Research on Comparing Z-Score, O-Score and X-Score Models in Analyzing Factors Affecting Financial Risk in Medical Companies Listed on Vietnam Stock Market

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Abstract Based on financial risk studies, this chapter analyzes the factors affecting financial risk through the Z-score, O-score, X-score model and data of 21 medical enterprises listed on Vietnam stock market for the period 2016–2020. The study used descriptive statistical analysis, correlation and regression between the dependent variable Z-score (Altman, J Fin 23(4):589–609, 1968), O-score (Ohlson, J Account Res 18(1):109–131, 22:59–86, 1984) with other independent variables and control variables. The LS regression method (Least Squares) and hypothesis testing on EViews and Excel software were applied with a pooled data set of 105 observations of 21 listed medical companies. The research results comparing the Z-score, O-score and X-score models did not find a statistically significant relationship and economic significance between debt structure (DS), credit interest rate (IRS), listing location (PLA) and financial risk of listed medical enterprises. The financial structure expressed through equity ratio (NAR) has the greatest impact and simultaneously in the Z-score, O-score and X-score models. The X-score model (Zmijewski, J Account Res 22:59–86, 1984) is the most accurate model for identifying financial risks of listed medical companies with an accuracy rate of 80.0%

Keywords Financial risk · Medical companies · Debt structure · Z-score · O-score · X-score · Vietnam stock market

1 Introduction

In the modern economy, medical enterprises play an important role, especially in Vietnam in the process of industrialization and modernization. Currently, on Vietnam stock market, there are 21 listed medical companies, of which there are 9 companies on HNX and 12 enterprises on HOSE. The number of listed medical enterprises is not much, although the scale of these enterprises is mainly large, compared to unlisted medical enterprises which are too small, accounting for about 3.5% of the total

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number of medical enterprises. Due to the number of medical enterprises, competition in the market is not significant (GSO, 2021).

Doing business in a fiercely competitive and volatile international environment, medical companies listed on the Vietnam stock market face many risks, especially financial risks. Factors affecting financial risk can be debt structure, solvency, profitability, operating performance, financial structure, credit interest rate, inflation, exchange rate, age and size of the business. For example, the chemical and petrochemical industry has not yet developed strongly, so about 90% of raw materials for drug production come from imports. Therefore, the fluctuations in exchange rates and prices will be difficult to control and affect the profits of enterprises in general and listed medical enterprises in particular. In the context of competition with imported products, listed medical companies depend on imported materials for the most part, while the high price of imported materials will contribute to reducing the gross profit margin of medical listed companies such as Hau Giang Pharmaceutical Joint Stock Company (DHG), Binh Dinh Pharmaceutical—Medical Equipment Joint Stock Company (DBD), Cuu Long Pharmaceutical Joint Stock Company (DCL), Import Export Joint Stock Company, Domesco Medical Import Export Corporation (DMC). Some listed medical companies have negative after-tax profits, for example, Viet Nhat Medical Equipment Joint Stock Company (JVC, 2016, 2020), Lam Dong Pharmaceutical Joint Stock Company—Ladophar (LDP, 2018, 2020), Cai Lay Veterinary Pharmaceutical Joint Stock Company (MKV, 2018). In addition, listed medical companies have not strongly promoted new products, the main segment is still pharmaceutical products for sales channels through pharmacies, drugstores (OTC).

However unexpected, financial risks are always present in every financial investment decision or business transaction of an enterprise. Depending on the risk levels, company can incur financial losses, but can also push businesses into bankruptcy or even bankruptcy. Therefore, in their operations, a very important thing that all enterprises in general and medical enterprises listed on Vietnam stock market in particular should always pay attention to effectively control financial risks. Doing this well will help medical businesses minimize the damage that financial risks can cause.

Theoretical research on financial risk in the world is quite a lot, approached from many different angles. Financial institutions often use the "expert" method to analyze the factors affecting the financial risks of enterprises. However, many researchers argue that financial institutions have not used expert methods on a regular basis, but have turned to methods with more objective scientific basis, for example, the application of quantitative models to analyze factors affecting financial risks of enterprises such as models: Beaver (1966), Z-score (Altman, 1968, 1983, 1993), S-score (Altman, 1968, 1983, 1993), Z-score (Springate, 1978), O-score (Ohlson, 1980), B-score (Bathory, 1984), H-score (Fulmer et al., 1984), X-score (Zmijewski, 1984). Although these models have been widely used in the world, when applied in Vietnam, it is necessary to study and adjust accordingly.

Based on the research on financial risk, this chapter analyzes the factors affecting financial risk through the Z-score, O-score, X-score model and data of 21 medical enterprises listed on Vietnam stock market for the period 2016–2020. The study

uses descriptive statistical analysis, correlation and regression between dependent variables Z-score, O-score and X-score with independent and control variables. The LS regression method (Least Squares) and hypothesis testing on EViews and Excel software were applied with a pooled data set of 105 observations of 21 listed medical companies in the period 2016–2020. Finally, the author applies the researched theory in combination with objective reality to explain the economic significance of the relationship between the dependent and independent variables, the control variable to clarify the research results and from that draw appropriate conclusions.

2 Literature Review

Financial risk is the possibility of loss associated with financial activities and usually originates from the performance of transactions directly related to financial activities such as buying, selling, investing, borrowing and a number of other business activities; but it can also be an indirect consequence of changes in government policies, domestic and international political events, or it can be caused by the impact of natural disasters. In the scope of the study, financial risk is understood as the risk of inability to pay due debts due to the use of financial leverage by enterprises—using borrowed capital in production and business activities.

Z-score (Altman, 1968), O-score (Ohlson, 1980) and X-score (Zmijewski, 1984) models have been widely used in research to predict financial risks of listed companies in many countries around the world such as China (Chunsheng & Duanduan, 2006), Greece (Lagkas & Papadopoulos, 2015), India (Singh & Mishra, 2016), USA (Sayari & Mugan, 2017), Kuwait (Musaed et al., 2018), Pakistan (Ashraf et al., 2019), Turkey (Kiracı, 2019), Indonesia and Singapore (Nilasari & Haryanto, 2018; Tanjung, 2020; Imelda & Alodia, 2020; Andriani & Sihombing, 2021; Muzanni & Yuliana, 2021) through secondary databases collected at stock exchanges with all types of enterprises in different production and business industries.

Chunsheng and Duanduan (2006) empirically study the financial risk of privately owned listed companies in China through the Z-score model and find the average level of financial risk of the listed companies in China. Meihui (2005) used a questionnaire to study the financial risk of enterprises in central Taiwan with multivariate analysis and logit regression. Meihui (2005) came to four conclusions: (i) enterprise managers should accumulate a lot of professional knowledge; (ii) a significant environmental change will cause corporate mismanagement (such as a change in government policy); (iii) a sound financial system is needed; (iv) enterprises need to build an effective risk monitoring system. Enterprises need to implement these solutions well to contribute to minimizing financial risks.

Lagkas and Papadopoulos (2015) emphasize that during more than a decade of liberalization of the Greek telecommunications market and in the adverse conditions caused by the economic crisis, a small number of enterprises have survived and maintained a relative stable position in the market. The study analyzes the financial position of telecommunications companies listed on the Athens Stock Exchange,

Greece. Financial data of OTE, Forthnet and HOL for the period 2008–2012, analyzed by traditional methods such as comparison, ratio analysis. On the other hand, the study presents a relatively original approach to analyze the business viability of enterprises, by combining four widely accepted financial risk forecasting models including Z-score (Altman, 1968), S-score (Springate, 1978), O-score (Ohlson, 1980) and X-score (Zmijewski, 1984). Research results have shown the reliability and applicability of these models in specific fields.

Singh and Mishra (2016) researched and developed a financial risk forecasting model for Indian manufacturing enterprises with a total sample of 208 enterprises. The study uses Z-score (Altman, 1968), O-score (Ohlson, 1980) and X-score (Zmijewski, 1984) models and also compares the original models and the re-estimated models to discover how sensitive these models are to variation over time periods and financial conditions. The performance of all the original models is re-estimated, and the new proposed models are evaluated through the accuracy of the forecast results and the significance of the parameters. The main findings of the study showed that the overall predictive accuracy of all three models improved when the coefficients were re-estimated. Singh and Mishra (2016) suggest that industry-specific financial risk forecasting models should be developed with a combination of financial ratios to forecast the financial risks of firms in a particular country. The study also shows that the coefficients of the model change with time periods and financial conditions. Therefore, researchers should be cautious when choosing financial risk forecasting models, need to recalculate the model's coefficients by looking at recent data to get a higher accuracy of the results and forecast results.

Musaed et al. (2018) studied and verified the financial soundness of listed companies in the oil and gas sector at the Kuwait Stock Exchange in the period 2010–2017. Kuwait is an oil-rich country, where oil exports accounted for nearly 92% of GDP or $138.51 billion in 2017. Its huge dependence on oil has resulted in the oil and gas industry becoming important to the whole world. Kuwait Ministry of Economy. Companies listed in the oil and gas sector on the Kuwait Stock Exchange are key government contracts and represent a very important role for the Kuwaiti economy. To determine the financial soundness of these businesses, the X-score model (Zmijewski, 1984) was used by Musaed et al. (2018). Research results show that listed companies in the oil and gas sector have a healthy financial position and are at a safe financial threshold. In addition, the research results also show that listed companies in the oil and gas sector with a decrease in X-score have applied for delisting on the Kuwait Stock Exchange.

Nilasari and Haryanto (2018) research aims to determine the most suitable financial risk forecasting model to apply to retail businesses in Indonesia. This study compares three financial risk prediction models including Z-score (Altman, 1968), S-score (Springate, 1978) and X-score (Zmijewski, 1984) by analyzing the degree of accuracy of each model. The model with the highest degree of accuracy is used to forecast the financial risk of retail businesses in the future. Research data is collected from the financial statements of retail businesses listed on the Indonesian Stock Exchange (IDX) for the period 2012–2016. The study used non-random sampling technique and selected 12 retail businesses. The analytical method used is logistic

regression. The research results show that the Z-score (Altman, 1968) and X-score (Zmijewski, 1984) models can be used to forecast financial risks of retail businesses. The most accurate financial risk prediction model of retail companies listed on the Indonesian Stock Exchange is the X-score (Zmijewski, 1984) with an accuracy rate of 97.9%.

Kiracı (2019) studies the factors affecting financial risk of 13 airlines, implementing a low-cost business model in Turkey in the period 2004–2017. The study uses panel data, Z-score (Altman, 1968) and S-score (Springate, 1978) models are two cases of dependent variables to analyze factors affecting financial risk. Research results show that debt structure (Debt Structure), financial leverage (Leverage Ratio), asset structure (Fixed Asset Ratio), business size (LogTA), profitability (Return On Assets) and liquidity (Current Ratio, Cash Flow Ratio) have an impact on the financial risk of the business.

Ashraf et al. (2019) study aims to compare the forecasting accuracy of traditional financial risk forecasting models for enterprises in the early and late stages of the financial crisis and financial difficulties in Pakistan during the period 2001–2015. This method involves building model scores for businesses that are experiencing financial distress and financial stability and then comparing the models' forecast accuracy with the original results. In addition to testing for the entire period, a comparison of the accuracy of risk prediction models before, during and after the financial crisis was also performed. Research results show that the X-score model (Zmijewski, 1984) has the highest predicting accuracy for the sample population, while the Z-score model (Altman, 1968) more accurately predicts the risk of solvency for both groups of businesses, those in the early stages and those in financial difficulty. The study also concludes that the predictive power of all traditional financial risk forecasting models declines during times of financial crisis.

Imelda and Alodia (2020) study and analyze the Z-score (Altman, 1968) and O-score (Ohlson, 1980) models in forecasting financial difficulties of 40 manufacturing companies listed on the Indonesian stock market in the period 2010–2014. Listed companies are divided into groups with financial difficulties and without financial difficulties. Research is using MDA and logit analysis techniques. Research results show that O-score model and logit analysis are more accurate than Z-score model and MDA analysis in predicting bankruptcy of listed manufacturing companies. Besides, retained earnings on total assets (RE/TA); earnings before interest and taxes on total assets (EBIT/TA); market value of equity to total liabilities (MVE/TL); sales to total assets (S/TA); debt to total assets (D/TA), return on assets (ROA), working capital to total assets (WC/TA) and net income (NI) have all been negative in the last two years. These indicators form an indication of the financial distress or financial risk of the business.

Tanjung (2020) studies to test the research hypothesis: (1) There is a difference between the Z-score (Altman, 1968), S-score (Springate, 1978), O-score (Ohlson, 1980) and X-score (Zmijewski, 1984) in forecasting financial risk or not; (2) the most accurate model for forecasting financial risks of pharmaceutical companies listed on the Indonesian Stock Exchange. The study uses a non-random sampling method with

45 observations from 9 pharmaceutical companies listed on IDX in the period 2013–2017. The dependent and independent variables are measured using a scale. Data analysis methods include descriptive statistics, normality test, t-test through SPSS software. The research results show that: (1) There is a significant difference between the Z-score (Altman, 1968), S-score (Springate, 1978), O-score (Ohlson, 1980) and X-score models (Zmijewski, 1984) in forecasting financial risks; (2) Z-score model (Altman, 1968) most accurately predicts financial risk of pharmaceutical companies listed on IDX.

Andriani and Sihombing (2021) compare and analyze financial risk forecasting models of businesses in the field of real estate and real estate listed on IDX in the period 2017–2019. Experimental research focuses on comparing the accuracy between the Z-score (Altman, 1968), S-score (Springate, 1978) and X-score (Zmijewski, 1984) models in predicting the financial risk of the companies, real estate and real estate businesses. The research sample includes 20 enterprises and is carried out using non-random sampling technique. To obtain an appropriate level of accuracy, each firm's financial distress or non-financial distress scores associated with financial risk models were compared with earnings per share (EPS) implemented via a dummy variable. The research results show that X-score (Zmijewski, 1984) is the most accurate financial risk prediction model of real estate and real estate businesses listed on the Indonesian Stock Exchange (IDX) with the most accurate ratio (90%).

Muzanni and Yuliana (2021) study to determine whether there is a difference in financial risk prediction results between the Z-score (Altman, 1968), S-score (Springate, 1978) and X-score (Zmijewski) models, 1984) and the most accurate forecasting model to forecast financial risks of retail businesses in Indonesia, and Singapore. Non-randomized sampling method with the research sample is including 15 Indonesian retailers, 15 Singapore retailers. The applied research methods are descriptive statistics, normality test and One-Way Anova through SPSS software. The research results show that: (1) there is a difference between the Z-score (Altman, 1968), S-score (Springate, 1978) and X-score (Zmijewski, 1984) models of Indonesian retail businesses; (2) there are significant differences between the Z-score (Altman, 1968), S-score (Springate, 1978) and X-score (Zmijewski, 1984) models of Singapore retail firms; (3) the most accurate model in predicting financial risk of Indonesian retail businesses is the X-score (Zmijewski, 1984) with an accuracy rate of 87%; (4) the most accurate model in predicting financial risk of Singapore retail businesses is the Z-score (Altman, 1968) with an accuracy rate of 86%.

In Vietnam, financial risk is often associated with the risk of bankruptcy or insolvency of the enterprise. Researches are mainly related to the application of the Z-score model of Altman (1968, 1983, 1993) or Zeta model (Altman et al., 1977), B-score model (Bathory, 1984) to analyze the factors affecting financial risk, credit rating or calculate the possibility of bankruptcy of enterprises. These include research by Cuong and Anh (2010), Hien (2016), Hau (2017), Chi (2020).

Hien (2016) announced the results of research on financial risk management of pharmaceutical enterprises in Vietnam in the period 2009–2014, which mainly focused on financial risks such as price, trade credit risk, liquidity risk and leverage

risk. Research results have contributed to: (i) systematize and clarify general theoretical issues about financial risks and financial risk management of enterprises, lessons learned from foreign enterprises, in corporate financial risk management; (ii) describe the current status of financial risk management content of pharmaceutical enterprises in Vietnam, including identification, measurement, control and financing of financial risks; (iii) proposing some solutions to strengthen financial risk management of pharmaceutical enterprises in Vietnam. However, Hien (2016) has not analyzed the factors affecting financial risk management of Vietnamese pharmaceutical enterprises, thereby reducing the persuasiveness of solutions to enhance financial risk management.

Hau (2017) focuses on analyzing five groups of factors affecting financial risk (including debt structure, solvency, profitability, operating performance and financial structure), using financial data for the period 2013–2015 of 34 companies listed in the real estate industry at HOSE. The study used descriptive statistical analysis, correlation and regression with the dependent variable B-score (Bathory, 1984). The research results show that the financial risk of listed companies in the real estate industry has a negative relationship with the overall ratio of liquidity (ALR), current ratio (CR), liquidity ratio and current ratio, quick calculation (QR), fixed asset ratio (FAR) and has no relationship with debt structure (DS), return on sales (ROS), return on assets (ROA), inventory turnover (IT), fixed asset turnover fixed asset turnover (FAT), total asset turnover (TAT), accounts receivable turnover (ART) and self-financing ratio (NAR).

Chi (2020) analyzed influencing factors (debt structure, solvency, profitability, operating performance, financial structure, interest rate, company age and company size) to financial risks in listed telecommunications companies. Chi (2020) used B-score (Bathory, 1984) as the dependent variable and 15 independent variables. Research results show that capital structure (ES) has a positive linear relationship with B-score; interest rates have a positive linear relationship with B-score but opposite with financial risk and have statistical significance; profitability (ROS) has a positive and statistically significant relationship with B-score; operating performance (RT) has a positive effect on B-score, a negative effect on financial risk and is statistically significant; solvency (CR) has a positive relationship with B-score and negative relationship with financial risk; AGE has a positive impact with B-score, opposite with financial risk and is statistically significant; SIZE is negatively related to B-score but not statistically significant; and DS has no association with B-score.

Hang et al. (2020) analyzed influencing factors (including debt structure, solvency, profitability, operating performance, financial structure, business size, age of enterprises and growth rate) to financial risk of 524 listed non-financial enterprises in the period 2009–2019. The financial risk of enterprises is measured by B-score (Bathory, 1984). Research results show that, in order to prevent and limit financial risks, listed non-financial enterprises need to pay attention to variables reflecting debt structure (DS), quick ratio (QR), return on assets (ROA), total assets turnover (TAT), accounts receivable turnover (ART), self-financing ratio (NAR) and fixed asset ratio (FAR). Hang et al. (2020) concluded that there is a difference in the influence of these factors on financial risk in listed state-owned and non-state enterprises. The findings

of this study are very useful and help the managers of listed non-financial enterprises to make the right financial decisions, contributing to improving the efficiency of financial risk management.

Z-score (Atlman, 1968), O-score (Ohlson, 1980), X-score (Zmijewski, 1984) models have been widely used in financial risk studies in the world (China, USA), Greece, India, Kuwait, Pakistan, Indonesia, Singapore, etc.), but when applied in Vietnam, appropriate research and adjustment is required. Besides, research on factors affecting financial risks of enterprises in general and listed medical enterprises is not much and not systematic. Research and application of theoretical models to verify with the database of listed medical enterprises explain research results and present recommendations are not available, especially the O-score model (Ohlson, 1980) and X-score (Zmijewski, 1984). Therefore, within the scope of the study, the Z-score (Altman, 1968), O-score (Olhson, 1980), X-score (Zmijewski, 1984) model represents three fundamental analysis techniques MDA, logit and probit continues to be simultaneously verified in Vietnam to identify financial risks and analyze factors affecting financial risks of listed medical companies, thereby creating a scientific basis for establishing measures to prevent and limit financial risks to an acceptable level.

3 Research Model and Hypothesis

3.1 Research Models

Within the scope of the study, the financial risks of healthcare companies listed on the Vietnamese stock market are identified through the Z-score (Altman, 1968), O-score (Ohlson, 1980) and X-score models. (Zmijewski, 1984) associated with the index scale shown in Table 1. If the Z-score $\geq$2.99, the enterprise is in the safe zone, the financial risk is low; 1.81 $\leq$ Z-score < 2.99, enterprises in warning zone, medium financial risk; Z-score <1.81, enterprises in dangerous areas, high financial risk. If the O-score <0.38, the enterprise has a healthy financial position, low financial risk and vice versa, the enterprise has high financial risk. If X-score <0, the enterprise has a healthy financial position, low financial risk and vice versa, the enterprise has high financial risk.

Fauzi et al. (2021) measured the accuracy and error ratio of the financial risk recognition model compared to the binary condition (DAR—Debt to Asset Ratio). If the DAR is >50%, the enterprise is facing financial difficulties, there is a risk of financial risk, and vice versa, the enterprise has a healthy financial position, no financial risk. Similarly, the scale of accuracy (T) and error (F) of the financial risk identification models of listed medical enterprises include Z-score (Altman, 1968), O-score (Ohlson), 1980) and X-score (Zmijewski, 1984) associated with the index as shown in Table 2.

Table 1 Financial risk identification scale of listed medical enterprises

Models	Financial risk levels		
	High	Medium	Low, acceptable
Z-score	Z-score <1.81	1.81 ≤ Z-score < 2.99	Z-score ≥2.99
O-score	O-score ≥0.38	O-score < 0.38	
X-score	X-score ≥0	X-score < 0	

Altman (1968), Ohlson (1980), (Zmijewski, 1984)

Table 2 Scale of accuracy (T) and error (F) of the recognition model financial risks of listed medical enterprises

Models	True (T)		False (F)	
	Case 1	Case 2	Case 1	Case 2
Z-score	Z-score ≥2.99 DAR ≤0.5	Z-score <2.99 DAR >0.5	Z-score ≥2.99 DAR >0.5	Z-score <2.99 DAR ≤0.5
O-score	O-score >0.38 DAR >0.5	O-score ≤0.38 DAR ≤0.5	O-score ≤0.38 DAR >0.5	O-score >0.38 DAR ≤0.5
X-score	X-score >0.0 DAR >0.5	X-score ≤0.0 DAR ≤0.5	X-score ≤0.0 DAR >0.5	X-score >0.0 DAR ≤0.5

Fauzi et al. (2021)

Dependent variable: Within the scope of the study, the Z-score (Altman, 1968), O-score (Ohlson, 1980) and X-score (Zmijewski, 1984) models are, respectively, used as dependent variables for analysis and factors affecting financial risk of medical enterprises listed on Vietnam stock market

$$Z - \text{score} = \beta_0 + \beta_1 X_1 + \cdots + \beta_p X_p + u_i \quad (1)$$

$$O - \text{score} = \beta_0 + \beta_1 X_1 + \cdots + \beta_p X_p + u_i \quad (2)$$

$$X - \text{score} = \beta_0 + \beta_1 X_1 + \cdots + \beta_p X_p + u_i \quad (3)$$

Independent and control variables: Within the scope of the study, it is possible to summarize the main factors affecting the financial risks of medical enterprises listed on the Vietnam stock market, including debt structure (DS), solvency (CR, QR, ALR, CFL, WCL), profitability (ROS, ROA, ROE, REE), operating performance (IT, FAT, TAT, ART), financial structure (NAR, FAR), credit rate (IRS), age of business (AGE), size of business (SIZE) and listing location (PLA). The results of 20 indicators are shown in Table 3 as independent variables and control variables to describe the main factors affecting financial risks of listed medical companies.

Table 3 Definition of independent and control variables

Variables	Symbol	Definition	References
A. Dependent variables			
Debt structure	DS	Ratio of short-term debt to total debt	Defang and Zen Muli (2005), Bhunia and Mukhuti (2012), Gang and Dan (2012), Kiracı (2019)
Liquidity	CR	Current ratio	Beaver (1966), Ohlson (1980), Zmijewski (1984), Bhunia and Mukhuti (2012), Gang and Dan (2012), Simantinee and Phanikumar (2015), Kiracı (2019)
	QR	Quick ratio	Bhunia and Mukhuti (2012), Gang and Dan (2012), Simantinee and Phanikumar (2015)
	ALR	Aggregate liquidity ratio	Bhunia and Mukhuti (2012), Gang and Dan (2012)
	CFL	Cash flow to liabilities	Beaver (1966), Fulmer et al. (1984)
	WCL	Working capital to liabilities	Fulmer et al. (1984)
Profitability	ROS	Return on sales	Bhunia and Mukhuti (2012), Gang and Dan (2012)
	ROA	Return on assets	Beaver (1966), Ohlson (1980), Zmijewski (1984), Bhunia and Mukhuti (2012), Gang and Dan (2012), Kiracı (2019)
	ROE	Return on equity	Haydarshina (2008)
	REE	Retain earnings to equity	Sandin and Porporato (2007)
Operating performance	IT	Inventory turnover	Bhunia and Mukhuti (2012), Gang and Dan (2012), Simantinee and Phanikumar (2015)
	FAT	Fix assets turnover	Bhunia and Mukhuti (2012), Gang and Dan (2012), Simantinee and Phanikumar (2015)
	TAT	Total assets turnover	Altman (1968, 1983, 1993), Springate (1978), Fulmer et al. (1984), Bhunia and Mukhuti (2012), Gang and Dan (2012), Simantinee and Phanikumar (2015)

(continued)

Table 3 (continued)

Variables	Symbol	Definition	References
	ART	Account receivable turnover	Bhunia and Mukhuti (2012), Gang and Dan (2012)
Financial structure	NAR	Shareholder's equity to total E&L	Altman (1968, 1983, 1993), Bhunia and Mukhuti (2012), Gang and Dan (2012)
	FAR	Fix assets ratio	Bhunia and Mukhuti (2012), Gang and Dan (2012), Kiracı (2019)
B. Control variables			
Credit interest rate	IRS	Average short-term loan interest rate (%)	Defang and Muli (2005)
Firm's age	AGE	Calculated from the establishment of the enterprise to the time of the study (years)	Tingwei (2006)
Firm's size	SIZE	Log (Total assets)	Ohlson (1980), Fulmer et al. (1984), Kiracı (2019)
Listing location	PLA	HOSE: PLA = 1 HNX: PLA = 0	

3.2 Research Hypothesis

Based on theoretical and empirical studies in the world, the author establishes 11 research hypotheses to identify financial risks and factors affecting financial risks of medical companies listed on the stock market. Vietnam (H1–H11) as follows:

H1: Financial risk of listed medical companies has a positive relationship with debt structure (Debt Structure).

H2: Financial risk of listed medical companies has a negative relationship with solvency.

H3: Financial risk of listed medical companies has a negative relationship with profitability.

H4: Financial risk of listed medical companies has a negative relationship with operating performance (Operating performance).

H5: Financial risk of listed medical companies has a negative relationship with the financial structure (Capital Structure).

H6: Financial risk of listed medical companies has a positive relationship with loan interest rate (Average interest rate on bank loans).

H7: Financial risk of listed medical companies has a negative relationship with the firm's age (AGE).

H8: Financial risk of listed medical companies has a negative relationship with firm size (SIZE).

H9: Place of stock listing (PLA): The model will study whether listing location affects financial risk of listed medical companies, HOSE (PLA = 1) and HNX (PLA = 0).

H10: There is a difference in financial risk identification results of listed healthcare companies through the Z-score (Altman, 1968), O-score (Ohlson, 1980) and X-score (Zmijewski) models, 1984).

H11: The X-score model (Zmijewski, 1984) is the most accurate model for identifying financial risks of listed medical companies.

On the basis of studying financial risk models in the world, the author proposes a model to analyze the factors affecting financial risk for medical enterprises listed on the Vietnam stock market shown in Fig. 1. In which, financial risks of listed medical companies are represented by Z-score, O-Score and X-score, respectively. The higher the Z-score, the lower the O-score and the lower the X-score, the lower the financial risk of the listed medical enterprise and vice versa. In other words, the models will, in turn, test whether the financial risks of medical companies listed on the Vietnam stock market (Z-score, O-score, X-score) are influenced by many factors, which is consistent with the theory.

4 Research Results

4.1 Descriptive Statistical Analysis

The results of descriptive statistical analysis of dependent variables include Z-score (Altman, 1968), O-score (Ohlson, 1980), X-score (Zmijewski, 1984) and independent and control variables. Controls (DS, CR, QR, ALR, CFL, ROA, ROS, ROA, REE, IT, ART, TAT, FAT, NAR, FAR, AGE, SIZE, IRS, PLA) shown in Table 4 show that there is a difference and there is a distinction about factors affecting financial risks of medical enterprises listed on Vietnam stock market in the period 2016–2020.

- Dependent variables Z-score, O-score and X-score: The lowest value of Z-score is −0.32 times (JVC, 2020), the highest value reaches 8.05 times (AMV, 2019), and the mean value is 8.05 times (AMV, 2019). Average is 3.43 times; standard deviation is 1.63. The lowest value of O-score is −9.52 times (DMC, 2020), the highest value is 5.67 times (VMD, 2019), the mean is 0.82 times, and the standard deviation is 2.91 times. The lowest value of X-score is −5.12 times (AMV, 2018),

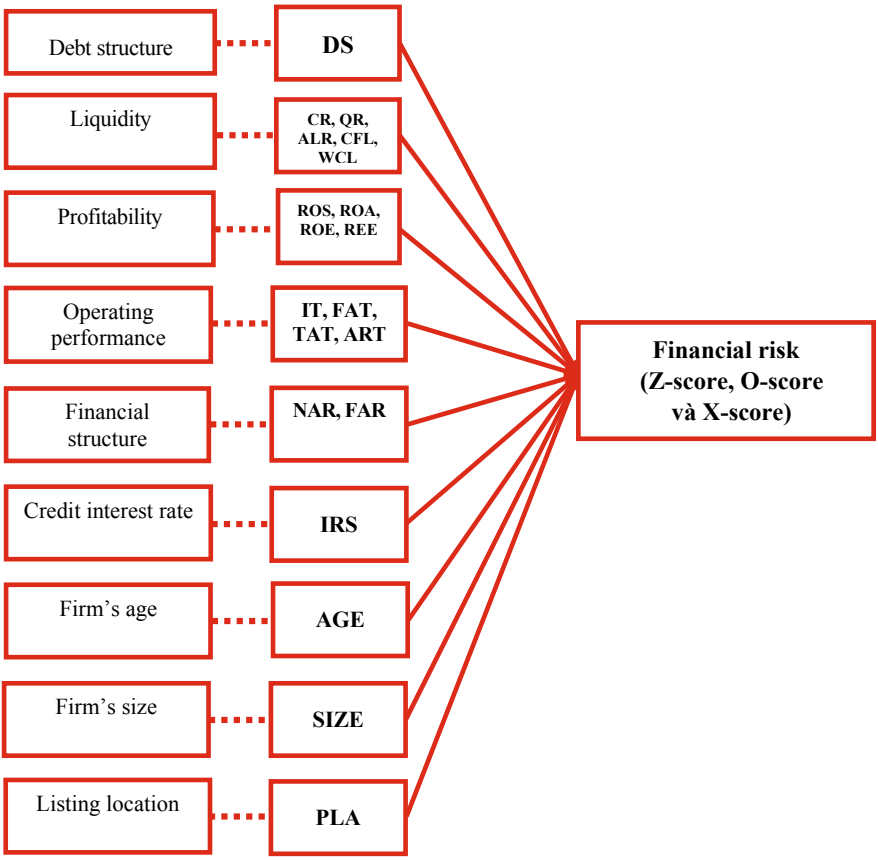

Fig. 1 Analysis model of factors affecting financial risk for medical companies listed on Vietnam stock market (Altman, 1968; Ohlson, 1980; Zmijewski, 1984)

the highest value is 1.13 times (VMD, 2016), the mean value is −2.56 times, and the standard deviation is 1.43.

- Independent variables and control variables: Debt structure (DS): The largest value of DS is 1.0 times (in 2016: SPM, PMC, 2017: VDP, DNM, PMC, 2018: VDP, PMC, 2019: VDP, DP3, PMC, 2020: SPM, VDP, DP3, PMC), 2.71 times higher than the minimum value (DCL, 2018), the mean is 0.89 times, the standard deviation is 0.15. The results of descriptive statistical analysis show that the debt structure (DS) of listed medical companies is mainly short-term debt. This leads to pressure to pay short-term debts and financial risks of medical companies listed on Vietnam stock market.

Liquidity (ALR, CR, QR, CFL, WCL): The maximum value of ALR is 10.85 times (AMV, 2019), 10.47 times more than the minimum value (VMD, 2016), average value 3.54 times, standard deviation is 2.00. The maximum value of CR is 13.33

Table 4 Descriptive statistics of dependent and independent variables, control variables

Variables	(Obs)	(Min)	(Max)	(Mean)	(Std. dev)
Z-score	105	−0.3195	8.0545	3.4269	1.6301
O-score	105	−9.5200	5.6704	0.8155	2.9060
X-score	105	−5.1238	1.1343	−2.5598	1.4257
DS	105	0.3690	1.0000	0.8876	0.1529
CR	105	0.8866	13.3278	2.6717	1.7946
QR	105	0.3631	12.7933	1.8859	1.6819
ALR	105	1.0362	10.8474	3.5421	2.0048
CFL	105	−13.1561	1.3626	−0.1178	1.3180
WCL	105	−0.0824	7.3582	1.4192	1.4047
ROS	105	−0.1864	0.5448	0.0990	0.1079
ROA	105	−0.1222	0.3368	0.0894	0.0795
ROE	105	−0.2352	0.4427	0.1374	0.1084
REE	105	−2.4012	0.5547	0.0713	0.4980
IT	105	1.0399	26.2133	4.0318	3.6865
FAT	105	1.1426	262.6357	14.0216	38.7834
TAT	105	0.1730	2.7664	1.0648	0.4910
ART	105	0.1962	18.5139	5.4776	3.5363
NAR	105	0.0349	0.9078	0.6181	0.2134
FAR	105	0.0059	0.6623	0.2425	0.1629
SIZE	105	4.3101	6.9889	5.8838	0.4913
IRS	105	0.0839	0.0924	0.0888	0.0030
AGE	105	13.0000	58.0000	32.0476	11.3573
PLA	105	0.0000	1.0000	0.5810	0.4958

Source Descriptive statistical analysis results on Eviews software

times (AMV, 2017), 15.03 times higher than the minimum value (PPP, 2017), the mean value is 2.67 times, the standard deviation is 1.79. The maximum value of QR is 12.79 times (AMV, 2017), 35.23 times higher than the minimum value (LDP, 2018), the mean value is 1.89 times, the standard deviation is 1.68. The lowest value of CFL is −13.16 times (PPP, 2020), the highest value is 1.36 times (PMC, 2018), the mean value is −0.12 times, the standard deviation is 1.32. The lowest value of WCL is −0.08 times (PPP, 2017), the highest value is 7.36 times (DMC, 2020), the mean is 1.42 times, the standard deviation is 1.40.

Profitability (ROS, ROA, ROE, REE): The lowest value of ROS is −0.19 times (JVC, 2020), the highest value is 0.54 times (AMV, 2017), the average value is 0.10 times, standard deviation is 0.11. The lowest value of ROA is −0.12 times (JVC, 2020), the highest value is 0.34 times (AMV, 2018), the mean is 0.09 times, the standard deviation is 0.08. The lowest value of ROE is −0.24 times (LDP, 2018), the highest value is 0.44 times (DP3, 2018), the mean is 0.14 times, the standard

deviation is 0.11. The lowest value of REE is −2.40 times (JVC, 2020), the highest value is 0.55 times (SPM, 2020), the mean is 0.07 times, the standard deviation is 0.50.

Operating performance (IT, FAT, TAT, ART): The maximum value of IT is 26.21 times (AMV, 2018), 25.21 times higher than the minimum value (OPC, 2019), the average value reaches 4.03 times, the standard deviation is 3.69. The maximum value of FAT is 262.64 times (VMD, 2017), 229.86 times higher than the minimum value (JVC, 2016), the mean is 14.02 times, the standard deviation is 38.78. The maximum value of TAT is 2.77 times (DHT, 2019), 15.99 times higher than the minimum value (AMV, 2020), the mean value is 1.06 times, the standard deviation is 0.49. The maximum value of ART is 18.51 times (DP3, 2019), 94.36 times higher than the minimum value (AMV, 2017), the mean value is 5.48 times, the standard deviation is 3.54.

Financial structure (NAR, FAR): The maximum value of NAR is 0.91 times (AMV, 2019), 26.01 times higher than the minimum value (VMD, 2016), the average value is 0.62 times, the deviation is different. standard is 0.21. The maximum value of FAR is 0.66 times (PPP, 2017), 112.25 times higher than the minimum value (VMD, 2017), the mean is 0.24 times, the standard deviation is 0.16.

Control variables (SIZE, AGE, IRS, PLA): The maximum value of SIZE is 6.99 times (VMD, 2018), 1.62 times higher than the minimum value (AMV, 2016), the mean value reaches 5.88 time. The maximum value of AGE is 58.0 years (DP3, 2020), 4.46 times higher than the minimum value (VDP, 2016), the average value reaches 32.05 years. The maximum value of the IRS is 9.24% (2019), 1.10 times higher than the minimum value (8.39%, 2016), the average value is 8.88%. PLA value is 1.0 (12 medical enterprises listed on HOSE) and PLA is 0.0 (09 medical enterprises listed on HNX).

4.2 Correlation and Regression Analysis

4.2.1 The Case of the Dependent Variable Z-score

The results of the correlation analysis between the Z-score and the independent and control variables through the correlation coefficient and the Prob value in Table 5 show that the Z-score coefficient has a statistically significant positive correlation. (P_value <0.05) with variables ALR, CR, QR, WCL, ROS, ROE, REE, ROA, NAR, AGE and has a statistically significant negative relationship (P_value <0.05) with FAR.

Using the dependent variable representing financial risk as Z-score and the values of 20 independent and control variables, the author ran the regression model on EViews software. Initially, the regression results were not satisfactory when all 20 variables were included in the model. Considering the results of the correlation analysis (Table 5) and the P_value of the independent variables, the author has removed the variables that have no statistical significance (P_value >0.05) and economic

Table 5 Correlation analysis results: Z-score and independent and control variables

Variables	Correlation	Probability	Variables	Correlation	Probability
DS	0.1465	0.1358	IT	0.1411	0.1510
ALR	0.8109	0.0000	FAT	−0.1748	0.0745
CR	0.6827	0.0000	TAT	−0.0132	0.8939
QR	0.6108	0.0000	ART	0.1486	0.1304
CFL	−0.0002	0.9985	NAR	0.6514	0.0000
WCL	0.7944	0.0000	FAR	−0.3603	0.0002
ROS	0.7444	0.0000	IRS	0.0901	0.3609
ROE	0.6346	0.0000	SIZE	0.1429	0.1458
REE	0.4392	0.0000	AGE	0.2007	0.0401
ROA	0.8205	0.0000	PLA	-0.0307	0.7560

Source Regression analysis results on EViews software

significance including DS, ALR, WCL, QR, CFL, ROE, ROS, REE, IT, FAT, ART, FAR, IRS, AGE, PLA and regression continuation. Table 6 shows the regression results of the 5% significance level of the Z-score model.

Table 6 Regression results with Z-score model

Dependent variable: Z-score				
Method: least squares				
Date: 09/09/22 Time: 20:31				
Sample: 1 105				
Included observations: 105				
Variable	Coefficient	Std. error	t-Statistic	Prob
C	−2.227900	0.924682	−2.409369	0.0178
CR	0.345263	0.047573	7.257489	0.0000
ROA	9.873491	1.110384	8.891960	0.0000
TAT	0.812277	0.181129	4.484513	0.0000
NAR	2.237717	0.520250	4.301235	0.0000
SIZE	0.272226	0.132256	2.058329	0.0422
R-squared	0.854026	Mean dependent var		3.426875
Adjusted R-squared	*0.846654*	S.D. dependent var		1.630104
S.E. of regression	0.638340	Akaike info criterion		1.995554
Sum squared resid	40.34033	Schwarz criterion		2.147209
Log likelihood	-98.76660	Hannan–Quinn criter		2.057008
F-statistic	115.8406	Durbin–Watson stat		2.044326
Prob(F-statistic)	0.000000			

Source Regression analysis results on EViews software

Regression results between the dependent variable Z-score and the independent and control variables using the LS model show that the independent variables and control variables can explain 84.67% (adjusted R2) significance for the variable and depend on Z-score, in which the independent variables: CR, ROA, TAT, NAR, SIZE have statistical significance, with the coefficient P_value <0.05. Test the significance of the model by F test, the result $F = 115.8406$ and the significance level of F, Prob (F-statistic) = 0.0000 <0.01, so it can be concluded that the above model is significant.

4.2.2 The Case of Dependent Variable O-score

The results of correlation analysis between O-score with independent variables, control variables through correlation coefficient and Prob value in Table 7 show that O-score has a statistically significant positive relationship (P_value <0.05) with FAT, TAT variables and has a statistically significant negative relationship (P_value <0.05) with variables ALR, CR, QR, WCL, ROS, ROE, ROA, NAR, AGE and PLA.

Using the dependent variable representing financial risk as the O-score coefficient and the values of 20 independent and control variables, the author has run a regression model of factors affecting financial risk of the company and medical businesses listed on EViews software. Initially, the regression results were not satisfactory when all 20 variables were included in the model. Considering the results of the correlation analysis (Table 7) and the P_value of the independent variables, the author has in turn removed the variables with no statistical significance (P_value >0.05) and economic significance including DS, QR, CFL, WCL, ALR, ROE, ROS, REE, IT, FAT, TAT, ART, FAR, IRS, AGE, PLA and regression continuation. Table 8 shows the results of the regression of the 5% significance level of the O-score model.

Table 7 Correlation analysis results: O-score and independent and control variables

Variables	Correlation	Probability	Variables	Correlation	Probability
DS	−0.1446	0.1411	IT	0.0440	0.6557
ALR	−0.8121	0.0000	FAT	0.3548	0.0002
CR	−0.7226	0.0000	TAT	0.2995	0.0019
QR	−0.6225	0.0000	ART	0.0128	0.8970
CFL	−0.0104	0.9158	NAR	−0.8344	0.0000
WCL	−0.8853	0.0000	FAR	0.1342	0.1722
ROS	−0.5095	0.0000	IRS	−0.0666	0.4996
ROE	−0.3588	0.0002	SIZE	−0.1570	0.1097
REE	−0.0668	0.4982	AGE	−0.1944	0.0469
ROA	−0.6171	0.0000	PLA	−0.2719	0.0050

Source Regression analysis results on EViews software

Table 8 Regression results with O-score model

Dependent variable: O-score				
Method: least squares				
Date: 09/09/22 Time: 16:11				
Sample: 1 105				
Included observations: 105				
Variable	Coefficient	Std. error	t-Statistic	Prob
C	12.33698	1.655358	7.452760	0.0000
CR	−0.396670	0.095559	−4.151061	0.0001
ROA	−7.678156	1.883709	−4.076083	0.0001
NAR	−7.837367	0.852942	−9.188629	0.0000
SIZE	−0.838104	0.266434	−3.145630	0.0022
R-squared	0.809197	Mean dependent var		0.815536
Adjusted R-squared	*0.801565*	S.D. dependent var		2.905965
S.E. of regression	1.294492	Akaike info criterion		3.400562
Sum squared resid	167.5710	Schwarz criterion		3.526941
Log likelihood	−173.5295	Hannan–Quinn criter		3.451773
F-statistic	106.0253	Durbin–Watson stat		2.209957
Prob(F-statistic)	0.000000			

Source Regression analysis results on EViews software

Regression results between the dependent variable O-score and the independent and control variables using the LS model show that the independent variables, the control variable can explain 80.16% (adjusted R2) of significance for the O-score dependent variable, in which the independent variables: CR, ROA, NAR, SIZE are statistically significant, with the coefficient P_value <0.05. Test the significance of the model by F test, the result F = 106.0253 and the significance level of F, P_value (F-statistic) = 0.0000 <0.01, so it can be concluded that the above model is significant.

4.2.3 The Case of the Dependent Variable X-score

The results of correlation analysis between X-score with independent variables, control variables through correlation coefficient and Prob value in Table 9 show that X-score has a statistically significant positive relationship (P_value <0.05) with variables FAT, TAT and has a statistically significant negative relationship (P_value <0.05) with variables ALR, CR, QR, WCL, ROS, ROE, ROA AND NAR.

Using the dependent variable representing financial risk is the X-score coefficient and the values of 20 independent and control variables, the author has run a regression model of factors affecting financial risk of the company. Medical enterprises listed on EViews software. Initially, the regression results were not satisfactory when all

Table 9 Correlation analysis results: X-score and independent and control variables

Variables	Correlation	Probability	Variables	Correlation	Probability
DS	0.0130	0.8957	IT	−0.1190	0.2268
ALR	−0.8377	0.0000	FAT	0.5624	0.0000
CR	−0.6483	0.0000	TAT	0.4271	0.0000
QR	−0.5872	0.0000	ART	−0.0340	0.7306
CFL	0.0464	0.6384	NAR	−0.9768	0.0000
WCL	−0.7373	0.0000	FAR	−0.0432	0.6613
ROS	−0.6469	0.0000	IRS	−0.0316	0.7488
ROE	−0.3897	0.0000	SIZE	0.0307	0.7562
REE	−0.0360	0.7157	AGE	−0.1451	0.1396
ROA	−0.6868	0.0000	PLA	−0.1649	0.0928

Source Regression analysis results on EViews software

20 variables were included in the model. Considering the results of the correlation analysis (Table 9) and the P_value of the independent variables, the author in turn removed the variables with no statistical significance (P_value >0.05) and economic significance including DS, QR, CR CFL, ALR, WCL, ROE, REE, ROA, IT, FAT, TAT, FAR, IRS, SIZE, PLA and regression continuation. Table 10 shows the regression results of the 5% significance level of the X-score model.

Regression results between the dependent variable X-score and the independent and control variables by LS model show that the independent variables, the control variable can explain 98.25% (adjusted R2) significance for the dependent variable, in which the independent variables: ROS, ART, NAR, AGE have statistical significance, with the coefficient P_value <0.05. Test the significance of the model by F test, the result F = 1457,615 and the significance level of F, P_value (F-statistic) = 0.0000 <0.01, so it can be concluded that the above model is significant.

4.3 Test the Difference and Accuracy of the Financial Risk Model

The Anova—Single Factor test method is used to study the difference in financial risk identification results between the Z-score (Altman, 1968), O-score (Ohlson, 1980) and X-score models. (Zmijewski, 1984). The results of the Anova—Single Factor test on Excel shown in Table 11 show that the significance value of the P-value test is 0.0000 < 0.05, which means that there is a difference in the results of financial risk identification between the models. Z-score (Altman, 1968), O-score (Ohlson, 1980) and X-score (Zmijewski, 1984) of listed medical firms. In other words, hypothesis H10 has been accepted.

Table 10 Regression results with X-score model

Dependent variable: X-score				
Method: least squares				
Date: 09/09/22 Time: 20:26				
Sample: 1 105				
Included observations: 105				
Variable	Coefficient	Std. error	t-Statistic	Prob
C	1.717384	0.079402	21.62893	0.0000
ROS	−2.051924	0.205641	−9.978183	0.0000
ART	−0.034551	0.005434	−6.357877	0.0000
NAR	−5.968689	0.104041	−57.36884	0.0000
AGE	−0.006108	0.001696	−3.602118	0.0005
R-squared	0.983138	Mean dependent var		−2.559811
Adjusted R-squared	*0.982463*	S.D. dependent var		1.425686
S.E. of regression	0.188798	Akaike info criterion		−0.449835
Sum squared resid	3.564453	Schwarz criterion		−0.323456
Log likelihood	28.61632	Hannan–Quinn criter		−0.398623
F-statistic	1457.615	Durbin–Watson stat		2.233208
Prob(F-statistic)	0.000000			

Source Regression analysis results on EViews software

Table 11 Results of anova—single factor test

Summary				
Groups	Count	Sum	Average	Variance
Z-score	105	359.8219	3.4269	2.6572
S-score	105	85.6313	0.8155	8.4446
X-score	105	−268.7802	−2.5598	2.0326

Anova						
Source of variation	SS	df	MS	F	P-value	F crit
Between Groups	1891.8366	2	945.9183	216.0542	0.0000	3.0247
Within Groups	1365.9834	312	4.3782			
Total	3257.8200	314				

Source Anova—Single Factor test results on Excel software

The research results in Table 12 determine the accuracy and error rates of the financial risk identification model of listed medical companies. The results show that the X-score model (Zmijewski, 1984) is the correct model for identifying financial risk of medical companies listed on the Vietnam stock market with an accuracy rate of 80.0% and an error rate of 20.0%. Therefore, hypothesis H11 is accepted.

Table 12 Accuracy and error rates of financial risk identification models

No.	Models	Accuracy (%)	Error (%)
1	Z-score (Altman, 1968)	70.48	29.52
2	O-score (Ohlson, 1980)	63.81	36.19
3	X-score (Zmijewski, 1984)	80.00	20.00

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5 Conclusion

The research results analye the factors affecting financial risks of medical companies listed on the Vietnam stock market in the case of the dependent variable Z-score as shown in Fig. 2, in which, the variables CR, ROA, TAT, NAR and SIZE accounted for 84.67% of the variation in financial risk of healthcare firms; CR, ROA, TAT, NAR and SIZE are positively related to Z-score and negatively related to financial risk.

Research results analyze the factors affecting financial risk of medical companies listed on Vietnam stock market in the case of dependent variable O-score as shown in Fig. 3, in which, the variables CR, ROA, NAR and SIZE explain 80.16% of the change in financial risk of listed medical companies; CR, ROA, NAR and SIZE have negative relationship with O-score and positive relationship with financial risk.

The research results analyzing the factors affecting financial risk of medical companies listed on the Vietnam stock market in the case of the dependent variable X-score are shown in Fig. 4, in which, the variables ROS, ART, NAR and AGE

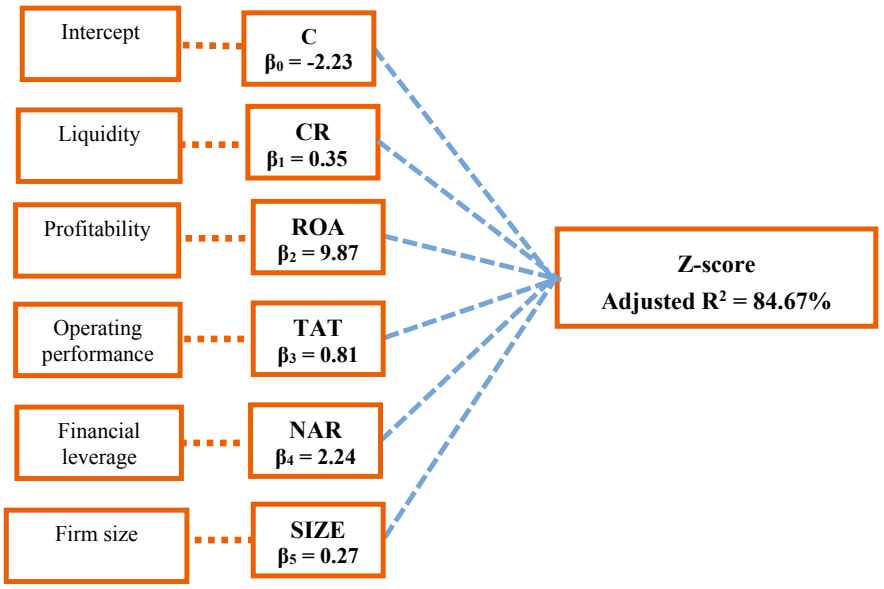

Fig. 2 Z-score model of medical companies listed on Vietnam stock market

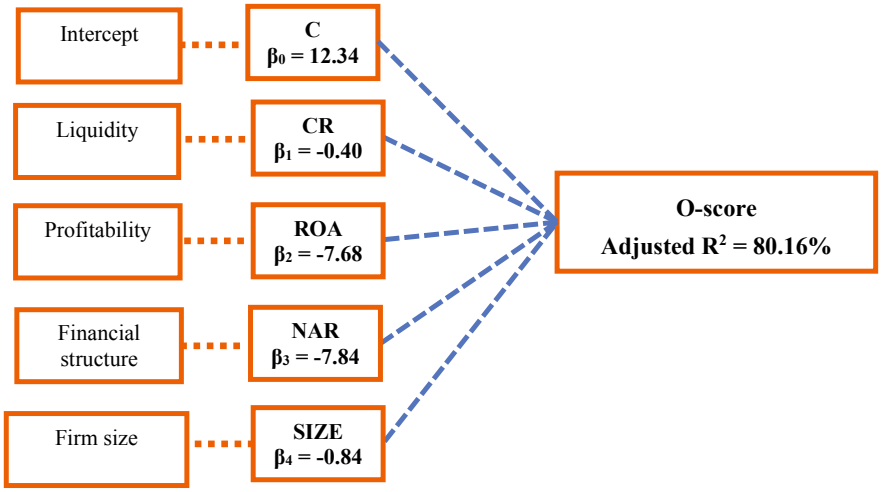

Fig. 3 O-score model of medical companies listed on Vietnam stock market. *Source* Regression results on EViews software

explained 98.25% of the change in financial risk of listed medical companies; ROS, ART, NAR and AGE are negatively related to X-score and positive to financial risk.

From the research results comparing the Z-score, O-score and X-score models in analyzing the factors affecting financial risk in medical companies listed on the Vietnam stock market, it is possible to draw the following conclusions:

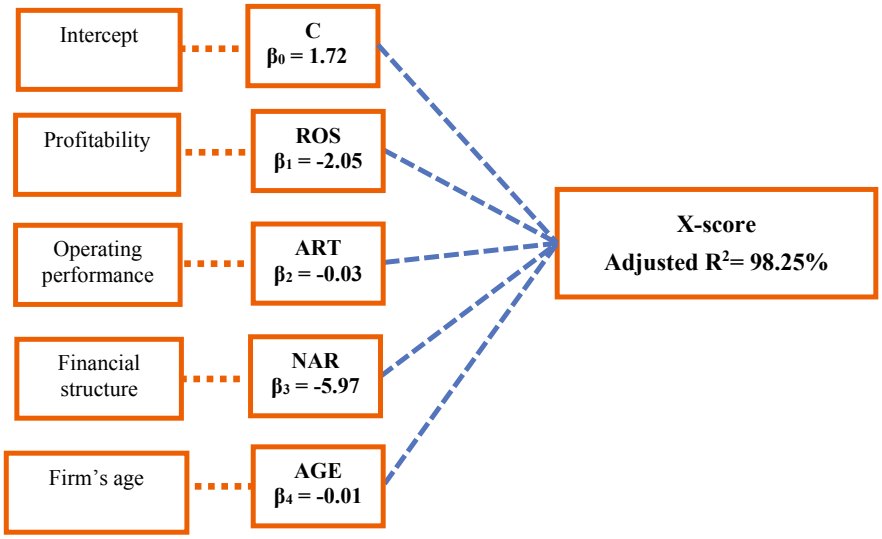

Fig. 4 X-score model of medical companies listed on Vietnam stock market. *Source* Regression results on EViews software

Firstly, debt structure, credit interest rate and listing location (HOSE or HNX) have no statistically significant relationship with financial risk (H1, H6 and H9 are not accepted). This is because the debt structure of listed medical companies is unbalanced, short-term debt accounts for a large proportion of total liabilities, and long-term debt ratio is very low (average DS VSM period 2016–2020 is 0.89 times). Listed medical companies mainly depend on short-term financial liabilities; however, due to the large number of short-term assets, it reduces the pressure to pay short-term debts, leading to a reduction in financial risks. Debt structure did not become the main factor affecting financial risk of listed medical enterprises in the sample regression analysis. This is also consistent with the research results of Defang and Muli (2005), and needs to be verified in further studies. The research results also show that the data on average short-term lending interest rates of commercial banks for corporate customers in general and listed medical enterprises in the period 2016–2020 in particular are limited. There are enough grounds to conclude the impact of interest rates on financial risk. Similarly, the listing location on HOSE or HNX does not affect the financial risks of listed medical companies.

Secondly, the analysis results of factors affecting financial risk of listed medical companies in the case of dependent variables Z-score and O-score both show that solvency has a significant relationship statistics with financial risk (H2 is accepted). CR increases by 1.0 times, Z-score increases by 0.35 times or financial risk decreases by 0.35 times; CR increases by 1.0 times, O-score decreases by 0.40 times or financial risk decreases by 0.40 times. This explains that listed medical companies mainly use short-term debt, then the business will need a lot of short-term assets to pay principal and interest. Thus, CR directly affects financial risk even though these firms can meet a lot of liquidity spending on short-term liabilities. Some listed medical companies have CR lower than average CR in the period 2016–2020 (2.67 times) such as OPC Pharmaceutical JSC (OPC), Vidipha Central Pharmaceutical JSC (VDP), Vimedimex Medicine and Pharmaceutical JSC (VMD). Ben Tre Pharmaceutical Joint Stock Company (DBT). In contrast, the analysis results of factors affecting financial risk of listed medical enterprises, the case of the dependent variable X-score shows solvency. There is no statistically significant relationship with financial risk (H2 is not accepted).

Thirdly, the analysis results of factors affecting financial risk of listed medical companies in the case of dependent variable O-score show that operational performance has no statistically significant relationship with risk and financial risk (H4 is not accepted). In contrast, in case the dependent variable Z-score, TAT increases by 1.0 times, then Z-score increases by 0.81 times or financial risk decreases by 0.81 times; ART increases by 1.0 times, X-score decreases by 0.03 times or financial risk decreases by 0.03 times (H4 is accepted). This means that the listed medical companies have not fully exploited their existing assets, especially those with TAT and ART lower than the industry average, such as pharmaceuticals and trading JSC and Vietnam My Medical Equipment (AMV), Cuu Long Pharmaceutical JSC (DCL), SPM Joint Stock Company (SPM).

Fourthly, the analysis results of factors affecting financial risk of listed medical companies in case the dependent variable Z-score, O-score and X-score all show

that profitability is related and statistically significant relationship with financial risk (H3 is accepted). ROA increases by 1.0 times, Z-score increases by 9.87 times or financial risk decreases by 9.87 times; ROA increased by 1.0x, O-score decreased by 7.68× or financial risk decreased by 7.68×. Similarly, ROS increases by 1.0 times, X-score decreases by 2.05 times or financial risk decreases by 2.05 times. When ROS and ROA increase, it shows that the production and business results of businesses are expanded, the profit growth rate is higher than the growth rate of net revenue, average total assets. When profits grow well, it will create conditions for businesses to increase undistributed after-tax profits. Creating conditions for enterprises to supplement equity, set up funds such as investment and development funds, and reward and welfare funds, to expand the scale of production and business activities or to pay debts and risks, financial decline. If the listed medical companies suffer a loss for a long time, which will result in negative equity, the enterprise must mobilize loans to finance assets and cover losses, such as Medical Equipment Viet Nhat (JVC), Lam Dong—Ladophar Pharmaceutical JSC (LDP), Cai Lay Veterinary Medicine Joint Stock Company (MKV).

Fifthly, the analysis results of factors affecting financial risk of medical enterprises in case dependent variables Z-score, O-score and X-score all show that financial structure (NAR) has a relationship and statistically significant relationship with financial risk (H5 is accepted). NAR increased by 1.0 times, Z-score increased by 2.24 times or financial risk decreased by 2.24 times; NAR increased by 1.0 times, O-score decreased by 7.84 times or financial risk decreased by 7.84 times; NAR increased by 1.0 times, X-score decreased by 5.97 times or financial risk decreased by 5.97 times. Low NAR or high DAR will increase the pressure to pay due debts and may affect other business activities of listed medical companies. In case of maintaining an unreasonable capital structure, listed medical companies are at risk of facing financial risks such as Vimedimex Medicine and Pharmaceutical Joint Stock Company (VMD), DANAMECO Medical Corporation (DNM), Pharmaceutical Joint Stock Company Ben Tre products (DBT) are typical examples. Theoretically, firms with high FARs may have more opportunities to mortgage assets to access external capital. However, Berger and Udell (1994) argue that firms with close relationships with capital sponsors can borrow without having to provide much collateral. This has been verified and is suitable in the condition that 95.2% of listed medical enterprises selected for research are large-scale enterprises and have close relationships with the system of commercial banks. Therefore, when analyzing sample regression, asset structure (FAR) does not become a factor affecting financial risk of listed medical companies.

Sixthly, the analysis results of factors affecting financial risk of listed medical enterprises in the case of the dependent variable X-score show that the size of the enterprise (SIZE) does not have a statistically significant relationship and statements with financial risk (H8 is not acceptable). In contrast, SIZE increases by 1.0 times, Z-score increases by 0.27 times or financial risk decreases by 0.27 times; SIZE increases by 1.0 times, O-score decreases by 0.84 times or financial risk decreases by 0.84 times (H8 is accepted). The trade-off theory explains the advantages of large-scale listed medical enterprises and general enterprises that will enjoy more incentives in loans.

This will help listed medical companies increase their reasonable costs and take advantage of tax shields. Under the current conditions, large-scale listed medical enterprises are eligible to expand their product distribution systems; extensive operation through cooperation with supermarkets and drugstore chains; keep up with e-commerce trends. For example, Hau Giang Pharmaceutical JSC (DHG), Traphaco JSC (TRA), Imexpharm Pharmaceutical JSC (IMP), Cuu Long Pharmaceutical JSC (DCL).

Seventhly, the results of the analysis of factors affecting financial risk of listed medical companies in the case of dependent variables Z-score and O-score both show that the age of the enterprise (AGE) has no relationship and statistically significant relationship with financial risk (H7 is not accepted). In contrast, AGE increases by 1.0 times, X-score decreases by 0.01 times or financial risk decreases by 0.01 times (H7 is accepted). When a listed medical enterprise has an older age, the longer it operates in the market, the more experience it has in managing production and business activities, building a good brand and business strategy will help to businesses increase business efficiency. Thereby helping listed medical enterprises to consolidate their sustainable capital structure, improve their financial independence and contribute to reducing financial risks, such as Central Pharmaceutical Joint Stock Company 3 (DP3), Traphaco Joint Stock Company (TRA), Hau Giang Pharmaceutical Joint Stock Company (DHG)… .

Eighthly, the results of hypothesis testing by Anova (Single Factor) show that P-value = 0.000 < 0.05, which means that there is a difference in the results of financial risk identification between the Z-score, O models and X-score of listed medical companies (H10 is accepted). The difference in the results of financial risk identification of the models is due to the different variables in each financial risk research model. Similarly, Huda et al. (2019) suggested that there is a difference in the results between Z-score models Altman (1993), S-score (Springate, 1978) and X-score (Zmijewski, 1984) in forecasting. Financial risks in companies listed on the Indonesian Stock Exchange. Muzanni and Yuliana (2021) found that there is a significant difference between the Z-score model Altman (1993), the S-score model (Springate, 1978) and the X-score model (Zmijewski, 1984) in risk prediction. Financial risks to listed companies in Indonesia and Singapore. Nurcahyanti (2015) states that the difference in forecast results occurs due to the difference in the variables used by each model and the coefficients in the calculation formula for each forecasting model, so the results forecast is different. Permana et al. (2017) argued that the forecasting results of each model are different because the forecasting models have different components or variables. Tanjung (2020) argues that there are differences in each forecasting model because the measurements of each model are different. Winaya et al. (2020) stated that the forecast results of each model are different because the indicators used as analytical variables in the forecasting models are different.

Ninthly, research results comparing financial risk models with binary conditions (DAR) show that X-score is the most accurate model to identify financial risks of listed medical companies with accuracy rate is 80% (H11 is accepted). Zmijewski (1984) suggested that the X-score model can be used to predict financial risk with an accuracy of 94.9%. Similarly, Nilasari and Haryanto (2018) concluded that the

X-score model is the most accurate model to predict the financial risk of companies listed on the Indonesian Stock Exchange with a rate of 97.9%. Similarly, Muzanni and Yuliana (2021) stated that the X-score model is the most accurate model for predicting financial risks of listed companies in Indonesia with the rate of 87%; Z-score model is the most accurate model for predicting financial risk of listed companies in Singapore with the rate of 86%. The main reason is that the X-score model can predict the sample of businesses with healthy financial position, without the greatest financial risk among the research models.

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