Financial Risk Control Based on optimized Z-Score Financial Warning Model

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ABSTRACT: *Financial risk control is an important link in enterprise risk management. Traditional financial risk control methods often rely on experience and intuition, lacking scientific validity and accuracy. In recent years, with the improvement of financial data availability, more researchers have begun using data mining and machine learning technologies for financial risk control. This article studies how to control financial risks using an optimized Z-Score financial warning model. We have adopted data mining and machine learning methods to improve the traditional Z-Score model and propose a new optimization model to predict financial risks more accurately and effectively control risks.*

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1. Introduction

Whether the long-term development goals of enterprises can be achieved has a great relationship with the financial risk situation of enterprises. Research on enterprises' financial risk has gradually become a key research topic in related fields [1]. Faced with an increasingly complex market economy environment, enterprises' financial risk will not only be affected by the external macroeconomic environment, but also the internal micro-factors. Enterprises have to be at financial risk because of the uncertainty caused by various internal and external factors. No matter which business, if the financial risk it faces is relatively large, the possibility of bankruptcy crisis will be greater, which will seriously affect the stable and healthy development of the national economy [2]. Based on this background, this paper effectively evaluates the financial risk of the enterprise itself. It concludes with specific results, and gives effective suggestions to control the financial risk, which can play a positive role in promoting the long-term development goal of the enterprise [3]. At present, the research on the

financial risks of foreign trade enterprises in China is focused on the classification of financial risks of foreign trade enterprises, the control means, and other related angles, but the targeted research that carries out for the financial risks faced by China's foreign trade enterprises is very much at least [4]. Therefore, this paper makes a practical reference to the advanced financial risk evaluation model of foreign countries, fully analyzes the particularity of the enterprises engaged in foreign trade activities in China, and analyzes the financial risk of foreign trade enterprises using empirical research, which can play a positive role in the theoretical research on the financial risk of enterprises in China [5].

2. State of the Art

The formal decision model proposed by Fitzpatrick (1932) belongs to the earliest research on the enterprise financial risk warning; he specifically selected 19 enterprises as the actual research objects and divided them into two types according to the financial index of a single level, namely, the bankruptcy and non-bankruptcy [6]. According to the empirical analysis, two indexes can effectively show excellent discrimination ability, that is, net profit shareholders' equity and shareholder equity liabilities [7]. Beaver (1966) selected 80 enterprises as the actual research samples for the exercise and tested the predictive power of the 40 variables that can show the characteristics of the enterprise between 1 and 8 years when the company entered the bankruptcy state [8]. A was the official proponent of the Z-score model, which carried out an adequate evaluation of the relevant financial risks that the enterprise needs to face [9]. The Z-score model chose five key financial indicators, selected five typical financial indicators, and calculated and obtained the Z value by giving weights to the relevant indicators to scientifically define the corporate financial risk situation according to the standard threshold [10]. Professor Altman selected 40 bankrupt and 40 non-bankrupt enterprises to conduct a comparative study, used the criteria of minimizing the probability of misjudgement to obtain the weights of the five typical financial indicators, and obtained the multiple linear discriminant models [11]. Artin (1977) used the logistic model to study the risk assessment of 6,000 enterprises selectively from 1980 to 1987. After comparison, it was found that the predicted effect obtained by the Logistic model is excellent [12].

3. Methodology

3.1. Z-Score Model Construction

Based on the purpose of scientific inspection and early warning of the risk of the enterprises and the stocks that need to be invested, Professor Altman formally proposed the Z-Score financial early warning model, brought the actual financial situation of early warning analysis of listed companies, chose 5 financial indicators to multiply with different coefficients, and constructed the Z-Score financial early-warning model, so s to analyze the risk of listed companies effectively [13].

$$Z = 1.2X1 + 1.4X2 + 3.3X3 + 0.6X4 + 1.0X51 \quad (1)$$

Z in formula (1) represents Z-Score, $X1$, $X2$, $X3$, $X4$, $X5$ represent different types of financial indicators, $X1$ = working capital / total assets; $X2$ = retained earnings / total assets; $X3$ = Net profit before interest and tax / total assets; $X4$ = shareholder equity/book value of total liabilities; $X5$ = sales amount / total assets. According to formula (1), it can be concluded that Altman concludes that in the case of Z-Score ≥ 2.675, the financial state is sound, and Z-Score <2.675, the financial situation is not good, so the Z-Score model can be used to analyze the financial crisis of the listed company [14].

3.2. SQA Algorithm

The basic idea of the *SOA* algorithm is that the *SOA* algorithm effectively simulates the random search behavior of people and applies the intelligent search behavior of people to the search optimization problem. In terms of the optimization calculation process, unexpected search behavior of people can be interpreted in this way: in the process of searching continuous space, the more optimal solution is often near the optimal solution, that is, the optimum solution, which is possible to appear in the neighborhood of optimal solution [15]. So, if the location is better, searchers need to expand search operations in smaller neighborhoods; if the location is poor, searchers need to search in larger neighborhoods. It can be said that *SOA* can efficiently use the fuzzy logic covered by natural language and uncertainty reasoning to model the above search principle and draw the specific search step. SOA uses social and cognitive to learn and get the necessary social and cognitive experience, and under the premise of effectively associating the self-organized agglomeration behavior possessed by the intelligent community, it takes the behavior that is beneficial to itself and establishes its search target.

The *SOA* algorithm includes the following steps: ***Step* 1**: t→0; ***Step* 2:** initialization can cause s initial positions in the domain

of the feasible solution: $\{\vec{x}_i(t)|\vec{x}_i(t)=(x_{i1},x_{i2},...x_{iM})\}$; ***Step* 3:** The objective function value of any position is evaluated and calculated; ***Step* 4:** it is needed to search mode, so as to calculate the search direction *dij(t)*and the step size *aij(t)* for any individual *i* in any dimension *j*, and define altruism as well as pre-action, self-interest orientation $\vec{d}_{i,ego}$, altruistic orientation $\vec{d}_{i,alt}$ and proactive orientation $\vec{d}_{i,pro}$ of any of the first *i* search individuals, and then the actual expression is:

$$\vec{d}_{i,ego}(t)=\vec{p}_{i,best}-x_i(t) \tag{2}$$

$$\vec{d}_{i,alt}(t)=\vec{g}_{i,best}-x_i(t) \tag{3}$$

$$\vec{d}_{i,pro}(t)=\vec{x}_i(t_1)-\vec{x}_i(t_2) \tag{4}$$

Considering the type (2), type (3), type (4), the direction of search is determined by random weighted geometric averaging of three directions. The search direction is shown in equation (5):

$$\vec{di}_j(t)=sign(\omega\vec{d}_{ij,pro}+\varphi_1\vec{d}_{ij,ego}+\varphi_2\vec{d}_{ij,alt}) \tag{5}$$

In the formula (1) to (5), $\vec{x}_i(t_1)$, $\vec{x}_i(t_2)$ are the best positions in $\vec{x}_i(t-2)$, $\vec{x}_i(t-1)$, $\vec{x}_i(t)$ respectively; is the collective historical best position of the neighborhood where the *i-th* search individual is located, $\vec{p}_{i,best}$, $\vec{g}_{i,best}$ are the constant between [0 1] of the best location φ_1, φ_2 ever experienced by *i-th* search individual; ω is the inertia weight, and then the position is updated to update each searcher position according to equation (6) and (7).

$$\Delta x_{ij}(t+1)=\alpha i_j(t)d_{ij}(t) \tag{6}$$

$$x_{ij}(t+1)=x_{ij}(t)+\Delta x_{ij}(t+1) \tag{7}$$

Here, t→t + 1, if the stop condition is met, then the search is stopped. Otherwise, it moves forward.

$$\alpha_{ij}(t)\geq 0 \qquad d_{ij}(t)\in\{-1,0,1\} \tag{8}$$

3.3. Z-Score optimization Model based on SQA

The excellent optimization ability of the *SOA* algorithm is used to make an effective optimization adjustment for the Z-Score model coefficients, so that it can be more accurate to forecast the financial risk of the listed companies in China. The specific algorithm flow is shown in Figure 3 If there are five unknown variables, respectively, which belong to *KmKz, K: i, K,} K*, so that the error of equation (9) is the lowest, and (9) is as follows:

$$Fitness(K)=Z_{实际}-Z_{预测} \tag{9}$$

In equation 9, *Z* reality and *Z* predictions represent the Z-Score actual score and the Z-Score prediction score, respectively; the expressions are shown in equations 10 and 11, respectively:

$$Z_{实际}=1.2X_1+1.4X_2+3.3X_3+0.6X_4+1.0X_5 \tag{10}$$

$$Z_{预测} = K_1X_1 + K_2X_2 + K_3X_3 + K_4X_4 + K_5X_5 \quad (11)$$

$X1$, $X2$, $X3$, $X4$, and $X5$ in equation 10 and equation 11 denote different financial indicators, respectively, as shown in equation (1).

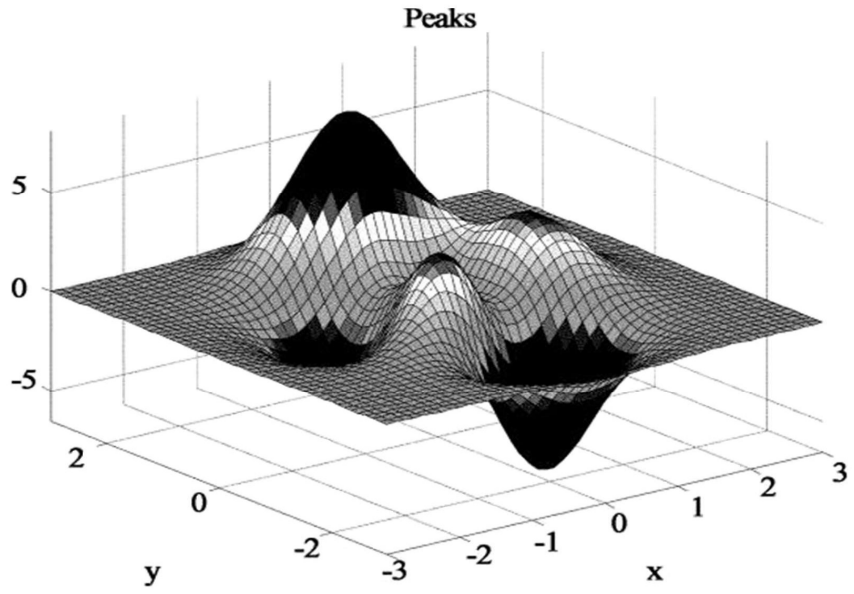

Figure 1. Function image

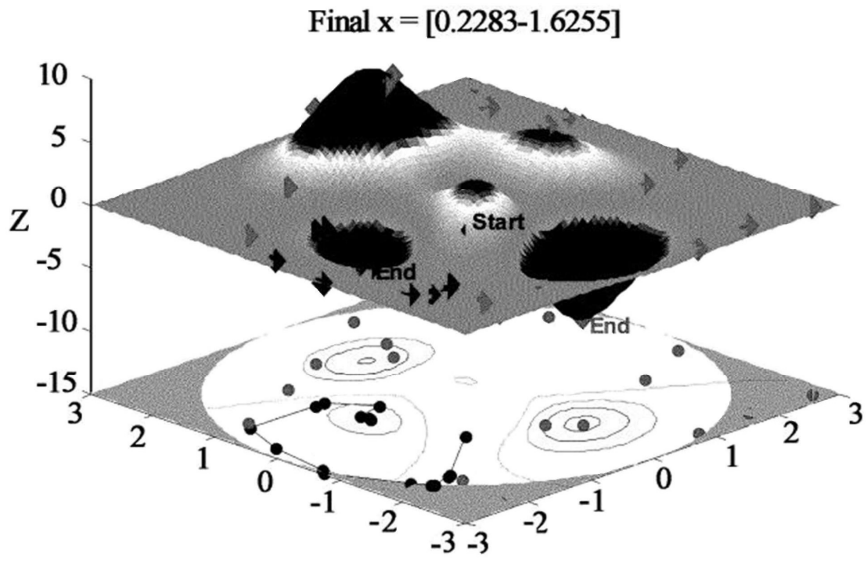

Figure 2. Optimization process diagram of *SOA* algorithm

4. Result Analysis and Discussion

4.1. An Empirical Analysis of Financial Data of Listed Companies

This paper chose financial data of 20 listed companies as a research sample. Due to limited space, the Z-Score of 20 listed

companies was calculated and compared with the data information contained in the tables, and it was known that only the financial situation of the first, the seventh, the ninth and the thirteenth listed companies met the standard. So, it can be found that the Z-Score model used in the past also has a relatively large adjustment space. *SOA* algorithm parameter settings: population size, *sizepop* = 100, the maximum iterations *Iteration* = 100, the maximum membership value *Umax* = 0.9500, the minimum membership value *Umin* = 0.0111, the maximum weight *Wmax* = 0.9.

S.No	*X*1	*X*2	*X*3	*X*4	*X*5	Y
1	0.017	0.182	0.4195	1.123	0.045	0
2	1.1202	0.1698	0.2648	0.8451	0.9654	1
3	0.2654	0.2314	0.5412	0.4215	0.0214	1
4	1.2514	0.2165	0.3214	1.0214	1.0321	1
5	0.3512	0.2154	0.2445	0.9844	0.9124	1
6	1.6215	0.3214	0.2654	1.0124	1.0321	1
7	1.1354	0.2155	0.3214	0.9874	0.5124	0
8	0.3512	0.2145	0.3214	0.1985	0.1346	1
9	0.8965	0.2145	0.2564	0.987	0.9541	0
10	0.5414	0.2654	0.2346	0.8425	0.0033	1
11	0.9541	0.214	0.1654	0.854	0.2157	1
12	0.0845	0.2677	0.2012	0.874	0.985	1
13	0.4451	0.2877	0.2114	0.564	0.217	0
14	0.8741	0.325	0.4115	0.1357	1.0146	1
15	0.4551	0.748	0.4645	0.557	0.8436	1
16	0.4687	0.2441	-0.543	-0.154	0.615	0
17	0.6173	0.311	0.1256	0.714	0.848	0
18	0.7541	0.2145	0.8445	0.548	0.844	1
19	0.4115	0.5178	0.2587	0.0257	0.548	0
20	0.1547	0.1235	0.3541	1.6574	1.214	1

Table 1. Financial Data of 20 Listed Companies

As can be seen from the above table, with the increase of population size and iteration times, the ability of *SOA* algorithm to

optimize Z-Score model parameters is stronger and faster, and can quickly get the optimal value, and the effect is good.

S.No	Z-Score	Y
1	2.3214	0
2	3.6254	1
3	2.5412	1
4	4.9874	1
5	3.5412	1
6	4.5421	1
7	4.8745	0
8	2.5421	1
9	3.5576	0
10	2.7542	1
11	3.8136	1
12	2.5413	1
13	1.9542	0
14	4.1264	1
15	2.9465	1
16	1.2134	0
17	2.4324	0
18	3.8445	1
19	2.5457	0
20	3.2354	1

Table 2. Z-Score Values of 20 Listed Companies

Z-Score model is optimized by *SOA* algorithm. When the fitness is the smallest, the corresponding model parameters $K1$, $K2$, $K3$, $K4$ and $K5$ are 1.3204, 1.4531, 3.2482, 0.6751 and 1.1912 respectively. The average recognition rate of this algorithm is as high as 96.33%, which is much higher than that of the *SVM* algorithm and AdaBoost algorithm.

4.2. An Empirical Analysis of Financial Data of Case Enterprise

By using the financial data of the annual report of Jiangsu Sainty Companies limited by shares from 2012 to 2016, according

to the formula, the values of the relevant indicators were given, as shown in Table 4.

S.No	Z-Score	*SOA* algorithm optimization Z-Score	Y
1	2. 3154	2.2267	0
2	3. 8251	4.4524	1
3	2. 1475	2.5624	1
4	4. 8254	4.9854	1
5	3. 1243	3.8457	1
6	4.6551	5.8544	1
7	4. 5412	4.8745	0
8	2. 1445	2.6571	1
9	3. 9845	4.2354	0
10	2. 5154	2.8745	1
11	3.5215	3.4151	1
12	2. 8457	2.9251	1
13	1.6012	1.7451	0
14	3. 8544	4.5412	1
15	3.4621	3.4654	1
16	1.3261	1.1687	0
17	2.8464	3.1046	0
18	3. 4658	4.4628	1
19	2.4289	2.7875	0
20	3. 4748	3.7456	1

Table 3. *SOA* Algorithm for 20 Listed Companies optimize Z-Score Contrast Results

From the above table, it can be seen that from 2012 to 2016, the performance of financial risk value *Z* of sainty in Jiangsu Province was poor, and the company belonged to the “dangerous enterprise” for four years. In 2003, the financial risk value *Z* of sainty in Jiangsu Province was raised from 1.7336 to 1.9945, with a growth rate of 15.05%, and it was transformed from the original bankruptcy zone into a grey area. Among them, *X*4 increased from 1.0847 to 1.1459, with an increase of 5.64%; *X*5 increased from 0.8844 to 1.1271, with a rise of 27.44%. It can be said that the growth of *X*4 and *X*5 made the *Z* value of financial risk improve effectively, in which the role of *X*5 was more prominent. Following the formula *X*5 = operating

income/assets to calculate, it can be seen that in 2013, the company's overall increase in assets reached 5.31%, its operating income also increased by 34.21%, and operating income growth was more significant than the overall increase in assets, which made *X*5 growth relatively large, and significantly improved the *Z* value of the company's financial risk. This shows that in 2013, the negative impact of the global economic crisis triggered by the impact of the US subprime mortgage crisis was gradually weakened. The traditional foreign trade industry was full of vitality, which significantly improved total asset utilization efficiency.

Year	*X*1	*X*2	*X*3	*X*4	*X*5	Z
2012	0.0594	0.0367	0.0232	1.0847	0.8844	**1.7336
2013	0.0407	0.0421	0.0222	1.1459	1.1271	*1.9945
2014	-0.0940	0.0479	0.0416	0.7085	1.2311	**1.7464
2015	-0.1088	0.0824	0.0484	0.7719	2.0012	*2.6068
2016	-0.1266	0.1935	0.1616	0.8399	2.0315	3.1859

Table 4. The Parameters of Jiangsu Sainty Limited by Share Ltd Value

In terms of 2014, *Z* value of financial risk of sainty in Jiangsu Province decreased from 1.9975 in the previous year to 1.7463, and the actual decrease was 12.34%, and *X*4 decreased from 1.0435 to 0.7073, with a drop of 43.63%; *X*5 increased from 1.1263 in the previous year to 1.2302, with an increase of 9.13%. The decline in *X*4 and the growth of *X*5 reduced the *Z* value of the company's financial risk, in which *X*4 played a more pronounced effect. Following the formula *X*4 = total market value/liabilities to calculate, it can be seen that in 2014, the company's overall market value decreased by 37.73%, liabilities increased by 0.72%, the significant reduction in the total market capitalization of the company represented that the capital market was not optimistic about the development of Jiangsu Sainty stock, investors had no confidence in the company's stock. The company's capital structure was not reasonable, so the *Z* value was lower than in 2013, and the financial risk was also increasing. Even if the company was still in a dangerous state, it fell from the grey zone of 2013 to a more dangerous bankruptcy area, and the financial risk situation deteriorated markedly.

In terms of 2015, the *Z* value of the financial risk of sainty in Jiangsu Province increased from 1.7358 in the previous year to 2.6075, with an increase of 49.27%; the actual increase was more pronounced, but still in the grey area, still not out of the ranks of dangerous enterprises. Among them, *X*4 increased from 0.7075 in the previous year to 0.7623, with an increase of 8.65%; *X*5 increased from 1.2342 in the last year to 2.0031, with a rise of 62.75%. The growth of *X*4 and *X*5 improved the *Z* value of corporate financial risk. In this case, the effect of *X*5 was more pronounced. Using the calculation, it can be seen that the company's total assets decreased by 8.31% in 2015, while the operating income decreased by 3.45%, and the decline in active income was smaller than the decline in overall assets. It can be learned that the asset utilization ratio of enterprises has improved compared to 2014, and the enterprise financial risk situation has been enhanced to some extent.

In 2016, the *Z* value of the financial risk of sainty in Jiangsu Province rose from 2.6035 in the previous year to 3.18642, with an increase of 23.42%. Its *Z* value had already exceeded the critical standard of 2.99, so it could enter the security area. This year, the company had been out of danger for the first time in five years. Among them, *X*1 decreased from -0.1045 in the previous year to -0.1238, with a decrease of 16.43%; *X*2 increased from 0.0734 in the last year to 0.1823, with an increase of 126.76%; *X*3 increased from 0.0484 in the previous year to 0.1672, with a rise of 243.58%; *X*5 increased from 2.0012 in the last year to 2.0315, with an increase of 145%. Among them, only *X*1 showed a downward trend; the growth of *X*2, *X*3, *X*4 and *X*5 significantly increased the *Z* value of the company's financial risk, in which the role of *X*2 and *X*3 was even more pronounced. With the calculation of the relevant data, it can be seen that when enterprises remove the risk, the company retained earnings and earnings before interest and tax, and these two indicators play a very critical role. The promotion of *X*2 shows that the company's ability to use retained earnings to invest has been strengthened. The growth of *X*3 shows that the company's total assets and profitability have also been strengthened. With the effect of *X*2 and *X*3, *Z* value of financial risk

of sainty in Jiangsu Province has moved into the safe area from its former grey areas and implemented a fundamental change from a dangerous business to a safe enterprise.

According to the analysis carried out above, it can be found that in addition to the effects of external macro-environmental factors, there are still many internal factors that lead to the financial risk of foreign listed companies in China, such as the low utilization rate of assets and the lack of reasonable distribution of benefits. So, based on the Z-Score model, this paper launched the empirical analysis of many listed companies engaged in foreign trade activities in China, and on the level of the enterprise itself, drew the relevant strategies to control the financial risks: the first is to construct a financial risk control system that is fully related to the Z-Score model; the second is to get a rationalized income distribution strategy, the efficient use of the company's accumulated profits; the third is to select appropriate financing methods to optimize the capital structure of enterprises; the fourth is to strengthen the management capacity of enterprise working capital; the fifth is the use of various types to enhance the company's profitability effectively; the sixth is the effective use of the particularity of listed companies. Overall, our enterprises must effectively improve their management level and continue to give market feedback positive signals.

5. Conclusion

With the increasing complexity of the market economy environment, enterprises' financial risk will be affected by the external macro environment and internal micro factors. The uncertainty caused by various internal and external factors causes enterprises to be at financial risk. No matter which business, if the financial risk faced by the company is relatively large, the possibility of a bankruptcy crisis will be greater. In a serious way this will have a serious impact on the steady and healthy development of the country's economy. Because the diagnosis rate of the traditional Z-Score financial early-warning model is poor, it is difficult to judge the financial risk of listed companies clearly. In this paper, the excellent optimization capability of the *SOA* algorithm was chosen to be fully correlated with the Z-Score financial early warning model, and an optimized Z-Score financial early warning model was derived. The fitness function of *SOA* algorithm optimization Z-Score financial early warning model was derived. By using the simulation comparison, it can be learned that the Z-Score financial early warning model after optimization has an average recognition rate of 996.33%, which is much higher than the average recognition rate of the *SVN* algorithm and the AdaBoost algorithm, which significantly enhances the financial predictive capabilities of Z-Score economic early warning model, to make it more adaptable.

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