Research on the Evaluation Method of Supply Chain Health Degree for the Financial Risk Early Warning of Reverse Factoring Supply Chain

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Abstract: In order to alleviate the financing difficulties of small and micro companies, some commercial banks pay close attention to the core company in the supply chain and provide financing services for small and micro companies in the upstream and downstream of the supply chain through the reverse factoring model. This paper comprehensively considers the business risk control requirements, takes the financial risk of core companies as the starting point of research, introduces the supply chain data and the small and micro company data, and uses the fuzzy comprehensive evaluation method to establish the supply chain financial health degree evaluation system based on the comprehensive qualitative and quantitative data. Finally, an example is given to illustrate how to realize the supply chain financial risk early warning based on the supply chain health degree evaluation method.

Keywords: Supply chain finance; Reverse factoring; Risk early warning; Supply chain health degree; Evaluation method

1 INTRODUCTION

Small and micro companies are an important part of the national economy and play an important role in economic development and social stability[3]. Some commercial banks actively carry out the supply chain finance business of Small and micro companies, and enter the supply chain through capital services such as loans and factoring, which helps to reduce the financing threshold of Small and micro companies and promote the smooth operation of the supply chain [4].

In the process of supply chain financing for Small and micro companies, due to their small scale, opaque financial information, management confusion and other reasons, commercial banks will refuse to approve loans in the face of serious information asymmetry, which makes such companies lose their development opportunities because they cannot have credit lines in the bank [10].

In recent years, in response to the call of the state to increase loan support for Small and micro companies and vigorously promote inclusive financial business, commercial banks have launched a series of new products based on the supply chain financial business to help Small and micro companies obtain loan opportunities. The supply chain financial business under the

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reverse factoring model, which is based on the promotion of core company credit, has been widely used by major commercial banks and has proved that it plays a vital role in alleviating the financing difficulties of Small and micro companies [3].

Reverse factoring means that the opposite of the accounts receivable bought out by the factoring agent is some buyers with high credit level. In this way, the bank only needs to assess the buyer's credit risk to carry out factoring, and the credit recovery capital flow directly comes from the buyer. In reverse factoring, lenders only purchase accounts receivable from specific high-quality buyers with transparent information. Credit risk becomes the default risk of high-quality buyers rather than high-risk Small and micro companies, which makes it possible to provide low-risk financing to high-risk suppliers [12].

At present, the research on financial risk early warning of reverse factoring supply chain is mainly aimed at the credit line of core company. This paper proposes to establish a supply chain health degree evaluation system by combining the financial data of core company, Small and micro companies and the supply chain data between small and micro companies and core company, aiming to provide a new risk early warning idea for commercial banks to carry out business.

2 REVERSE FACTORING SUPPLY CHAIN FINANCE AND RISK WARNING

2.1 The Characteristics of Supply Chain Finance Under Reverse Factoring Mode

Reverse factoring has been applied to many supply chain financial financing schemes, which are generally initiated by the core company in the supply chain to ease the financing difficulties of Small and micro companies in the upstream of the supply chain [5]. The business is mainly based on the tripartite agreement between large companies with high quality ratings, commercial banks and Small and micro companies in the upstream of the supply chain. In this business mode, the core company in the supply chain promise to transfer the accounts receivable formed after signing the purchase contract to the bank so that the bank can discount (prepay) the accounts payable in time to the upstream Small and micro companies[15].

Its operation mode is shown in Figure 1, under this model, whether the upstream Small and micro companies can get bank loans in time depends largely on the credit rating of the core company, which is also the success of the application of reverse factoring model. He successfully transferred the financial risk from the upstream Small and micro companies of the supply chain to the core company of the supply chain. From the perspective of the business form of supply chain finance, reverse factoring is similar to the traditional factoring mode [9].

However, in terms of risk early warning requirements, it has the following characteristics：

（1） Factoring risk assessment is based on the core company of the supply chain, and the credit of suppliers, namely Small and micro companies in the supply chain, is not considered in the risk control in the whole business process.

（2）Factories can choose the accounts receivable that the core company have agreed to pay for financing. On the one hand, it reduces the risk assumed by the factorials, and on the other

hand, it reduces the financing costs of suppliers.

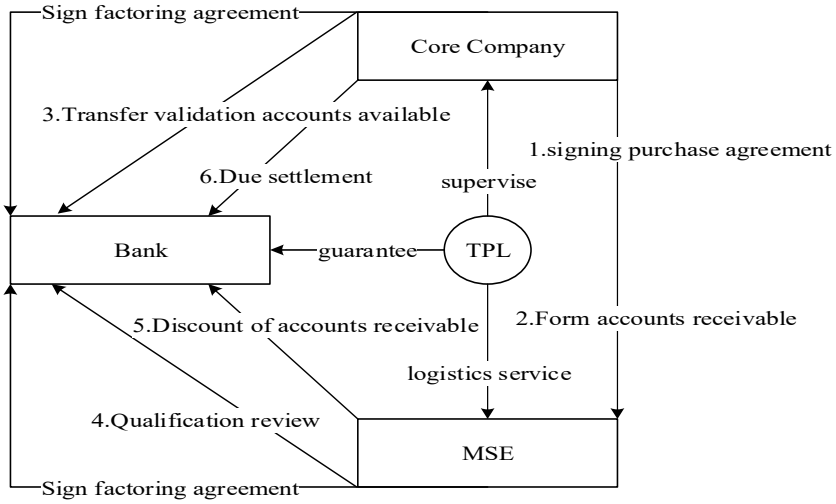

Figure 1: Supply chain finance business process

2.2 Requirements for Early Warning of Supply Chain Financial Risks in Reverse Factoring Mode

Under the reverse factoring mode, the supply chain finance business provides financing for the seller (upstream seller) by occupying the credit line of the buyer. Generally, the buyer proposes to use its own credit resources in the bank to support its upstream seller's financing.

To conduct this business, the seller (upstream Small and micro companies) and the buyer should have a good and stable cooperative relationship. The seller (Small and micro companies) should have good qualifications, and the buyer should have good credit.

Therefore, we need to do a good job of risk early warning under the supply chain financial business. We need to do a good job of financial risk early warning for core company and focus on the factors related to the supply chain of core company and upstream Small and micro companies.

3 SUPPLY CHAIN FINANCIAL RISK WARNING BASED ON SUPPLY CHAIN HEALTH UNDER REVERSE FACTORING MODE

3.1 Measurement and Calculation of Supply Chain Health Under the Supply Chain Financial Reverse Factoring Model

The supply chain financial reverse factoring business risk early warning of commercial banks needs to comprehensively consider the financial situation of core company, the qualifications of Small and micro companies, and the real supply chain data between Small and micro companies

and core company. We selected the financial analysis database of listed companies and the supply chain research database from the CSMAR database. We found that the qualitative data and quantitative data must be comprehensively considered to study the health of the supply chain, so we decided to use the fuzzy comprehensive evaluation method to establish the supply chain health evaluation system.

Many foreign scholars have conducted research on enterprise health. [6] carried out the earliest research on health evaluation. It selected 19 bankrupt companies as negative samples, compared with companies in normal operation as positive samples, and compared with the financial data of companies, it came to the conclusion that the company's equity ratio can better judge whether the company is in a healthy state than other indicators.

Altman (1968) combines the five financial indicators with obvious distinction to evaluate the enterprise health, and obtains the classic Z score multiple discriminant model. The model gives each indicator corresponding weights according to the different contributions of indicators to the evaluation results, and finally obtains the Z score representing the enterprise health status. The level of Z score can be used to intuitively judge the enterprise's health.

Under the background of rapid development of artificial neural network [13] took the indexes in the model as the input of neural network on the basis of Z-score multivariate discriminant model, and obtained more effective results. Based on the data frequently selected by domestic and foreign scholars to study the company's financial risk, and combined with the classification of financial status in the financial statement analysis database, we selected 13 data from the following 6 aspects in the core company dimension for analysis. Our specific indicators are selected as follows:

(1) Solvency: current ratio, quick ratio, cash ratio and asset liability ratio;

(2) Business ability: ratio of accounts receivable to income and turnover rate of accounts receivable;

(3) Profitability: ROA;

(4) cash flow: cash content of net profit;

(5) risk level: financial leverage, operational leverage and comprehensive leverage;

(6) Developing capacity: capital maintenance and appreciation rate and capital accumulation rate.

In order to find out the possible impact of specific financial indicator factors on the company's financial risk, we try to use regression analysis to find the impact of each indicator[11]. We conducted regression analysis based on whether the core company was treated by ST, and obtained the impact of the 13 factors we selected on the financial risk of the enterprise as shown in Table 1 and Table 2.

Table 1: Regression statistics

Multiple R	0.187388287276217
R Square	0.0351143702083141
Adjusted R Square	0.0231801884649552
Standard error	0.176039154850603
Observations	1067

Table 2: Regression factors

financial index	Coefficients
current ratio	0.00429480507941802
quick ratio	0.0151117870346344
cash ratio	-0.0249326055999505
asset liability ratio	-0.0124547319013206
ratio of accounts receivable to income	-0.0177858805536828
turnover rate of accounts receivable	-2.5128112579322E-07
ROA	-0.309543931749908
cash content of net profit	-0.0000690512681582228
financial leverage	-0.0115315247117356
operational leverage	-0.0178102137773693
comprehensive leverage	0.0115556275019133
capital maintenance and appreciation rate	0.0380453092753866
capital accumulation rate	0

The supply chain financial reverse factoring business of commercial banks is generally initiated by core company to alleviate their upstream companies in the supply chain. The requirement for risk control of this business is that the upstream Small and micro companies and the core company in the supply chain should maintain a good cooperative relationship. Therefore, when establishing the supply chain health evaluation system, we add the supply chain data to the model:

(1) Trade indicators: The supplier procurement index includes the procurement amount from suppliers of listed companies in the current period and the proportion of the amount collected by suppliers in the current period in the annual total procurement number of listed companies. This indicator can directly reflect the close relationship between Small and micro companies and core company in the supply chain.

(2) Geographic distance index of supply chain: It includes the space distance, whether the enterprise is in the same province, and whether the enterprise is in the same city. The close relationship between core company and Small and micro companies is reflected by measuring the distance.

(3) Supply chain concentration index: It includes supplier concentration, supplier concentration Herfindahl index and supply chain concentration, highlighting the supply chain integration capability of core company.

At the same time, commercial banking business requires that upstream Small and micro companies also need to have good qualifications to obtain loans through this business, so the factor considered in the third part of the system is the qualification of Small and micro

companies themselves [7]:

(1) Enterprise comprehensive qualification: Including the registered capital, the number of insured persons, the number of years of registration and other indicators.

(2) Supply chain management level: Whether the leadership has a clear plan and arrangement for the company's supply chain management, and the business level of the enterprise's employees' awareness of the importance of supply chain management.

(3) Risk level: Query the data to check whether the enterprise has other risk factors.

By analyzing the specific requirements of commercial banks' reverse factoring supply chain financial business, we selected the data of core company, supply chains and Small and micro companies as the system research. At the same time, we found the possible proportion of different factors affecting the core company's financial risk through regression analysis. After the completion of the selection of indicators, we will provide the following comments on the supply chain health indicators and the requirements for risk early warning.

3.2 Supply Chain Financial Risk Based on Reverse Factoring Mode of Supply Chain Health Early Warning

This paper comprehensively considers the characteristics of the supply chain financial reverse factoring business model, selects business related indicators to establish a supply chain health evaluation index system, and uses five comments to evaluate the supply chain: good, good, fair, poor, and poor. This helps to enhance the confidence of commercial banks in conducting business, and boldly make loans in the face of the supply chain whose health evaluation is still acceptable.

On the other hand, in the data collection stage, a supply chain health indicator registration form is established to compare whether a single indicator meets the industry standard. When the supply chain health evaluation can locate the indicator location that may lead to supply chain risk, and when some indicators have large fluctuations, it can also alert the supply chain financial risk. in the whole process of business development, commercial banks can require core company to provide financial data regularly to achieve dynamic early warning of supply chain risks.

The supply chain health degree model is used to evaluate the supply chain health degree. Table 3 is the evaluation analysis table, we can find out whether commercial banks are recommended to carry out supply chain financial business, and according to the different supply chain health degree evaluation, we can propose targeted suggestions for improving the supply chain health indicators. Using supply chain health indicators to warn risks, on the one hand, you can warn risks in real time through specific indicator changes; on the other hand, you can give a comprehensive evaluation of supply chain health after comprehensive consideration of all indicators.

Table 3: Risk early warning table

very good	The supply chain is healthy, the probability of risk generation is low, and all indicators are not lower than the industry standard, so the supply chain financing business can be carried out continuously and stably.
preferably	The supply chain is relatively healthy, and there are indicators that do not meet the industry standards, which can gradually improve the health in the process of business.
Fair	The health of the supply chain is fair, and many indicators are lower than the industry standards. In the process of business development, we should strengthen supervision to control risks in real time.
Poor	There are indicators that are far lower than the industry standard, and the risk is likely to occur. It is recommended not to conduct business until the health of the supply chain is improved.
Very bad	Most of the indicators are far below the industry standards, and the health is very poor, so it is not recommended to carry out business.

Compared with the traditional evaluation method based on single enterprise reputation, it can effectively reduce the threshold of financing for Small and micro companies, Commercial banks in the supply chain can conduct business according to the system conclusion if the health of the supply chain is acceptable, that is, most of the indicators can meet the standard, and then pay attention to the changes of key indicators in the whole process of business development to achieve risk early warning and risk prevention. In the next two chapters, we will use the fuzzy comprehensive evaluation method to establish the supply chain health evaluation system, and then use specific examples to illustrate the application of the entire evaluation system.

4 EVALUATING THE SUPPLY CHAIN HEALTH DEGREE UNDER THE SUPPLY CHAIN REVERSE FACTORING MODE

4.1 Selection of Evaluation Indicators and Methods for Supply Chain Health

After determining the indicators in the previous chapter, we considered the nature of specific indicators. We found that the three indicators can give qualitative evaluation according to the corresponding standards, so we considered using the fuzzy comprehensive evaluation method as the main method to establish the model. The concept of fuzzy evaluation method was first proposed by an American scholar (L.A. Zadeh), who proposed to give up the thinking mode of absolute tendency and accurate classification of things in the evaluation of things, but adopted comprehensive multifactor decision-making evaluation based on fuzzy sets. The fuzzy comprehensive evaluation method has been widely used by scholars in the evaluation of indicator systems in various fields [2]. Here we give the specific process of the model:

(1) Determine comment set

First, we determine the comment set.

$$V=\{\text{Very good } V1, \text{ good } V2, \text{ fair } V3, \text{ poor } V4, \text{ very bad } V5\} \quad (1)$$

(2) Establish a set of influencing factors for each category.

$$U=\{u1，u2，u3，u4，u5\} \tag{2}$$

Ui represents n influencing factors of the assessment object, and the specific indicators have been given above.

(3) Building weight sets.

$$W=\{W1, W2,\ldots,Wn\} \tag{3}$$

Wi gives different weights for the importance of corresponding Ui, and the weights are given by the analytic hierarchy process.

(4) Determine single factor evaluation matrix

$$R=\begin{bmatrix} r11 & r12 & r13 & r14 & r15 \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ rn1 & rn2 & rn3 & rn4 & rn5 \end{bmatrix} \tag{4}$$

Rij is the membership of the ith factor in factor set U to the jth element in comment set V.

(5) Fuzzy comprehensive evaluation.

$$B=W*R=\{W1,W2,\ldots,Wn\}*=\begin{bmatrix} r11 & r12 & r13 & r14 & r15 \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ rn1 & rn2 & rn3 & rn4 & rn5 \end{bmatrix}=(b1,b2,b3,b4,b5) \tag{5}$$

Bj is the membership degree of the judgment object to the jth element in the evaluation set V under the condition that all influencing factors are comprehensively considered. Then the corresponding comments or grades shall be determined according to the principle of maximum membership.

4.2 Determination of Weight of Supply Chain Health Degree Evaluation Index

We use AHP to determine the weight [8]. We use a to f order to mark solvency, business ability, profitability, cash flow, risk level and developing capacity as shown in Table 4.

Table 4: Paired comparison of factors

	a	b	c	d	e	f
a	1	2	2	1	1/3	3
b	1/2	1	1	1/2	1/2	2
c	1/2	1	1	1/2	1/3	2
d	1	2	2	1	1	3
e	3	2	3	1	1	5
f	1/3	1/2	1/2	1/3	1/5	1

The matrix is used as the judgment matrix in AHP to calculate the maximum eigenvalue $\lambda= 6.12$ The normalized corresponding eigenvector is w= (0.1845,0.1144, 0.1058, 0.2190, 0.3162, 0.0601)

Consistency index CI= (6.12-6)/(6-1)=0.024

Random consistency index RI=1.26

Consistency ratio CR=0.024/1.26=0.019 ＜0.1 passed the consistency test.

Using the same method, we can calculate the weights of other factors. After calculation, the weight diagram of fuzzy comprehensive evaluation is given as shown in Figure 2.

Then we can get the system evaluation through the fuzzy comprehensive evaluation method, and we will give an example below.

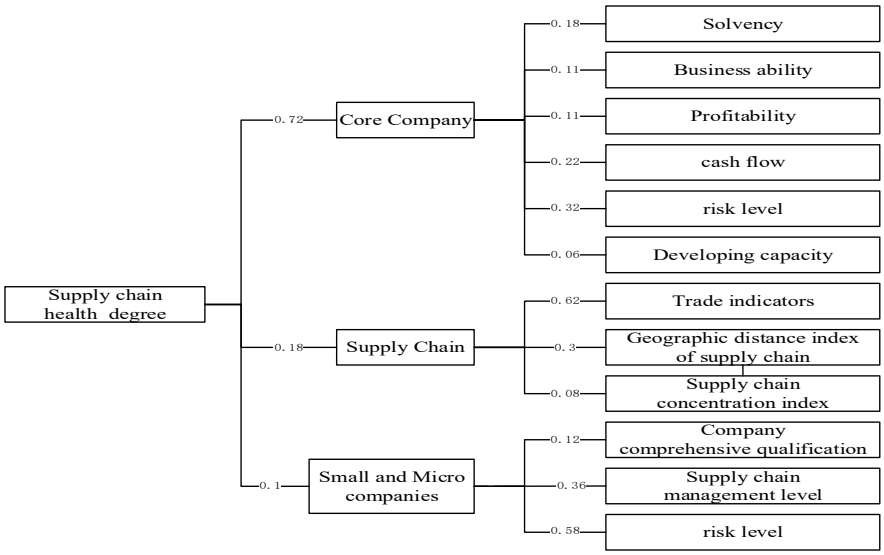

Figure 2: Weight Table

5 APPLICATION EXAMPLES OF SUPPLY CHAIN FINANCIAL RISK BASED ON SUPPLY CHAIN HEALTH DEGREE AND EARLY WARNING REVERSE FACTORING MODE

Our data source is the financial situation analysis database of listed companies in CSMAR.

We selected 90 listed companies in the wholesale industry from March 2021 to June 2022 according to the industry division of the CSRC.

We selected the financial data of a core company in 21 years and a small and micro company associated with it to fill in the supply chain health index rating table as follows.

From the perspective of company health, the intuitive information we can get is whether all indicators meet the industry standards, whether there are indicators that do not meet the industry standards, and whether there are indicators that have a large gap with the industry standards.

When the supply chain is evaluated as good, although there may be indicators that do not meet the standards, the overall impact is small, and the supply chain risk is small. You can start business with confidence. When the supply chain is evaluated as good, focus on indicators that do not meet the standards.

When these indicators further decline, the probability of risk will increase significantly. When the supply chain is evaluated as acceptable, there must be multiple substandard indicators and a certain number of indicators that are significantly lower than the standard, and the probability of supply chain risk is extremely high. To do a good job of risk early warning, we should always pay attention to these indicators and require supply chain related companies to improve the indicators in a timely manner.

We can analyze how to conduct risk early warning when some indicators fail to meet the standard based on the regression analysis results. Then we give the analysis of the indicators in Table 5.

Table 5: Comparison of core company indicators

core company	factor	value	reference
Solvency	current ratio	1.090071	2
	quick ratio	0.517282	1
	cash ratio	0.040175	0.862977
	asset liability ratio	0.386334	0.4-0.6
Business ability	ratio of accounts receivable to income	0.269206	0.412256
	turnover rate of accounts receivable	3.714628	3
Profitability	ROA	0.006855	0.0205319
cash flow	cash content of net profit	0.424166	-4.63
risk level	financial leverage	1.299524	3.070197
	operational leverage	1.187144	1.361462
	comprehensive leverage	1.542722	3.556708
Developing capacity	capital maintenance and appreciation rate	1.031828	1.144394
	capital accumulation rate	0.031828	0.144394

We adopt a subjective and objective evaluation standard to measure supply chain indicators. The core company supply chain indicators and supply chain geographical distance indicators are relatively stable throughout the business process. Therefore, in most cases, changes in supply chain trade indicators will affect the health of the supply chain. Therefore, we should focus on the closeness of trade links between Small and micro companies and core company as shown in Table 6 and Table 7, Once the index decreases, the health of the supply chain will decrease, and the probability of supply chain risk will increase.

Table 6: Supply Chain trade indicators

Supply chain trade indicators	factor	reference
Amount of procurement from Small and micro companies by listed companies	24561613.58	39298580
Proportion of supplier purchase amount in total annual purchase amount	4.94%	8%

Table 7: Supply chain indicators of core company

Core company supply chain indicators	factor	reference
Supplier concentration	54.51	41
Herfindahl index of supplier concentration	9.362422	11.51
Supply chain concentration	52.6	34.62

Part III Relevant indicators from the perspective of Small and micro companies belong to the subjective evaluation part, which is directly reflected in the single factor judgment matrix below.

Then we conduct fuzzy comprehensive evaluation and analysis as follows:

First, consider the health of core company. We will compile the data and consult industry experts for judgment, and then give a single factor judgment matrix.

$$R1=\begin{bmatrix} 0 & 0.2 & 0.5 & 0.2 & 0.1 \\ 0 & 0.4 & 0.3 & 0.2 & 0.1 \\ 0 & 0.1 & 0.6 & 0.3 & 0 \\ 0.6 & 0.2 & 0.2 & 0 & 0 \\ 0.1 & 0.7 & 0.1 & 0.1 & 0 \\ 0.1 & 0.5 & 0.4 & 0 & 0 \end{bmatrix}$$,Comprehensive evaluation matrix B1 calculated by W1 weight and R1.

W1=[0.18,0.11,0.11,0.22,0.32,0.06]

B1=W1*R1=[0.170,0.389,0.289，0.123，0.0290]

$$R2=\begin{bmatrix} 0.1 & 0.3 & 0.4 & 0.2 & 0 \\ 0.1 & 0.3 & 0.3 & 0.2 & 0.1 \\ 0 & 0 & 0.8 & 0.1 & 0.1 \end{bmatrix}$$,Comprehensive evaluation matrix B2 calculated by W2 weight and R2.

W2= [0.62,0.3,0.08]

B2=W2*R2=[0.0920，0.2760，0.4020，0.1920，0.0380]

$$R3=\begin{bmatrix} 0.7 & 0.2 & 0.1 & 0 & 0 \\ 0.2 & 0.3 & 0.3 & 0.2 & 0 \\ 0.8 & 0.1 & 0.1 & 0 & 0 \end{bmatrix}$$,Comprehensive evaluation matrix B3 calculated by W3 weight

and R3.

W3=[0.12,0.36,0.52,]

B3=W3*R3=[0.5720，0.1840，0.1720，0.0720，0]

New judgment matrix can be obtained through B1, B2 and B3.

R=$\begin{bmatrix} B1 \\ B2 \\ B3 \end{bmatrix}$,Finally, we make a comprehensive evaluation through the first level elements. W=[0.72,0.18,0.1]

B=W*R=[0.1962，0.3482，0.2976，0.1303，0.0277]

According to the principle of maximum subordination, since 0.3482 is the largest, the overall assessment of the supply chain health is good, and the risk generation probability is low, so it is recommended to carry out supply chain finance business. However, we also found that the company's health deduction is largely due to its solvency analysis as a standard. Through regression analysis, we found that the low data in this item will increase the possibility of financial risk for core company, Therefore, for the supply chain, we need to make early warning of risks, focus on the continuous improvement of the solvency of core company, and improve the health of the supply chain.

6 CONCLUSION

On the basis of the research on company health degree, this paper considers the relevant factors of the supply chain, establishes a supply chain health degree evaluation model, and puts forward the possibility of realizing risk early warning through this model, hoping that more Small and micro companies can obtain financing opportunities through the supply chain financial reverse factoring business model. However, the model is currently operated largely based on the opinions of industry experts, and there is indeed a problem of subjectivity. At the same time, when the company's health fails to meet the expectations, it is difficult to reverse locate the weak indicators through the system level, and more rely on the further analysis and judgment of experts in relevant fields. The next improvement direction of the model is to consider machine learning and deep learning methods for data processing, improve the accuracy of prediction, strengthen the model risk positioning ability, and further improve the reliability of the model.

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