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A Z-score-based early warning study of financial risk in the medical device industry

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Abstract: *It has become urgent to find a solution for the problem of how to use the financial risk early warning system to effectively evaluate the financial risk of enterprises and determine whether the risk threshold is standard across different industries (Lei, Menghao, & N, 2021). This paper applies the Z-Score model and focuses on the medical device industry. Using a total of 48 listed companies on the Science and Technology Innovation Board as observation samples, empirical analysis of the companies' financial risks is conducted in addition to establishing a more reliable and practical financial risk early warning model suitable for the medical device industry. APT Medical and Endovastec were selected as observation samples, followed by an empirical analysis using traditional indicators and the Z-Score model. The results show that the applicability of the Z-Score model to a certain company in financial risk early warning is low. Furthermore, the threshold of the financial risk early warning model should be dynamically adjusted according to various industries to assist enterprises in realizing the financial risk crisis in time to take adequate measures. (Lu & Zhan, 2018)*

Keywords: *early financial warning, Z-Score model, listed companies, medical device industry*

1. Introduction

In recent years, competition between enterprises has been intensifying due to the complexity of the domestic and foreign market economic environment. In order to achieve sustainable and healthy development, the focus of enterprises has gradually shifted to risk early warning in risk management. The practical financial risk identification index system can effectively evaluate the risks faced by enterprises, thus allowing them to take prompt preventative and control measures when the expansion of financial risks fails to occur (Moreno, Martínez, & Ponce, 2021). For example, reducing enterprises' corresponding financial expenditure can indirectly increase the benefit[1].

2. Theoretical Background

In 1968, American scholar Edward Altman proposed the Z-Score model, which uses a multivariate analysis method to select five key variables from more than 20 financial ratios to predict the financial situation of enterprises (M.M., K.B., & M.M., 2021). The model is as follows:

$$Z = 1.2X_1 + 1.4X_2 + 3.3X_3 + 0.6X_4 + 0.999X_5$$

Table 1: Z-Score model index calculation formula and specific meanings

Index	Concrete formula (%)	Express meaning
X_1	Working capital/total assets	Reflects the liquidity level of all assets of the enterprise
X_2	Retained earnings/total assets	Reflects the proportion of retained earnings to total assets
X_3	Ebit/total assets	Reflect corporate profitability
X_4	Market value of equity/total liabilities	Reflect the financial structure of the enterprise
X_5	Sales/total assets	Reflects corporate profitability or total asset turnover speed

The univariate analysis model does not offer advantages that the Z-Score model does (Wilson & Lange, 2015). It includes every indicator with strong forecasting ability and effect, serving as a forecasting and preventative tool for enterprises. To assess the firm's financial situation, the model naturally combines indicators X_1 and X_4 to reflect the enterprise's solvency, indicators X_2 and X_3 to

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reflect the enterprise's profitability, and indicator 5 to reflect the operation ability of the enterprise, as shown in Table 1. For instance, the enterprise is at risk of a bankruptcy crisis when the Z-value is less than 1.81. When the Z-value is between 1.81 and 2.675, it is called the "gray zone", denoting the severely unstable financial state of the enterprise. The current financial position is considered healthy when the Z value exceeds 2.675. (Sari & Haugesti, 2020)

3. Empirical Study

3.1 Research Hypothesis

Assuming the Z-Score model applies to China, the listed companies in the scientific innovation board of the medical device industry will display the following distribution pattern (CHANG, 2011):

Hypothesis 1: During the epidemic period, the medical device industry orders continue to increase, and its Z value should be greater than 2.675.

Hypothesis 2: Following the natural growth and aging of the global population, the demand for the medical device industry keeps rising, and an upward trend in the Z-value is observed year by year[2-3].

3.2 "Z-Score" Model Research Procedures and Methods

3.2.1 Sample Data

(1)A total of 48 listed companies on the Science and Innovation Board in the medical device industry are chosen as research samples, as shown in Table 2 (Petra Maresova, 2015). APT Medical and Endovastec were selected as samples.

Table 2: 48 listed companies in the medical device industry

Stock Code	Stock Abbreviation	Stock Code	Stock Abbreviation	Stock Code	Stock Abbreviation
688013.SH	Touchstone	688085.SH	SANYOU	688212.SH	AOHUA
688016.SH	Endovastec	688108.SH	SINOMED	688217.SH	RIGHTON GENE
688026.SH	BIOFIL	688114.SH	MGI	688236.SH	CHUN Li
688029.SH	Micro-Tech	688139.SH	Haier Biomedical	688253.SH	INNOVITA
688050.SH	Eyebright	688151.SH	Huaqiang High-Tech	688271.SH	UIH
688067.SH	AVE Science & Technology	688161.SH	WEGO ORTHO	688273.SH	Medlander
688068.SH	Hotgen Biotech	688193.SH	RENDU BIOTECHNOLOGY	688277.SH	TINAVI
688075.SH	Assure Tech	688198.SH	Alance Medical	688289.SH	Sansure Biotech
688389.SH	Lifotronic	688606.SH	ALL TEST	688298.SH	AOBO
688393.SH	Ambitree	688607.SH	CARERAY DIGITAL MEDICAL	688301.SH	iRay Technology
688399.SH	Bioperfectus Biotech	688613.SH	Allgens	688314.SH	KONTOUR MEDICAL
688410.SH	SWS Medical	688617.SH	APT Medical	688317.SH	Liferiver
688426.SH	CWBIO	688626.SH	XIANGYU Medical	688338.SH	SUCCEEDER
688468.SH	CHIVD	688656.SH	HOB	688351.SH	MicroPort Electrophysiology
688575.SH	YHLO	688677.SH	NOVELBEAM TECHNOLOGY	688358.SH	CHISON
688580.SH	VISHEE	688767.SH	Biotest Biotech	688366.SH	Haohai Biological Technology

(2)The sample spans six years, from 2017 to 2022.

(3)The sample data comes from the Z-value data of the 2017-2022 flush iFinD of 48 listed companies on the Science and Technology Innovation Board. Five companies, RENDU BIOTECHNOLOGY, INNOVITA, UIH, MEDLANDER and CWBIO, did not have Z-value data in 2017.

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4. Demonstration and Analysis of Empirical Results

4.1 Traditional Index Analysis

4.1.1 Solvency

Table 3: Short-term solvency indicators of APT Medical Inc and Endovastec from 2017 to 2022

index	Company	2017	2018	2019	2020	2021	2022
Current ratio	APT Medical	4.73	4.27	2.70	3.20	7.98	3.54
	Endovastec	3.48	2.96	14.13	10.44	9.00	9.15
Quick ratio	APT Medical	6.78	6.09	4.50	10.12	12.69	-
	Endovastec	2.19	1.88	13.18	9.60	8.13	7.93

Generally, the current ratio of APT Medical has a downward trend, yet still within a reasonable range from the solvency perspective. Hence, the company should make an appropriate adjustment in advance to avoid adverse consequences. In terms of changes, the flow ratio and quick ratio of APT Medical in 2017 were 4.73 and 6.78, respectively, while in 2021, they increased by 3.25 and 5.91, respectively. The current ratio of Endovastec in 2017 was 3.48 and its quick ratio in 2019. By 2021, the current and quick ratios will rise by 5.67 and 5.74, respectively, showing a significant improvement in the two companies' short-term liquidity. The ratios indicate that the debt-paying ability is good, and there is little strain on current and quick assets to cover current liabilities. Moreover, the current ratio and quick ratio are reasonable. (Chang, 2019), as shown in Table 3.

4.1.2 Operational Capacity

Table 4: Operating capacity indicators of APT Medical and Endovastec from 2017 to 2022

Index	Company	2017	2018	2019	2020	2021	2022
Inventory turnover ratio	APT Medical	1.09	1.22	1.06	0.99	1.24	0.89
	Endovastec	1.47	1.64	1.53	1.42	1.59	1.35
Turnover of total assets	APT Medical	0.61	0.84	0.91	0.83	0.64	0.43
	Endovastec	0.80	0.94	0.47	0.37	0.44	0.36

Regarding operation capacity, APT Medical's average inventory turnover rate from 2017 to 2022 was 1.08, compared to 1.5 for Endovastec during the six years. In comparison with the other two, the average inventory turnover rate of APT Medical was slightly lower than that of Endovastec. The turnover rate of APT Medical's total assets showed a downward trend as the company's asset scale was constantly expanding. However, the operating income did not increase correspondingly, thus causing the total assets turnover rate to reduce, as shown in Table 4. Generally speaking, the operational capacity of APT Medical is slightly weaker[4-6].

4.1.3 Profitability

Table 5: Profitability indicators of APT Medical and Endovastec from 2017 to 2022

Index	Company	2017	2018	2019	2020	2021	2022
Net interest rate on sales (%)	APT Medical	17.68	6.90	19.33	21.73	23.51	27.91
	Endovastec	38.38	39.22	42.48	45.64	45.79	44.84
Return on assets (%)	APT Medical	12.03	8.03	20.51	21.02	16.99	18.45
	Endovastec	35.81	42.49	21.79	19.11	22.38	24.70
Return on equity (%)	APT Medical	16.10	7.97	23.62	24.06	11.69	15.74
	Endovastec	33.71	41.94	13.30	17.39	21.14	18.11

Profitability-wise, the sales net profit margin of APT Medical exhibits certain volatility, with a small value implying its low profit margin. On the contrary, Endovastec's sales net profit margin is generally on the rise, which is near 46% in 2021. The main reason is that the growth of the sales scale results in an increase in operating income. Despite a negative trend in both the rate of return on assets and the rate of return on equity, Endovastec outperformed APT Medical every year. Therefore, the profitability of Endovastec is higher, as shown in Table 5.

4.1.4 Growth Ability

Concerning growth ability, the growth rate of APT Medical's operating income in the six years showed an upward trend, reaching 72.85% in 2021. The company's published restricted stock incentive plan maintains rapid income growth, which is the contributing factor. Similarly, APT Medical's operating profit and total asset growth rates reached their six-year peak in 2021. While Endovastec mainly involves

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the aorta and peripheral vascular direction, its operating revenue and total assets have steadily increased as a result of new product commercialization, new pipeline expansion, and the continuous investment in research and development. Consequently, the two companies display significant development capacity in the medical machinery industry market, as shown in Table 6.

Table 6: Growth ability indicators of APT Medical and Endovastec from 2017 to 2022

Index	Company	2017	2018	2019	2020	2021	2022
Revenue growth rate (%)	APT Medical	--	57.84	67.08	18.68	72.85	49.53
	Endovastec	39.96	44.39	40.91	45.59	30.20	31.76
Operating profit growth rate (%)	APT Medical	--	-24.16	290.21	29.70	86.28	56.49
	Endovastec	41.83	56.67	52.15	45.15	19.48	64.80
Growth rate of total assets (%)	APT Medical	--	28.91	72.19	4.93	241.95	12.40
	Endovastec	19.87	329.93	19.07	27.43	14.00	18.91

4.1.5 Cash Flow Capacity

Table 7: Cash flow capacity indicators of APT Medical and Endovastec from 2017 to 2022

Index	Company	2017	2018	2019	2020	2021	2022
Net operating cash flow/total operating revenue (%)	APT Medical	8.43	7.71	13.59	30.92	21.89	31.51
	Endovastec	42.00	46.23	42.91	46.24	43.86	39.68
Cash recovery on all assets	APT Medical	0.05	0.06	0.10	0.25	0.09	0.13
	Endovastec	0.31	0.40	0.12	0.16	0.17	0.14

With regard to cash flow capacity, the ratio of cash flow generated by operating activities to the operating income of APT Medical increased steadily from 2017 to 2022. Conversely, Endovastec maintained a high level over the six years, indicating that the two companies have a solid ability to generate cash from operating activities, that is, having a strong "hematopoietic" function, as shown in Table 7.

4.2 Z-Score Model Analysis

Table 8: Comparison of Z-score models between APT Medical and Endovastec

	Company	2017	2018	2019	2020	2021	2022
X_1(%)	APT Medical	49.86	48.71	30.81	40.91	67.49	50.34
	Endovastec	28.10	28.58	79.63	78.63	73.94	61.75
X_2(%)	APT Medical	43.58	40.41	24.98	42.62	21.14	29.00
	Endovastec	32.96	24.49	16.01	25.65	34.44	39.81
X_3(%)	APT Medical	12.03	7.13	16.21	20.53	10.98	13.44
	Endovastec	32.96	38.97	13.43	17.58	19.97	17.84
X_4(%)	APT Medical	0.00	0.00	0.00	0.00	8,408.21	3,188.66
	Endovastec	0.00	0.00	11,787.40	12,724.63	7,734.75	5,550.81
X_5(%)	APT Medical	60.60	74.20	72.00	81.44	41.17	41.55
	Endovastec	73.63	85.98	28.88	34.17	39.04	35.09
Z-value	APT Medical	2.21	2.13	1.97	2.58	52.33	21.00
	Endovastec	2.62	2.83	72.64	78.57	48.83	35.54
Z-value description	APT Medical	unstable	unstable	unstable	unstable	healthy	healthy
	Endovastec	unstable	healthy	healthy	healthy	healthy	healthy

By comparing variables X_1-X_5 and taking 2022 as the time node for reference, all variables for Endovastec are greater than APT Medical, except X_5. Thus, indicating that Endovastec outperforms APT Medical in terms of asset liquidity, profitability, financial structure, and other aspects. Additionally, it can be observed that the market is more optimistic about the development of Endovastec. By calculating the Z-value of the two companies, the longitudinal comparison shows that the Z-value of APT Medical from 2017 to 2020 is within the range of 1.81 and 2.675, implying an unstable financial status. In 2021 and 2022, the Z-value is greater than 2.675, indicating good financial standing. Nevertheless, Endovastec's Z-value has been greater than 2.675 since 2018, indicating a strong financial position. In conclusion, Endovastec has a greater Z-value, less financial risk, and a better financial position, as shown in Table 8.

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4.3 Establish a new financial risk early warning model

Given that the Z-Score model's key values of 1.81 and 2.675 are universal standards and that different industries have distinct operating characteristics, their financial indicators differ greatly. Hence for some companies, the critical value of the Z-Score model is less applicable as the financial risk warning threshold of the medical device industry. In addition, the financial risk warning threshold of the medical device industry can be determined by calculating the industry mean value through the Z-value of Whittel Medical and Cardiology Medical, which has limitations due to the sparse sample size.

Therefore, this paper calculates the maximum, minimum, average, and median Z-values of 48 listed companies on the scientific innovation board of the medical device industry from 2017 to 2022 to determine the financial risk warning threshold of the medical device industry. If the Z-value of a company is too large or too small (i.e., there is extreme value), then the calculated median Z-value of 48 listed companies on the Science and Technology Innovation Board in the medical device industry is used as the financial risk warning threshold. If otherwise, the calculated average Z-value of 48 listed companies on the Science and Technology innovation board in the medical device industry is the financial risk warning threshold[7].

According to the financial information of 48 listed companies on the Science and Technology Innovation Board, the results are calculated and summarized as follows shown in Table 9:

Table 9: Calculation results of Z-value of 48 listed companies in medical device industry from 2017 to 2022

	2017	2018	2019	2020	2021	2022
Max Z-Value	3.26	3.27	105.54	127.32	345.94	146.31
Min Z-Value	-1.15	-1.66	-1.05	0.6	0.9	1.27
Ave Z-Value	1.57	1.66	9.44	21.01	34.53	19.19
Med Z-Value	1.66	1.97	2.27	5.13	17.65	13.86
Whether the extreme value exists	NO	NO	YES	YES	YES	YES
Risk Limit	1.57	1.66	2.27	5.13	17.65	13.86

It can be seen from the above data that:

(1) The financial risk early warning threshold of the medical device industry served as the average Z-value of 48 listed companies on the Science and Technology Innovation Board since there was no extreme value in 2017 and 2018. Though, the extreme value between 2019 to 2022 resulted in the median Z-value of 48 listed companies on the science and technology innovation board to pose as the financial risk early warning threshold of the medical device industry[8-10].

(2) According to different years, the financial risk warning threshold of the medical machinery industry should be dynamically adjusted. Take 2022 as an example, the industry risk limit standard is 13.86. Thus, the company's financial risk is high, and its financial situation is unstable if its Z value is less than 13.86. Correspondingly, the company should promptly modify its business strategy. If a company's Z-value exceeds 13.86, it is considered to be performing financially well. The larger the Z-value, the more stable the company's financial condition is.

The above data indicate:

(1)The mean Z-values from 2019 to 2022 are all greater than 2.675, which is consistent with hypothesis 1.

(2)The mean and median Z-values support hypothesis 2 in absolute numbers and time.

5. Conclusion

Although the Z-Score model is applicable to the empirical study of 48 listed companies on the Science and Technology Innovation Board in the medical device industry, its accuracy is low when the analysis focuses on a single company. In general, most Chinese medical device industry enterprises are financially sound, but businesses still face financial risks. Therefore, dynamic adjustment of the financial risk threshold can better help improve the overall anti-financial risk management ability of the Chinese (YASH & VASANTI, 2021).

ISSN 2616-5902 Vol. 5, Issue 5: 127-132, DOI: 10.25236/AJBM.2023.050518

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