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Financial crisis early-warning model for listed company in China energy industry based on logistic regression

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Energy industry plays an important role on the economic development in China, so their financial position has become the focus study problems for many scholars. According to China energy industry's financial statements and sustainable development, how to find their financial crisis is one of the directions of energy industry's finance. This paper describes the energy industry financial crisis management, constructs the financial crisis early-warning indicator system and descripts all indicators, takes ST shares and non-ST shares of China A-share energy industry listed companies as a sample, filters out a series of financial indicators by the normality and the factor analysis, and constructs the Logistic regression early-warning model, and proves the validity of the proposed model by the predictive tests of training samples and testing samples. Finally, the results show that the Logistic model can give an ideal warning for energy industry listed companies' financial position, can give the judgment before listed companies meet financial crisis.

Key words: Energy industry listed company; Early-warning model; Logistic regression.

INTRODUCTION

In China, the capital market is greatly develop; the market economic system is gradually perfect; competition between enterprises is increasingly fierce under this situation, and some enterprises will inevitably fall into financial crisis, or even go bankrupt. If enterprises fall into crisis, they will threaten many aspects of economic life, and create the tremendous impact. Energy industry play an important role on the economic development in China, and help to fasten the development of China's capital market, so their financial position has become the focus study problems for many scholars. At present, many energy industry listed companies in china meet the problem of Special Treatment, one of the main reasons is that they fall into financial crisis. If we can make timely and effective measures before those companies appear financial crisis, it is possible to avoid greater losses.

The main reason of financial crisis is enterprise's various financial and operational risks. Financial crisis early-warning system can monitor and detect all activities in the course of company business, and can identify, evaluate and analyse the unstable operation status and the financial unusual phenomenon caused by expanding financial crisis, the early-warning system can warn the company manager when the financial crisis gets the soften warning limits, help the managers to find the source of financial crisis, take timely measures of effective regulation, then financial crisis can be reduced to be a relatively safe level.

Based on this consideration and financial crisis early-warning's study situation and methods, this paper puts the identification of financial crisis factor and the construction of financial crisis evaluation indicators into the study frame of energy industry financial crisis early-warning system, so that energy industry managers can fully identify enterprise financial crisis factors and evaluate enterprises' financial situation to construct effective financial crisis early-warning model. According to financial crisis and early-warning theory, this paper takes the special treatment of energy industry in China A-share listed companies as the study objects, screens a series of financial indicators by the normality test and the factor analysis, establishes the Logistic regression early-warning model, and proves the validity of the proposed model through the predictive testing of training samples and testing samples..

LOGISTIC REGRESSION MODEL

Logistic regression is mainly used in the binary response variable or orderly response variable, its goal is to seek the conditional probability of the observed object, and judge the observed object's financial position and operating risks. It is built on the basis of the cumulative probability function, and the independent variables do not need to obey

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the multivariate normal distribution and equal between the two groups covariance assumptions. The model estimates the parameter values by using the maximum likelihood estimation method according to the sample data, obtains the probability of response variables' value by certain mathematical operations. If the calculated probability is greater than the setting point, it is determined that the company is in financial crisis. Specific mathematical principles are as follows

Assuming that X_i is a variable of the i -th financial crisis early-warning indicators, then there are the regression relationship between financial crises probability P_i and X_i:

$$P_i = \frac{\exp(Y_i)}{1+\exp(Y_i)} \qquad (1)$$

The concrete operational process is

$$Y_i = \alpha + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_i X_i = \alpha + \sum \beta_i X_i \qquad (2)$$

The value Y_i is the total discrimination, it reflects the i -th characteristics; β_i is the weight and the degree of the relevant independent variables X_i ; α is the financial crisis early-warning indicator variables; is a constant.

The formula (3) can be obtained by the formula (1):

$$Y_i = \ln(\frac{P_i}{1-P_i}) \qquad (3)$$

Y_i is the total discrimination value, P_i calculated by the linear regression model is the probability of financial crisis.

Thus $\alpha + \sum \beta_i X_i = \ln(\frac{P_i}{1-P_i})$

Calculate it, gets $P_i = \frac{\exp(\alpha + \sum \beta_i X_i)}{1+\exp(\alpha + \sum \beta_i X_i)}$

So $P_i = \frac{\exp(Y_i)}{1+\exp(Y_i)}$

The value of $Y_i = \ln(\frac{P_i}{1-P_i})$ can be obtained by substituting the selected variables into the regression equation, thus P_i -value can be calculated. Setting the thresholds as a criterion of the incident, if the P_i value is greater than the threshold value, it is determined that the event occurs, otherwise, it is determined that the event does not occur. Thus, each sample category can be determined. The curve of the logistic regression model is the type S , and its early-warning maximum value approaches 1, the minimum value approaches 0.

The logistic regression has not specific requirements for the distribution of the variable, the scope of application is more extensive, and the value is a probability value, it is simple and convenient. Therefore, this paper studies the financial crisis early-warning model by the Logistic regression method.

INDICATOR SYSTEM CONSTRUCTION

The financial data by which this paper builds the financial crisis early-warning model is from energy industry of China Shanghai and Shenzhen A-share listed company's true financial data. This paper takes the ST companies of China energy industry listed companies as the financial crisis enterprises, and selects the non-ST as the normal company according to the principle of the same industry and similar asset size, determines the financial anomalies first birthday as the reference day, chooses the financial statements date in two years before the reference day.

Thirty ST companies selected from energy industry of Chinese A-share listed companies at 2011 is the study samples, according to the principle of the same industry and similar asset size, thirty non-ST companies is the paired samples that form the training samples, financial data of those sixty companies are the training samples' financial data. In order to test the model's predictive ability, sixty energy industry listed companies at the same period are selected to be the testing samples, including thirty ST companies and thirty non-ST companies. The built early-warning model is tested by the training sample inspection and the test sample inspection to analyse their respective accuracy and false positive rate.

For the selection of financial indicators, experts and scholars at home and abroad have done a lot of exploration and research, we can learn from outstanding achievements.

According to the files of the National Safety Supervision Bureau and references, the paper builds the China energy industry listed companies' financial crisis warning indicator system (Table 1).

CHINA ENERGY INDUSTRY LISTED COMPANIES' FINANCIAL CRISIS EARLY-WARNING MODEL

Table 1. China energy industry listed companies' financial crisis warning indicator system

Target layer	Level indicators	Secondary indicators
China energy industry listed companies' financial crisis early-warning indicator system A	Profitability B1	ROA X1
		ROE X2
		OPE X3
	Solvency B2	liquidity ratio X4
		Current liabilities ratio X5
		Asset-liability ratio X6
	Operating capacity B3	Total asset turnover X7
		Accounts receivable turnover ratio X8
		Inventory Turnover X9
	The ability to grow B4	Main business revenue growth X10
		Net profit growth X11
		The growth rate of total assets X12
		The mail profit growth X13
	Cash flow indicators B5	Sales-to-cash ratio X14
		Asset cash Recovery X15
		Cash gearing ratio X16

Note: The data of this study comes from the CCER economic and financial research database in China.

This paper makes the normality test, factor analysis and logistic regression analysis on the financial indicators by the statistical software SPSS17.0, builds the early-warning model.

Data Factor Analysis

Making the factor analysis on sixty samples in 2009 by the SPSS Version 17 statistical software.

Factor Analysis Test

In order to determine the suitability of the factor analysis, this paper makes the KMO test and Bartlett test on the sample data, the results are shown in Table 2:

By inspection, the KMO sampling moderate determination is 0.520 which is bigger than 0.5, and the Bartlett test's χ^2 statistic significance probability value is 0.000, which is far less than the significance level 0.05, all that indicate that the sample data suits for the factor analysis.

Table 2. KMO test and Bartlett test

KMO and Bartlett's Test		
Kaiser-Meyer-Olkim Measure of Sampling Adequacy		520
Bartlett's Test of Sphericity	Approx. Chi-Square	513.026
	df	120
	Sig.	0

Table 3. The eigenvalues and the contribution rate

Total Variance Explained

Component	Initial Eigenvalues			Extractiom Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	3.41	21.317	21.32	3.411	21.317	21.317	3.104	19.397	19.397
2	2.55	15.946	37.26	2.551	15.946	37.263	2.074	12.960	32.357
3	2.08	13.028	50.29	2.084	13.028	50.291	1.931	12.066	44.423
4	1.74	10.867	61.16	1.739	10.867	61.157	1.785	11.158	55.581
5	1.18	7.365	68.52	1.178	7.365	68.522	1.753	10.958	66.539
6	1.07	6.674	75.2	1.068	6.674	75.196	1.248	7.801	74.340
7	1.01	6.294	81.490	1.007	6.294	81.490	1.144	7.150	81.490
8	.731	4.571	86.061						
9	.562	3.515	89.577						
10	.487	3.046	92.623						
11	.417	2.603	95.226						
12	.326	2.038	97.264						
13	.214	1.340	98.604						
14	.111	.692	99.296						
15	.085	.531	99.827						
16	.028	.173	100.000						

The Eigenvalues and the Contribution Rate

After completing factor analysis on the sixteen financial indicators of sample data, we can get sixteen eigenvalues. This paper extracts seven factor variables whose eigenvalues is bigger than 1 as the variables at the next step, and the cumulative contribution rate of the seven factors variable reaches 81.490% shown in table 3, they contain 81.490% information of the original sixteen financial indicators, so that, these seven factors variable basically reflects the difference of the original financial indicators.

Factors Explain

To make it easier to explain the initial factor, this paper uses the variance maximum method of the orthogonal rotation method for conversion. Because it can not only find a suitable explanation for each factor, but also avoid multicollinearity between variables. Factor loading matrix as shown in Table 4:

Table 4. Orthogonal rotation of factor loadings matrix.

Rotated Component Matrixa							
	Component						
	1	2	3	4	5	6	7
X1	.228	.583	-.012	.444	-.119	-.335	.173
X2	.020	.049	.018	.075	-.011	.854	.040
X3	-.498	.018	.145	.387	-.189	-.486	-.124
X4	.174	.132	.034	.855	-.123	.126	-.044
X5	.101	.402	.156	-.109	-.697	-.276	.100
X6	-.157	-.365	.083	-.709	-.157	.075	-.242
X7	-.031	.814	-.032	.067	.106	.216	-.141
X8	.055	.081	-.961	-.015	.097	.040	-.023
X9	.155	.261	.020	-.221	.736	-.123	.208
X10	-.105	-.093	.027	.095	-.118	.065	.918
X11	.046	.024	.972	-.021	.063	.023	.000
X12	-.109	.809	-.031	.216	-.020	-.055	-.034
X13	-.214	.041	.044	.037	.761	.002	-.334
X14	.935	-.098	-.043	.011	-.122	.000	-.001
X15	.953	.080	.033	.133	.009	-.005	-.035
X16	.925	-.016	.031	.240	-.050	.041	-.072

Table 4 shows that the contribution rate of ROE X2 reflecting the profitability indicators is up to 0.854, the contribution rate of liquidity ratio X4 reflecting solvency indicators is up to 0.855, the contribution rate of total asset turnover X7 reflecting the entrepreneurial capacity indicators is up to 0.814, reflecting business growth capacity indicators the greatest contribution to net profit growth rate X11 is 0.972, reflecting cash flow indicators, the greatest contribution to the recovery of cash assets X15 is 0.953. Therefore, the final ROE X2, liquidity ratio X4, total asset turnover X7, net profit growth rate X11 and asset cash recovery rate X15 can be the initial variable to build financial crisis early warning model.

Logistic Regression Early-Warning Model

Select the Critical Point

Before building the logistic regression model, we must firstly determine the model discriminate critical point. The logistic regression model has not the optimal split point, so the split point is selected depending on the specific objectives of the model user. In fact, for any critical point, all models will make two types of errors: the class I error and class II error. The class I error is that ST is usually mistaken as non-ST companies. Class II error is that non-ST is usually mistaken as ST. When class I error reduces, class II error increases, and the cost of two types of errors is the same. Most research ships 0.5 as the critical point, i.e., if the probability of an event calculated by the model is greater than or equal to 0.5, then it is determined that the event occurs, otherwise it is judged that the event does not occur. Selected sample in this article is paired, so, selecting 0.5 to be the critical point.

Logistic Regression Early-Warning Model

Using the version SPSS17 statistical analysis software, this paper makes the logistic regression analysis on the selected five variables and their sample data of the previous two years. By forward stepwise selection variable method, the results are shown in Table 5:

Table 5. Model Coefficients Test

		Chi-square	df	Sig.
Step 1	Step	14.812	1	.000
	Block	14.812	1	.000
	Model	14.812	1	.000
Step 2	Step	10.209	1	.001
	Block	25.020	2	.000
	Model	25.020	2	.000

Note: Chi-square is the chi-square value, df is freedom degrees, Sig is the p-value

The model corresponding p-value is 0.000, and is less than 0.05, therefore, the overall model is significant.

Table 6 shows that the statistics Cox & Snell R Square and Nagelkerke R Square are 0.341 and 0.455, respectively, that means that the model explains about 60% of the explained variable, the model fitting degree is higher.

Table 6. Model Summary

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	68.366a	.219	.292
2	58.157a	.341	.455

a. Estimation terminated at iteration number 5 because parameter estimates changed by less than .001

Table 7. Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1 a	X4	-.015	.005	8.682	1	.003	.985
	Constant	1.669	.594	7.884	1	.005	5.305
Step 2 b	X4	-.013	.005	6.272	1	.012	.987
	X7	-.026	.010	7.151	1	.007	.974
	Constant	3.053	.854	12.788	1	.000	21.172

a. Variable(s) entered on step 1:X4

b. Variable(s) entered on step 2:X7

Table 7 shows that two factor variables are through the significance test whose significance level is 0.05 and enter the final model, while the other three variables fail to pass the test, the final logistic early-warning model will be only two variables, respectively, X_4 and X_7.

According to the formula (2):

$$Y_i = \alpha + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_i X_i = \alpha + \sum \beta_i X_i$$

Substituting the above results into the above formula, we can get the listed companies' financial crisis early warning model:

$$Y_i = 3.053 - 0.026 X_4 - 0.013 X_7 \quad (4)$$

Substitute into equation (1): $P_i = \dfrac{\exp(Y_i)}{1+\exp(Y_i)}$

We can get the financial crisis early warning model of energy industry listed companies:

$$P_i = \frac{\exp(3.053 - 0.026 X_4 - 0.013 X_7)}{1+\exp(3.053 - 0.026 X_4 - 0.013 X_7)} \quad (5)$$

X_4 represents the current ratio, reflects the company's solvency indicators;

X_7 represents the total asset turnover, reflects the company's entrepreneurial capacity indicators.

Table 8 shows that the financial crisis Logistic early-warning model obtains a better discriminate accuracy rate before two years. The overall accuracy rate is 75.0%; the accuracy of non-financial crisis is 70.0%, the error rate is 30.0%; the accuracy rate of financial crisis company is 80.0%, the error rate is 20.0%.

Table 8. Classification Table

	Observed		Predicted crisis occur or not		Percentage Correct
			0	1	
Step 1	crisis occur or not	0	21	9	70.0
		1	9	21	70.0
	Overall Percentage				70.0
Step 2	crisis occur or not	0	21	9	70.0
		1	6	24	80.0
	Overall Percentage				75.0

a. The cut value is .500

Financial Crisis Early-Warning Model Test

Training Sample Test Results

Using the built early-warning model to test sixty training samples, if P-value is bigger than or equal to 0.5, we can judge that the company falls into financial crisis, if less than 0.5, the company does not fall into financial crisis.

Sixty training samples are used to test the accuracy of the built early-warning model, the results show in Table 9:

Table 9. Training samples' test results

		Predictive value: Whether the crisis No	Yes	accuracy rate
Whether crisis	No	25	5	83.33
	Yes	4	26	86.67
Total		29	31	85.00

There are five non-financial crisis companies judged to be financial crisis by Logistic early-warning model, the error rate is about 16.67%; Four financial crisis companies are judged to be non-financial crisis, the error rate is about 13.33%. The total error rate both is 15%, the general warning accuracy rate is 85%.

The Test Results of Samples

The early-warning model is derived from the training sample data, so the training sample test results will overestimate its early-warning capacity. To further test the early-warning capability of the model, sixty samples which were not used in the

modeling process test the model, 0.5 is the critical point, the results are shown in Table 10:

Table 10. Test results of the testing samples

		Predictive value		
		Crisis occur or not		accuracy rate
		No	Yes	
Crisis occur or not	No	22	8	73.33
	Yes	7	23	76.67
Total		29	31	75.00

The test results are that the general warning accuracy rate of the model is 75%, so the built logistic regression early-warning model has also a good prediction in practical applications.

CONCLUSION

This paper firstly defines the study object of the early-warning model, and selects sixty energy industry listed companies as the financial indicators data and then makes the normal distribution test on the financial indicators data and determines that they are suitable for factor analysis or not. Then, the logistic early-warning model is constructed based on the principal component factors screened by the forward stepwise variable selection method. Finally, this paper gets a good prediction of the model checking through the training and testing samples.

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