Construction and Demonstration of Early-Warning Index System for Capital Chain Rupture of New Energy Vehicles Enterprises Based on Cox Model

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Abstract: The fund penetrates each link of the Enterprise Management Development, is the Enterprise Sustainable Management Survival Foundation. This paper reviews the existing literature at home and abroad, based on the particularity of new energy vehicle capital chain analysis of its risk sources. On this basis, Mann-whitney U test and Pearson correlation test were used to identify the relevant risk variables, and Cox proportional risk was constructed, considering the performance of its investment early warning index, Operation Chain Early Warning Index and return chain Early Warning Index from 2017 to 2021, this paper designs a capital chain breaking early warning model based on new energy vehicle industry to make an empirical analysis, based on this, the paper puts forward some suggestions on the management and control of capital chain in the industry.

Keywords: capital chain; capital chain rupture risk early warning; Cox proportional hazard model; new energy vehicles

1. Introduction

The strong rise of China's new energy automobile industry has benefited from strong support from the government, especially financial subsidies. Since the beginning of 2017, subsidies have been greatly reduced by the impact of the new crown epidemic, the situation of the new energy vehicle market took a turn for the worse, sales began to fall sharply. According to statistics, as of 2021, 23 of the 412 companies listed in the new energy concept shares have encountered St, a few enterprises have entered bankruptcy delisting procedures. It is expected that as the 2021's new subsidy standards are further reduced, the financial pressure on the new energy vehicle industry will intensify.

At present, the new energy automobile industry has risen to the height of the national development strategy, has become an irreversible direction of development. However, the financial problem is like a "Damocles", always hanging above the industry. The operation of the capital chain is based on a certain relationship between supply and demand. The impact of the capital chain break

is definitely conductive and extensive, in the new energy automobile industry chain any single link Enterprise's fund control is not good may cause the risk chain to spread. At present, the power battery industry has structural overcapacity, the whole vehicle sales market is facing double squeeze, the spare parts raw material resources are scarce, the price fluctuation is obvious; The unrestrained blind expansion of the rear vehicle infrastructure leads to the multiple challenges to the profitability of the new energy vehicle industry chain and the obvious risk transmission benefits. To a large extent, effective risk identification and the establishment of a reasonable preventive mechanism and measures flow can prevent the capital chain from breaking and leading to business deterioration, thus strengthens the new energy automobile industry fund chain risk management ability, better protects our country new energy automobile industry development.

2. Review of the Literature

The capital chain refers to the relationship between the supply and demand of funds formed in the process of creating internal and external value of enterprises. When the demand of funds is greater than the supply of funds, there will be a gap, and if the gap of funds can not be filled, the capital chain will be broken [1]. Zhang Jinchang (2012), through the analysis of the supply-demand relationship of the three kinds of funds, concluded that the fundamental reason for the break of the capital chain is that there is a gap in the funds paid by enterprises, eight index systems are designed and tested to identify the risk of capital chain rupture [2]. Sima Zexi and Feng Lumin (2015) take 22 delisting companies in Shanghai as the research object, select the early-warning index of capital chain rupture risk from the perspective of capital chain, and construct a comparative efficacy early-warning model, and study the sensitivity of each early-warning index, found that the model is reliable, objective and can effectively assess the risk of funds [3].

As a kind of financial risk early-warning, capital chain rupture risk early-warning has changed from single-variable risk early-warning model to multi-variable risk early-warning model to logistic regression model. Recent

literature has gradually extended the application of early warning tools to artificial intelligence techniques such as genetic algorithms and neural networks. You Yi et al (2013) and Cao Tong (2014) have carried on the empirical analysis to the financial risk of the local manufacturing industry and the listed electric power enterprise by constructing the BP neural network model [4,5]. Zhu Zhaozhen (2017) established a three-stage enterprise life cycle of the Kalman filter and logic regression early warning model to achieve dynamic and static capital risk early warning [6].And for the study of risk management measures for capital chain break, Wang Yuhong (2010) pointed out that making appropriate expansion strategy, widening financing channels, improving the capital structure of enterprises, strengthening investment risk assessment and strengthening internal management can effectively avoid the risk of capital chain rupture [7]. Gan Xiaowu and Gan Xinwu (2018) proposed to establish a comprehensive budget management system, improve the management level of working capital and speed up the return of liquidity [8]. Zhang Jide and Guo Xudong (2020) put forward that it should deal with the crisis of capital chain break through some measures such as reasonable financing collocation, promotion of business "Hematopoiesis" and standard credit sale policy [9].

Looking through the above-mentioned literature, at present, most scholars analyze the cause of capital fracture risk based on the actual situation and the time-point data of financial statements, but less on the dynamic analysis of the capital chain turnover model, no research has focused on the risk transmission effect of capital chain risk based on cycle. In the study of the measures to prevent the break of the capital chain, most of the measures are put forward for the management of the capital chain of a single enterprise, but few for a specific industry. Based on the particularity of the capital chain of the new energy automobile enterprises, the author takes the Cox model as the main research tool and establishes the capital chain break early warning model to carry on the empirical analysis, in order to enrich the capital chain risk prevention and control theory, for the overall industry to strengthen the fund management and risk early warning to provide useful reference.

3. Research Design

3.1. Selection of Indicators

According to the definition of capital chain, capital chain is divided into three sub-chains: input chain, Operation Chain and return chain. Referring to Zhang Jinchang's publication in 2015 on the causes of capital chain disruption in enterprises, the former set up an index system to identify and measure capital chain disruption risk from a static and dynamic perspective, eight indexes are designed and the validity and gradualness of these indexes are tested. In this paper, choosing four financial indexes, which are monetary debt repayment satisfaction rate, long-term fund demand guarantee rate, operating debt repayment satisfaction rate, undistributed profit ratio, and 11 indexes, such as EBIT assets ratio, cash flow current debt ratio, interest guarantee multiple, to measure the capital chain rupture risk of new energy automobile industry. Specific fund risk early warning indicators set as follows table 1.

Table 1. Index system for early warning of capital chain rupture of listed companies of new energy vehicle

Categories of indicators	Indicator code	Indicator variable
Investment Chain Index	X1	EBIT asset ratio
	X2	Long-term capital requirement guarantee rate
	X3	Cash flow current liability ratio
	X4	Interest protection multiple
Operating Chain Index	X5	Working Capital turnover
	X6	Rate of return on working capital
	X7	Rate of satisfaction of operating liabilities
	X8	Satisfaction rate of monetary liabilities
Return Chain Index	X9	Percentage of undistributed profit
	X10	Turnover rate of accounts receivable
	X11	Inventory turnover

3.2. Definition of Survival Time and Selection of Study Samples

The sample data of this paper is mainly from the annual report of listed companies and CSMAR database, and the financial data of 59 listed companies in Shanghai and Shenzhen A shares from 2017 to 2021 are selected as the samples. Considering the late start time of the new energy automobile industry, most of the listed companies have the phenomenon of profit and loss fluctuation, this paper takes the sample data of 2017-2019 as the estimation sample, and the sample data of 2020-2021 as the forecast sample in order in the model demonstration.

Enterprises with two consecutive periods (every half-year) reporting net profit losses are selected as the risk samples for empirical analysis, and the quarter of the year in which the capital chain fracture crisis occurs is the survival end of the crisis samples, the second quarter of the 2021 was used as the survival end point for the healthy sample, and the time scale was the quarter. The estimated sample is a compositional population, while the predicted sample is a 1:1 ratio, as shown in table 2 below.

Table 2. Predictive sample matching methods.

	Estimated sample (2017-2019)6	Forecast sample (2020-2021)3
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Dangerous sample	17	23
Health sample	42	23
Total samples	59	46

3.3 Significance Test of Early Warning Indicators

In order to improve the prediction effect of the model, the relevant indexes with low sensitivity and significance are eliminated. In this paper, Stata15.0 is used to winsor the continuous variables, 2.5% and 97.5% quantile tail reduction are used, Mann-whitney U test is used, and P value is less than 0.10 is assumed as the standard to extract the significance index, the results show that the nine indexes, X11, X1, X2, X3, X4, X5, X7, X8 and X9, have passed the Mann-whitney U test, which means these

ten indexes can be analyzed in the next step (table 3 below).

3.4 Correlation Test of Early Warning Indicators

Considering that there may be multiple linear correlations between the above-mentioned indexes which have been sieved out by Mann-whitney U test, pearson correlation test will be conducted between the two of the sieved indexes, finally, the early-warning indexes which can meet the Cox model were selected. The correlation matrix resulting from the Pearson correlation test is shown in table 4 below.

Table 3. Results of Mann-whitney U nonparametric test for sample data.

Variable	X11	X1	X2	X3	X4	X5	X9	X7	X8
Z value	2.56	-10.02	-10.43	-5.02	-3.99	-6.12	-6.46	-4.30	-5.74
P value	0.011	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table 4. Pearson correlation coefficients for each early warning indicator.

	X11	X1	X2	X3	X4	X5	X9	X7	X8
X11	1.000								
X1	-0.093	1.000							
	0.033								
X2	-0.197	0.338	1.000						
	0.000	0.000							
X3	0.054	0.281	0.138	1.000					
	0.218	0.000	0.001						
X4	-0.032	0.109	-0.072	0.022	1.000				
	0.458	0.012	0.096	0.612					
X5	-0.132	0.039	0.034	-0.008	-0.159	1.000			
	0.002	0.369	0.437	0.860	0.000				
X9	0.198	0.534	0.077	0.278	0.011	0.024	1.000		
	0.000	0.000	0.078	0.000	0.803	0.578			
X7	-0.008	0.018	-0.029	-0.122	0.442	-0.026	-0.076	1.000	
	0.860	0.673	0.506	0.005	0.000	0.554	0.080		
X8	-0.132	0.053	0.034	-0.005	-0.157	0.996	0.035	-0.023	1.000
	0.002	0.222	0.437	0.911	0.000	0.000	0.416	0.593	

The results showed that six indexes, X11, X1, X2, X3, X4 and X7, could be used in Cox analysis.

4. Empirical Test and Result Analysis

4.1 Empirical Results and Analysis of Cox Model

In this paper, Stata15.0 software is used to construct Cox model, and "Forrward: LR" stepwise regression

method is used to judge whether the index can enter the model. The six indexes, Inventory turnover, EBIT asset ratio, long-term capital demand guarantee ratio, cash flow current liability ratio, interest guarantee multiple and operating liability repayment satisfaction ratio, are estimated as follows table 5.

Table 5. Results of cox analysis.

_t	Haz. Ratio	RobustStd. Err.	z	P>z	[95% Conf.	Interval]
X11	0.0003	0.0004	-5.4600	0.0000	0.0000	0.0053
X1	0.543918	0.563901	12.7	0.000	0.07129	0.4149603
X2	1.05289	2.72868	3.6	0.000	0.00655	1.691895
X3	0.00003	0.00004	-7.18000	0.00000	0.00000	0.00045
X4	0.004	0.007	-2.900	0.004	0.000	0.165
X7	0.0002	0.0003	-4.6800	0.000	0.0000	0.0064

The above table shows the overall test of the FIT model. From the regression results, it can be seen that the P value of each index is significantly less than 0.05,

therefore, it can make further analysis and draw the following conclusions: X11(inventory turnover rate), X1(EBIT asset ratio), X2(long-term capital demand

guarantee rate), X3(cash flow current liability rate), X4(interest guarantee multiple), X7(operating liability satisfaction rate) are all positively correlated with the capital chain rupture risk of listed companies in new energy automobile industry, the highest relative risk was 1.05289(X2) and the lowest was 0.00003(X3). The results show that the long-term capital guarantee and operational capital guarantee are directly related to the overall operational risk of the Enterprise's capital chain, the ratio of supply and demand between investment and financing decisions and operating funds will have a significant impact on capital adequacy and cash flow adequacy of enterprises. Secondly, the daily production and operation of inventory management is also directly related to the turnover of funds and occupation, weaken the use of funds efficiency. In addition, enterprises should pay more attention to the rationality of debt structure and term matching arrangement. The insolvency of debt due to short-term capital pressure is an important factor leading to the break of capital chain.

4.2 Cox Model Early Warning Effect Test

In order to verify the early-warning effect of the model, this paper uses Cox model to test the rationality and validity of the model by measuring the forecast accuracy in the above 59 sample enterprises. The ratio of the number of samples with estimated survival time T1-T6 in 2017-2019 was set as the warning point, and the predicted survival rate was calculated. The final risk model is estimated by means of the survival rate estimation method, and the survival rate data of the listed companies in the sample from 2020 to 2021 are obtained, and the survival rate data are compared with the discriminant value of the early warning point, determine if the sample company is in a funding crunch. Based on the above analysis, the accuracy of the model is shown in table 6 below.

Table 6. Model prediction accuracy.

Year	Survival rate	Accuracy rate
2017-2019	72.82%	88.1%
2020-2021	76.3%	69.5%

Observing the table above, the prediction accuracy of the model is 88.1% and 69.5%, both exceeding 50%, which shows that the model has good prediction ability.the results show that the longer the time span is, the more complete the data is, the stronger the interpretation ability of the early warning indicators is.

5. Research conclusions and recommendations

5.1 Study conclusions

The capital chain is very important to the development of the enterprise, it runs through all the activities of the enterprise, so it is very important to prevent the break of the capital chain. By constructing the Cox model of capital chain break warning of listed companies in China's new energy automobile industry and making a series of sample prediction tests, the stock turnover rate, the ratio of profit assets before interest and tax, the long-term fund demand guarantee rate, the cash flow current debt rate, the interest guarantee multiple, the operating debt repayment satisfaction rate these six factors can fully predict the new energy automobile profession listed company's fund chain ruptures risk.

5.2 Proposed Measures

First of all, the company should strengthen the sense of risk management, in the process of designing risk management plan, work out how to identify, evaluate and control the risk. standardize the use of equity financing and make a scientific and reasonable prediction and planning for our own financing needs, so as to avoid over-financing leading to idle funds. When making financing decision, it should not only pay attention to the leverage ratio, but also allocate the debt maturity and the long-term and short-term assets to reduce the possibility of capital chain break.

Secondly, adjust the company's business strategy in time, pay attention to the macro-environment change, understand the trend of industrial policy, rationally integrate the existing resources of the enterprise, formulate a scientific and long-term development strategy, and actively respond to market changes. With the decline of national and local subsidies for new energy vehicles, the car companies that rely only on government subsidies and do not effectively form their core competitiveness will face the risk of being eliminated.

Finally, actively improve their own level of management, the development of business should be based on their own sustainable profitability, to grasp the good inventory turnover control mechanism, increase short-term cash flow, so that the level of cash flow and debt matching. Enhance the company' R & D investment, improve product quality, in order to obtain a higher profit margin, to form their core competitiveness, to achieve substantial development.

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