-rent ratio u_{32}
	Political risk u_4	Corporate affinity for shipping policies u_{41}
		The possibility of social instability such as strikes and unrest u_{42}
	Credit risk u_5	Tax record u_{51}
		Social reputation u_{52}

2.3. Identify the Comment Set

The credit rating of each index in the evaluation index system is divided into five levels, which are as follows: safe, low, medium, high and high. To rate different indicators.

2.4. Determine the Index Weight Set

In short, the weight clarifies the latter' on the former, and an appropriate value is given. The value ranges from 0 to 1, and the sum of weights of each criterion layer is 1. Define m for the weight of index u set, then the weight of each criterion layer index sets $m = \{m_1, m_2, m_3, m_4, m_5\}$, among them $m_i (i = 1, 2, 3, 4, 5)$ said u_1, u_2, u_3, u_4, u_5 for u . So on, each index layer on its corresponding criterion layer weights of indicators sets $m_{ij} = \{m_{i1}, m_{i2}, m_{i3}, m_{i4}, m_{i5}\}$, among them $m_{ij} (i = 1, 2, 3, 4, 5; j = 1, 2, \dots, n)$ represents the weight of each index layer indicator to its corresponding criterion layer indicator.

Because it is difficult to compare factors with different attributes together, the analytic hierarchy process is used to compare two factors with similar properties. The specific steps to determine the weight by analytic hierarchy process are as follows:

(1) The 1-9 scale method is used to score each index in pairs to get the decision matrix A , which is the relative importance of each index.

$$A = \begin{pmatrix} a_{11} & \dots & a_{1n} \\ \vdots & \ddots & \vdots \\ a_{n1} & \dots & a_{nn} \end{pmatrix} \tag{1}$$

(2) Further, we can calculate the maximum characteristic root eigenvectors corresponding ω to λ_{max} , and satisfy the $A\omega = \lambda_{max} \omega$, will feature vector ω normalized after a quick the weight of each factor.

(3) To test evaluation of the reliability and consistency, consistency rate $CR = CI / RI$, including RI for random consistency index, as revised only related to the target dimension. The average random consistent index value RI is shown in Table 3.

Table 3. RI distribution of average random consistent index values

order	3	4	5	6	7	8	9
RI	0.52	0.89	1.12	1.26	1.36	1.41	1.46

Make $CR = CI / RI$, the consistency ratio $CR < 0.1$, can think judgment matrix consistency test results meet the requirements, beyond this value, must adjust the judgment matrix, consistency.

2.5. Determine the Index Membership Degree

Determining the index membership degree, the need to the shipping enterprise credit risk evaluation of each index $u_{1j}, u_{2j}, u_{3j}, u_{4j}, u_{5j} (j = 1, 2, \dots, 5)$, respectively, the single factor evaluation, the ratio between the number of people at each index evaluation level and the total number of people participating in the evaluation was taken as the membership degree of each index $r_{uij} (i = 1, 2, \dots, 6; j = 1, 2, \dots, 5)$. The fuzzy evaluation matrix r_{uij} of indicators u_1, u_2, u_3, u_4, u_5 relative to comment set v_i can be obtained.

$$r_{uij} = \begin{pmatrix} r_{u1v1} & r_{u1v2} & r_{u1v3} & r_{u1v4} & r_{u1v5} \\ r_{u2v1} & r_{u2v2} & r_{u2v3} & r_{u2v4} & r_{u2v5} \\ r_{u3v1} & r_{u3v2} & r_{u3v3} & r_{u3v4} & r_{u3v5} \\ r_{u4v1} & r_{u4v2} & r_{u4v3} & r_{u4v4} & r_{u4v5} \\ r_{u5v1} & r_{u5v2} & r_{u5v3} & r_{u5v4} & r_{u5v5} \end{pmatrix} \tag{2}$$

2.6. Evaluation Result

To u said shipping enterprise credit risk fuzzy comprehensive evaluation vector, from above, has been to evaluation index system of index weight and membership degree, into $u = m_{ui} * r_{uij}$, calculates the results of fuzzy comprehensive evaluation, based on the principles of maximum membership degree [10], the index of shipping enterprise credit risk evaluation results.

3. Case Study of Fuzzy Comprehensive Evaluation Method

In this paper, Chinese shipping Company A is selected as the case to conduct a comprehensive assessment and analysis of credit risk.

3.1. Determine the Membership Degree of the Index

Table 4. A Membership degree of enterprise credit risk evaluation index

Target layer	Index layer	V1	V2	V3	V4	V5
Credit risk evaluation of shipping enterprises	Risk of changes in market demand	0.2	0.1	0.2	0.3	0.2
	Rate variation	0	0.1	0.2	0.3	0.4
	Risk of changes in capacity	0.2	0.2	0.3	0.2	0.1
	The intensity of the competition	0.3	0.2	0.2	0.2	0.1
	The likelihood of an accident	0.3	0.3	0.3	0.1	0
	State of ship safety management	0.3	0.5	0.2	0	0
	Fuel price fluctuation range	0	0.1	0.2	0.2	0.5
	Freight safety level	0.3	0.3	0.1	0.2	0.1
	Return on investment	0.2	0.3	0.2	0.3	0
	Income-rent ratio	0.3	0.3	0.1	0.2	0.1
	Corporate affinity for shipping policies	0.4	0.3	0.2	0	0.1
	The possibility of social instability such as strikes and unrest	0.5	0.3	0.1	0.1	0
	Tax record	0.4	0.3	0.2	0.1	0
Social reputation	0.4	0.3	0.1	0.1	0.1	

Firstly, the evaluation of risk factors of A shipping enterprise is divided into five levels: Safety, low, medium, high and high were represented by V1, V2, V3, V4 and V5 respectively. A questionnaire was designed and 100 staff members from shipping companies and banks cooperating with Company A were invited to conduct the survey. Due to the professionalism of the survey objects, the credibility of the questionnaire was greatly improved. A total of 100 questionnaires were sent out in this study, of which 96 were valid with an acceptable recovery rate of 96%. After sorting out the recovered questionnaires, the index membership degree of enterprise A's credit risk evaluation index system is taken as the proportion, with one decimal place reserved, as shown in Table 4.

3.2. Determine the Weight of the Indicator

Twenty people from the partner company of Enterprise A are invited to score the second-level indicators. The score table is required to compare and score related indicators in pairs according to the scale of 1-9, and calculate the average of the scores to form a consistent judgment matrix. The market risk scoring table is shown in Table 5.

Table 5. Market risk judgment matrix

	Risk of changes in market demand	Rate variation	Risk of changes in capacity	The intensity of the competition
Risk of changes in market demand	1	1/3	1/2	3
Rate variation	3	1	2	4
Risk of changes in capacity	2	1/2	1	3
The intensity of the competition	1/3	1/4	1/3	1

That is:

$$A = \begin{pmatrix} 1 & 1/3 & 1/2 & 3 \\ 3 & 1 & 2 & 4 \\ 2 & 1/2 & 1 & 3 \\ 1/3 & 1/4 & 1/3 & 1 \end{pmatrix} \tag{3}$$

Table 6. A Weight of enterprise credit risk evaluation index

Target layer	Criterion layer	Index layer
Credit risk assessment of shipping enterprises	Market risk	Risk of changes in market demand 0.1802
		Rate variation 0.4598
		Risk of changes in capacity 0.2724
		The intensity of the competition 0.0876
	Operation and management risk	The likelihood of an accident 0.1095
		State of ship safety management 0.4836
		Fuel price fluctuation range 0.2974
		Freight safety level 0.1095
	Ship investment and charter risk	Return on investment 0.75
		Income-rent ratio 0.25
	Political risk	Corporate affinity for shipping policies 0.8
		The possibility of social instability such as strikes and unrest 0.2
	Credit risk	Tax record 0.6667
		Social reputation 0.3333

Using SPSSAU software to calculate the weight $\omega = (0.1802, 0.4598, 0.2724, 0.0876)$, the results are consistency check, it is concluded that the biggest characteristic root $\lambda_{max} = 4.0875$, $CI = (\lambda - n) / (n - 1) = 0.0292$, at last $CR = CI / RI = 0.0328 < 0.1$, the results show that the judgment matrix through the consistency check.

Similarly, the risk assessment weights of other indicators of Enterprise A are shown in Table 6.

3.3. Evaluation Result

By above his own evaluation index system of index weight and membership degree, in $u = m_{u1} * r_{u1vi}$ fuzzy comprehensive calculation.

$$m_{u1} = (m_{u11} \ m_{u12} \ m_{u13} \ m_{u14}) = (0.1082 \ 0.4598 \ 0.2724 \ 0.0876)$$

$$r_{u1vj} = \begin{pmatrix} r_{u11v1} & r_{u11v2} & r_{u11v3} & r_{u11v4} & r_{u11v5} \\ r_{u12v1} & r_{u12v2} & r_{u12v3} & r_{u12v4} & r_{u12v5} \\ r_{u13v1} & r_{u13v2} & r_{u13v3} & r_{u13v4} & r_{u13v5} \\ r_{u14v1} & r_{u14v2} & r_{u14v3} & r_{u14v4} & r_{u14v5} \end{pmatrix} = \begin{pmatrix} 0.2 & 0.1 & 0.2 & 0.3 & 0.2 \\ 0 & 0.1 & 0.2 & 0.3 & 0.4 \\ 0.2 & 0.2 & 0.3 & 0.2 & 0.1 \\ 0.3 & 0.2 & 0.2 & 0.2 & 0.1 \end{pmatrix} \tag{4}$$

$$r_{u1} = m_{u1} * r_{u1vi}$$

$$= (m_{11} \ m_{12} \ m_{13} \ m_{14}) * \begin{pmatrix} r_{u11v1} & r_{u11v2} & r_{u11v3} & r_{u11v4} & r_{u11v5} \\ r_{u12v1} & r_{u12v2} & r_{u12v3} & r_{u12v4} & r_{u12v5} \\ r_{u13v1} & r_{u13v2} & r_{u13v3} & r_{u13v4} & r_{u13v5} \\ r_{u14v1} & r_{u14v2} & r_{u14v3} & r_{u14v4} & r_{u14v5} \end{pmatrix}$$

$$= (0.1082 \ 0.4598 \ 0.2724 \ 0.0786) * \begin{pmatrix} 0.2 & 0.1 & 0.2 & 0.3 & 0.2 \\ 0 & 0.1 & 0.2 & 0.3 & 0.4 \\ 0.2 & 0.2 & 0.3 & 0.2 & 0.1 \\ 0.3 & 0.2 & 0.2 & 0.2 & 0.1 \end{pmatrix} \tag{5}$$

$$= (r_{u1v1} \ r_{u1v2} \ r_{u1v3} \ r_{u1v4})$$

$$= (0.1168 \ 0.136 \ 0.2272 \ 0.264 \ 0.256)$$

The same can be obtained

$$r_{u2} = (0.2108 \ 0.3372 \ 0.2 \ 0.0923 \ 0.1597)$$

$$r_{u3} = (0.225 \ 0.3 \ 0.175 \ 0.275 \ 0.0257)$$

$$r_{u4} = (0.42 \ 0.3 \ 0.18 \ 0.02 \ 0.08)$$

$$r_{u5} = (0.4 \ 0.3 \ 0.1667 \ 0.1 \ 0.0333)$$
(6)

According to the principle of maximum membership, the risk evaluation level of first-level indicators is obtained, as shown in Table 7.

Table 7. Risk assessment level

First-order index	Market risk	Operation and management risk	Ship investment and charter risk	Political risk	Credit risk
Evaluation level	higher	lower	lower	safety	safety

As can be seen from the above analysis, shipping market risk is the biggest factor affecting the credit risk evaluation of A shipping enterprise, and shipping enterprises will suffer huge economic losses due to the decline of freight rates in the transportation process [11]. The

traditional way to reduce market risk is to divide the fleet into two parts, one for shipping transactions and the other for time leases. In this way, shipping companies can not only obtain expected fixed income from ship leasing, but also make use of existing shipping capacity to achieve higher income [12]. A shipping company should also pay close attention to the changes of international trade and the world ship market, and do a good job in forecasting market demand, analysis and prediction of shipping capacity, so as to reduce the risk of changes in market demand and freight rate.

4. Conclusion

In the post-epidemic era, the recovery of the shipping industry is of great significance to the development of international trade. Due to the high investment, high risk, intensive capital and high professionalism of the shipping industry, shipping enterprises will encounter various risks when providing funds, technologies and talents, which will lead to credit risks and have an adverse impact on the financing and development of shipping enterprises. Therefore, it is very important for the development of shipping enterprises to establish a set of multi-level, complete and effective credit risk evaluation model. However, due to the complex and diverse relationship between shipping enterprises, there may be correlation among their evaluation indicators, which is not discussed in depth in this paper. We will continue to study and improve it in future research.

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