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Combined S&P and Z-score research in credit assessment of Vietnamese commercial banks

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Abstract

Economists often refer to banking as the "business of risk." Indeed, no industry presents risks as significantly as the monetary-credit sector. Banks face risks not only from their subjective causes but also from those caused by customers. Therefore, "the credit risk of banks is not merely additive but could be a multiplicative factor of the economy's risks." Given this critical role, this paper proposes a combination of a credit rating solution with Altman's Z-Score model (Altman [1]) and a scoring method to provide early warnings for corporate credit risks. This approach aims to equip commercial banks with an additional tool to support credit decision-making.

Keywords: Credit risk, Z-score model, Early warning model, Financial indicators, Non-financial indicators.

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1. Introduction

Commercial banks always face numerous risks, particularly in the credit sector. As Vietnam commits to opening its financial-banking market and integrates regionally and globally, this creates opportunities for Vietnamese banks but also generates higher levels of challenges and risks. Risk factors in banking operations have become increasingly complex, requiring timely preventive solutions. Developing an early warning system is crucial, especially in the context of deeper and broader international integration. Globally, there have been several significant studies on credit risk early warnings. For instance, Merton [2] has played a pioneering role in credit risk management, similar to the role of the Black-Scholes model in option pricing [2]. However, a limitation of this model is the assumption that enterprises only have a single debt and settle it at one specific time.

Altman's Z-Score model, initiated in Altman, et al. [3], is commonly used for credit rating for enterprises [1]. This model measures the probability of default for clients based on their fundamental characteristics. The Z-Score is a composite measure that classifies risk levels for borrowers, depending on the financial factors of the borrowers. The CreditMetrics model,

introduced by Morgan [4], is widely applied in practice. Originating from Merton's model, a fundamental difference is that the bankruptcy threshold in CreditMetrics is determined based on credit ratings rather than debts. Thus, this model allows for the determination of both default probability and credit deterioration probability [4].

In Vietnam, notable studies include Le [5] work "Exploring the Fascination of R Software in Quantifying Credit Risk," where the author researched and applied the KMV model for credit risk early warnings [6]. Another study by Le [5], "Application of Merton [2] Model in Teaching Credit Risk and Bond Valuation for Finance Students," clarified Merton's model and its application in credit risk early warnings at Vietnamese commercial banks Le [5]. Nguyen [7] study, "Early Warning Models and Policies for Macro-Economic Stability," constructed early warning systems (EWS) for macroeconomic risks and currency crises using parametric models [7]. However, these models are often complex and challenging to apply effectively in the practical context of Vietnamese commercial banks. Additionally, they primarily focus on financial factors, neglecting non-financial elements. Based on this observation, this paper proposes a solution combining Altman's Z-Score model to analyze financial factors with a scoring method for non-financial factors. This combination provides commercial banks with an additional tool for supporting credit decision-making.

2. Literature Review

2.1. Overview of credit rating

According to Standards & Poor's, credit ratings are current assessments of credit risk, credit quality, and the borrower's ability and goodwill to meet financial obligations in full and on time. According to Moody's Investors Service [8] credit ratings are opinions that evaluate the credit quality and debt solvency of borrowers based on basic credit analysis and expressed through the Aaa-C symbol system.

Thus, the credit scoring and customer rating system is a process of evaluating a customer's ability to fulfill financial obligations to a bank, such as interest payments and principal payments when due, or other credit conditions, in order to evaluate and identify risks in the bank's credit activities. The level of credit risk varies from customer to customer and is determined through an assessment process using a scale based on the available financial and non-financial information of the customer at the time of credit scoring and customer rating.

The subjects of credit rating include parameters and data of customers applying for loans at commercial banks, such as financial information derived from the financial statements of enterprises and non-financial information (e.g., management team experience, internal control environment, and dependence on business partners).

Commercial banks do not use credit rating results to represent the borrower's value. Instead, they provide a current opinion based on risk factors to formulate appropriate credit policies and lending limits. A high credit rating for a borrower does not guarantee full recovery of the principal and interest but serves as a foundation for making sound credit decisions adjusted to reflect the anticipated level of credit risk associated with the borrower and all their loans.

Borrower ratings primarily predict the risk of default at three basic levels: High Risk, Warning, and Safe, based on the Probability of Default (PD). This probability is calculated using the borrower's debt history over the past five years, including fully repaid debts, outstanding debts, and uncollectible debts. The data is categorized into three groups:

Financial data: Related to the borrower's financial ratios.

Non-financial qualitative data: Depending on the bank, this may involve management proficiency, research and development capacity for new products, and industry growth data.

Warning data: Related to indicators such as signs of default, deposit account balances, and overdraft limits.

Loan ratings are based on borrower ratings and additional factors, including collateral, loan duration, total outstanding debt across financial institutions, and financial capacity. The risk of a loan is measured by its Expected Risk Probability (ERP).

2.2. Importance of Credit Rating

2.2.1. Credit Risk

For the operation of commercial banks, credit risk arises when the bank fails to collect or collects fully and on time the principal and interest on debts. Credit risk not only appears in the field of the bank's lending activities but also stems from other activities such as guarantees, capital commitments, commercial financing approvals, etc.

Credit risks, when they occur, can severely affect the business activities of commercial banks. This type of risk can push the bank toward bankruptcy, result in a loss of credibility, and create confusion for depositors, thereby indirectly causing a chain collapse of the banking system, which is the vital capital distribution channel of the economy. The credit risks faced by commercial banks may also impact the economies of relevant countries due to the close integration of currency and investment links between nations.

2.2.2. The Important Role of Credit Rating

The credit rating system helps commercial banks manage risks, control customer credit levels, and establish appropriate credit and governance policies to minimize possible credit risks. As a result, commercial banks can evaluate the effectiveness of their loan portfolios by monitoring changes in outstanding loans and classifying debts within each group of rated customers, thereby adjusting their portfolios to prioritize resources for the group of safe customers.

2.2.3. The Role of Credit Ratings on Financial Markets

- Investors use credit rating results to implement investment strategies that minimize risk while achieving the desired outcomes.
- Borrowing institutions need to mobilize capital using credit rating results to create trust with investors, thereby implementing the strategy of raising capital at a low cost and mobilizing the desired amount of capital.
- Through credit ratings, other organizations utilize the rating results to enhance their organization's image, provide information to partners, and foster market confidence.

2.3. Principles and Procedures for Credit Rating

2.3.1. Credit Rating Guidelines

Credit ratings are conducted based on the principle of primarily including credit analysis that considers the awareness and willingness of customers to repay debts in their history, assessing repayment potential by measuring the financial capacity of customers. From there, a comprehensive and unified risk assessment is made based on the rating symbol system. In credit rating analysis, it is also necessary to pay attention to qualitative analysis to supplement the shortcomings of quantitative analysis. Analytical indicators are subject to change in accordance with general environmental factors.

2.3.2. Credit Rating Process

The credit rating of borrowed enterprises shall be carried out in the following 5 steps.

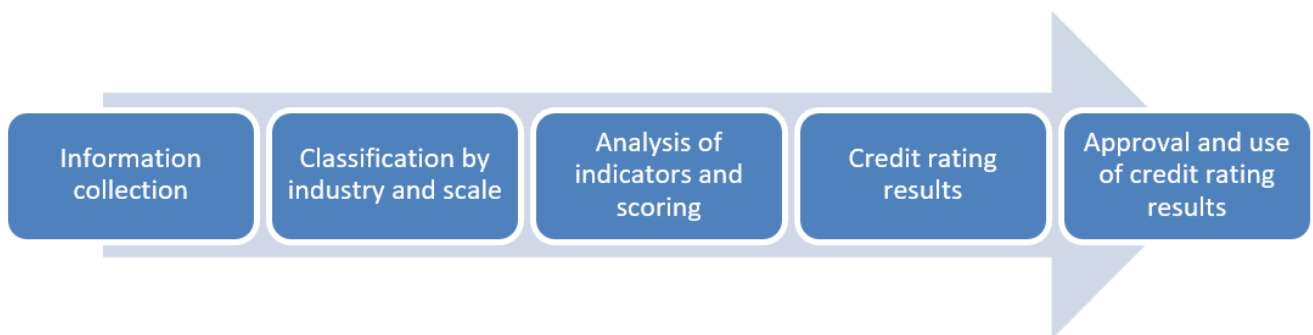


Figure 1.
Credit rating process.

2.3.3. Information Collection

To collect information related to the criteria used in the analysis and evaluation of rating information from other credit institutions concerning the rating objects. In the process of collecting information, in addition to the information provided by the customer, the appraisal officer must utilize various other sources of information, including mass media, data from the bank's credit center, and information from rating companies.

2.3.4. Classification By Industry and Size

Each business line has its own characteristics. The different nature of operations is affected by various factors that significantly influence the ability of enterprises to repay debts. For example, the industrial sector requires substantial capital, minimal labor, and has a long capital turnover, while the agricultural industry is heavily dependent on natural factors, exhibits seasonal characteristics, and employs a large number of manual laborers.

The size of the business is an extremely important factor, it affects business efficiency as well as the competitiveness of businesses in the market. For large-scale enterprises, they will have the advantage of low product cost scale, product diversification, large capital can invest in depth to improve equipment, etc. In contrast to small-scale enterprises, which are less competitive, they are prone to bankruptcy when they encounter negative external factors.

2.3.5. Analysis and Scoring of Indicators

Analyze information: Analyze with a model to draw conclusions about the rating. Simultaneous use of financial and non-financial indicators. Financial indicators that are scored based on the industry and size of the business usually include liquidity indicators, debt balance indicators, operating indicators, and income indicators. For each indicator, there is a different level of points and weighting. Non-financial indicators usually include indicators of debt repayment, the reputation of transactions with banks, cash flows, etc. Especially for non-financial indicators, they must be designed to be interspersed to ensure consistency in the process of evaluating indicators and must be used very flexibly, objectively, and in accordance with each type of enterprise and each business item.

2.3.6. Give Credit Rating Results

After scoring the financial and non-financial indicators, the credit officer summarizes the score by multiplying it by the corresponding weights. To give the rating results, the credit officer will compare the total customer score achieved with the customer classification table and give the customer rating results.

2.3.7. Approval and Use of Rating Results

In order to ensure that the credit rating system is in line with reality, the rating results accurately reflect the risk level of each customer. Banks need to periodically review, edit, and complete the specific system: monitor the credit status of the rated object to adjust the rating level; adjusted information is retained. Additionally, they should summarize the rating results compared with the actual risks occurring and, based on the frequency of ratings made for customers, consider adjusting the rating model.

2.4. Credit rating models being applied internationally and in Vietnam:

To rating credit, rating agencies around the world can use mathematical models, expert methods, and neural network techniques.

2.4.1. Mathematical Model of Credit Scoring

The Altman Z-score model was published in Altman [1] New York University. The model is used to calculate and forecast the likelihood of default of the enterprise within 02 years. The Z-score model is one of the models for calculating the likelihood of financial default of a business with the advantage of being easy to calculate by using data from financial statements to calculate. Z-score uses a first-order linear model between financial indicators quantified by coefficients. The model uses a regression method based on past data and then makes a forecast for the future.

2.4.2. Variations of the Altman Z-Score Model

+ The Z index was developed by Altman [1] New York University, based on an elaborate study of a large number of different companies in the United States. The Z-Index is the most widely recognized, recognized, and used instrument in both academia and practice in the world. Although the Z index was invented in the US, most countries can still use it with quite high reliability such as Mexico, India, etc. This index is based on a statistical method with the multi-factor differential analysis (MDA) tool.

+ Z index includes 5 ratios X1, X2, X3, X4, X5:

X1= Working capital/ total assets

In which:

- Working capital = short-term assets - short-term liabilities
- Losses in business activities will reduce the X2 ratio
- $X2 = \text{Retained Profit} / \text{Total Assets}$
- This ratio measures retained earnings accumulated over time.
- $X3 = \text{EBIT} / \text{Total Assets}$
- $X4 = \text{Market value of equity} / \text{Book value of debt}$
- $X5 = \text{Revenue} / \text{Total assets}$

From an initial Z-index, Altman further developed Z' and "Z" to be applicable to each type of business:

- For equitized enterprises, production industry: $Z = 1.2X1 + 1.4X2 + 3.3X3 + 0.64X4 + 0.999X5$
- For enterprises that have not yet been equitized, the production industry:

$$Z' = 0.717X1 + 0.847X2 + 3.107X3 + 0.42X4 + 0.998X5$$

For non-manufacturing enterprises:

$$Z'' = 6.56X1 + 3.26X2 + 6.72X3 + 1.05X4$$

The higher the Z index (or Z' and Z''), the lower the probability of default of the borrower. To increase this index, it is necessary to improve management capacity, review to reduce inactive assets, save reasonable costs, and build a brand. It is an indirect combination of many financial and non-financial factors in the new model create a safety index.¹

2.4.3. Expert Method

Using the logistic regression model with hard factors—financial indicators—and soft factors—non-financial indicators—contributes significantly to improving the ability to forecast the credit level of borrowers. Most banks utilize the scoring model of financial and non-financial indicators for each customer based on a set of standard values for each type of customer or different economic sectors. Due to the diverse nature of customers, to accurately score credit, banks scientifically categorize customers with credit relationships into three groups: financial institutions, economic organizations, and households and individuals.

For example, Fitch ranks businesses based on qualitative and quantitative analysis. Fitch's analytical methodology consists of analyzing financial and business data for a period of at least 5 years. Qualitative analysis includes analysis of industry risks, business environment, position of enterprises in the industry, capacity of the management board, accounting analysis. In its quantitative analysis, Fitch emphasizes cash flow measures of earnings, guarantees and leverage. Cash flow from business activities provides businesses with more credit risk assurance than from external funding. And Fitch is more interested in analyzing the trend of a group of ratios than analyzing any one individual ratio.

2.4.4. Neural Networks

It is another analytical technique for building forecasting models. Neural networks can mimic and perceive real states for incomplete input data or data with a very large number of variables. This technique is particularly suitable for forecasting models for which there is no known mathematical formula to describe the relationship between input and

output variables. Moreover, it is useful when the forecast goal is more important than the explanation. This technique requires large input data, these methods are also very complex and not popular in our country.

In general, the world's top credit rating agencies, including Fitch, S&P [9] and Moody's Investors Service [8], use the expert methodology to comprehensively assess the economy, industry and company. However, whether using the mathematical modeling method or the expert method, each credit rating system has certain drawbacks. If the quantitative method needs the support of soft factors, the expert method, which itself contains risks due to subjective factors in ranking, although the neural network technique overcomes the shortcomings of the above two models, it requires large input data, and the construction is very complicated. The method of building a credit rating or credit risk model based on the Logistic function is a suitable method for Vietnamese commercial banks because the sample requirements are not too high, less binding in terms of hypotheticals, and are currently widely used in the world. Therefore, the next sections will cover the elements necessary to build a credit rating system based on the expert method

3. Research Method

The paper employs a combination of qualitative and quantitative methods, where the qualitative method is utilized to analyze non-financial factors, and the quantitative method is used to assess financial factors. This is derived from the collection of information related to financial factors based on the Z and non-financial score model, which includes the ability to repay debts from cash flows, management level, relationships with banks, external factors, and other characteristics, among others. Consequently, the paper calculates the Z-score for financial factors and scores non-financial factors, with the proportion of factors determined based on their influence. Additionally, the paper conducts credit ratings of financial and non-financial factors based on S&P [9] credit rating theory, thereby providing commercial banks with an additional tool to assist in credit decision-making.

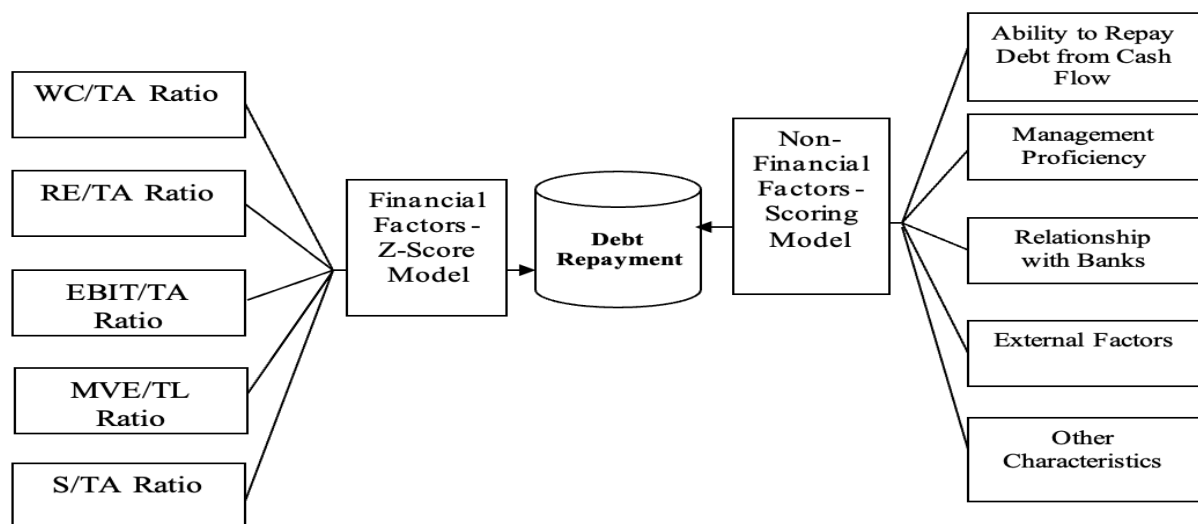


Figure 1.
Credit risk early warning model.

Note:

- WC/TA: Working capital to total assets
- RE/TA: Retained earnings to total assets
- EBIT/TA: Earnings before interest and taxes to total assets
- MVE/TL: Market value of equity to book value of total liabilities
- S/TA: Sales to total assets

4. Theoretical Basis

4.1. Non-Financial Coefficients

+ Ability to repay debts from cash flow

This indicator reflects the ability to repay medium- and long-term principal in the future. The calculation of this target is based on the expected sources of income from production and business plans, investment projects, and highly efficient production and business plans, indicating a strong ability to repay debts.

+ Management qualifications

Demonstrated in professional experience, education, executive leadership, dynamism, and sensitivity in business activities.

+ Relationship with banks

This indicator reflects whether the enterprise maintains timely repayment of debts to credit institutions and fully meets its commitments. When businesses consistently repay debts in full and on time, it demonstrates their creditworthiness to credit institutions and indicates effective use of loans.

+ External factors

Industry outlook; Degree of dependence on natural conditions

+ Other features

The number of years of operation of the enterprise; Revenue and profit growth rate; Development prospects of the enterprise

4.2. Financial Coefficient - Z-Score Model for Equitized Enterprises

The Z-score model is the product of research by Professor Edward I. Altman, Leonard N. Stern School of Business, New York University (USA) first published in 1968 in the Journal of finance

Generalized form of the Z-score model

$$Z = \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5$$

For equitized manufacturing enterprises, the model is in the form of:

$$Z = 1,2X_1 + 1,4X_2 + 3,3X_3 + 0,64X_4 + 0,999X_5$$

In which:

- Ratio of working capital to Total assets (X1)

Working capital represents the liquidity of the business, which is the difference between short-term assets and short-term liabilities. The larger the working capital, the higher the liquidity of the enterprise. The ratio of working capital to total assets indicates what percentage of working capital is in the total assets of the enterprise; the higher this ratio, the greater the ability of the business to repay debts, and vice versa.

- Retained Earnings Ratio to Total Assets (X2)

Retained earnings represent the difference between net income and dividends paid, which is the amount of proceeds used by the enterprise to reinvest or repay debts. The ratio of retained earnings to total assets indicates how efficiently the business utilizes its assets and how much profit the business earns per asset. A higher ratio signifies that the business uses its assets more efficiently and has a greater ability to repay debts.

- Return before interest and taxes on Total Assets (X3)

This ratio reflects the efficiency of using the company's assets to earn profits without considering income tax and interest expenses. The EBIT index has eliminated differences in capital structure and tax rates between businesses by excluding income and interest taxes. This index helps reflect the profitability of the business; it serves as a measure for investors to compare between businesses.

- Market value of equity to book value of Total debt (X4)

The market value of equity is the total value measured by the market value of all the shares of a company, while liabilities include both current and long-term obligations. This measure indicates that the company's assets can decline in value (measured by the market value of equity plus debt) before the debts exceed the assets and the company becomes insolvent. The higher this ratio, the greater the company's ability to repay its debts.

- Ratio of sales to Total assets (X5)

This ratio represents the company's ability to generate revenue from its assets. The higher the value of this ratio, the greater the efficiency of the company's use of its assets, and vice versa.

Evaluation of results according to the Z-score model

Table 1.

Interpretation of Z score results.

Z Score	Interpreting the results
$Z > 2.99$	The enterprise is in a safe zone, not at risk of bankruptcy
$1.8 < Z < 2.99$	Businesses are in the warning zone, may be at risk of bankruptcy
$Z < 1.8$	Enterprises located in danger zones, high risk of bankruptcy

Table 2.

Credit ratings according to S&P

Point	S&P	Content
> 92.3	AAA	Highest credit quality, lowest risk, highest ability to repay debts.
84.8 - 92.3	AA	High credit quality, low risk level, high repayment ability.
77.2 - 84.7	A	Reaching above average, the factors of ensuring short-term and long-term debt repayment are not very certain, but still highly reliable. Therefore, it is rated to be able to repay debts.
69.6 - 77.1	BBB	Reaching the average level, the safety and risk level is not high but also not low. The current ability to repay principal and interest is not very certain, but there are no signs of danger.
62.0 - 69.5	BB	Below average, the ability to repay principal and interest is uncertain and the level of safety of BBB.
54.4 - 61.9	B	This object lacks attractiveness for investment. The guarantee of future repayment of principal and interest is very small.
46.8 - 54.3	CCC	Low debt repayment capacity, prone to default.
39.2 - 46.7	CC	Very high risk, often defaulting.
31.6 - 39.1	C	Subjects in a state of imminent bankruptcy.
< 31.6	D	The possibility of bankruptcy is as certain as if it were even.

4.3. S&P Corporate Credit Rating

The paper conducts the bank's corporate credit rating based on the theory of Standard & Poor's, which is a financial services company based in the United States. It is a subsidiary of McGraw-Hill. Standard & Poor's is one of the three largest and most prestigious credit rating agencies in the world (the other two are [Moody's Investors Service \[8\]](#)). S&P rates borrowers on a scale of AAA to D.

4.4. Relationship between credit ratings according to S&P and Z-Score Ratings

Table 3.

The relationship between S&P and Z-Score Ratings in credit ratings.

Z-Score	S&P	Content
6.2	AAA	Highest credit quality, lowest risk, highest ability to repay debts.
4.73	AA	High credit quality, low risk level, high repayment ability.
3.74	A	Reaching above average, the factors of ensuring short-term and long-term debt repayment are not very certain, but still highly reliable. Therefore, it is rated to be able to repay debts.
2.81	BBB	Reaching the average level, the safety and risk level is not high but also not low. The current ability to repay principal and interest is not very certain, but there are no signs of danger.
2.38	BB	Below average, the ability to repay principal and interest is uncertain and the level of safety of BBB.
1.8	B	This object lacks attractiveness for investment. The guarantee of future repayment of principal and interest is minimal.
0.33	CCC	Low debt repayment capacity, prone to default.
-0.20	D	The possibility of bankruptcy is as certain as if it were even.

5. Results of Research and Discussion

5.1. Table of Results of Scoring Financial Indicators According to the Z-Score Model

Table 4.

Data for calculation of Z score model elements of enterprise B.

Quota	Calculation formula	DNB	Density	Result
X1	Working Capital / Total Assets	0.138	1.2	0.138
X2	Retained Earnings / Total Assets	0.174	1.4	0.174
X3	Earnings Before Interest and Taxes (EBIT) / Total Assets	0.114	3.3	0.114
X4	Market Value of Equity / Book Value of Total Liabilities	0.519	0.64	0.519
X5	Sales / Total Assets	1.989	0.999	1.989
Z-Score				3.104

From the [Table 4](#), we can see that DNB has a Z-Score = 3.104 > 2.9, which means that DNB is in the safe zone, not at risk of bankruptcy

5.2. Table of Results of Scoring of Non-Financial Indicators

Table 5.

Scoring Results for Non-Financial Indicators of DNB

No.	Weight	Non-Financial Indicators	Value	Score	Final Score
I	30%	Management Proficiency			
1.1	5%	Legal record of the company's head	Good legal record	100	5
1.2	7%	Professional experience of the company's head	15 years	100	7
1.3	7%	Educational level of the manager	University degree	60	4.2
1.4	6%	Leadership ability of the company's director	Excellent	100	6
1.5	5%	Organizational structure and internal control	Excellent	100	5
II	30%	Relationship with Banks			
2.1	4%	Debt repayment history in the past 12 months	Always on time	100	4
2.2	4%	The number of debt restructuring instances.	0 instances	100	4
2.3	3%	Number of off-balance-sheet defaults	0 instances	100	3
2.4	3%	Providing required information to banks	Always complete	100	3
2.5	4%	Bank service utilization	Highest among all banks	100	4
2.6	4%	Revenue channeled through the bank	80%	80	3.2
2.7	3%	Duration of relationship with the bank	5 years	100	3
2.8	3%	Overdue debts at banks	None	100	3
2.9	2%	Future orientation in customer relationships	Development	100	2

No.	Weight	Non-Financial Indicators	Value	Score	Final Score
III	25%	External Factors			
3.1	4%	Industry growth prospects	High	100	4
3.2	4%	Risk of product substitution	Low	100	4
3.3	5%	Supply stability	Stable	60	3
3.4	2%	Dependence on natural conditions	Low	60	1.2
3.5	4%	Competition among existing industry players	Moderate	60	2.4
3.6	2%	Ease of new entrants into the industry	Difficult	100	2
3.7	4%	Market demand for the company's products	High	100	4
IV	15%	Other Characteristics			
5.1	1%	Dependence on a few suppliers	Moderate	60	0.6
5.2	1%	Years of operation	10 years	100	1
5.3	4%	Revenue growth rate	20%	67	2.68
5.4	4%	Profit growth rate	125%	100	4
5.5	1%	Scope of operations	Nationwide	60	0.6
5.6	1%	Business development prospects	Development	100	1
5.7	1%	Competitive advantage	Favorable	80	0.8
5.8	2%	Company size	Large	100	2
Total	100%				89.68

Non-Financial Indicator Score for DNB: 89.68, falling within the range of 84.8 – 92.3.

Credit Rating by S&P: DNB is rated AA, indicating high credit quality, low risk, and strong debt repayment ability.

5.3. Convert Non-Financial Points to Z-Score

Table 6.

Convert non-financial points to Z-score.

Non-financial score	Scale	S&P boss	Z-Score (Deduced from AA)	Value explained
89.68	84.8-92.3	AA	4.73	High credit quality, low risk level, high repayment ability

According to S&P, DNB has a credit rating of AA. Based on the relationship between S&P's credit ratings and Z-Score, DNB's non-financial score has a Z-Score of 4.73.

5.4. Calculation of DNB's Final Z-Score

Determining the proportion of financial and non-financial factors

Table 7.

Proportion of financial and non-financial factors.

No	Quota	SOEs	Other businesses	Foreign nationals
		Density	Density	Density
1	Financial scoring	50%	40%	60%
2	Non-financial scoring	50%	60%	40%
3	Rewarded points for audited financial statements	+6 points	+6 points	+6 points

DNB's Z score calculation

$Z\text{-Score}_{DNB} = \text{Financial Z-Score} + \text{Non-Financial Z-Score}$

$$Z\text{-Score}_{DNB} = \frac{\text{WeightFinancial Score} + \text{WeightNon - Financial Score}}{2}$$

$$Z - \text{Score}_{DNB} = 40\% * 3,104 + 60\% * 4,73$$

$$Z - \text{Score}_{DNB} = 1,2416 + 2,838 = 4,0796$$

We see $3.74 < 4.73$. According to the relationship between S&P's credit rating and Z-Score, $Z\text{-Score}_{DNB}$ DNB's credit rating is from A to AA. Because DNB's Z-score is in the lower half, smaller than the average of 4,235, we can rate DNB's credit rating as A+, which means that DNB is above the average of factors in terms of ensuring short-term and long-term debt repayment is not very firm but still highly reliable. Therefore, it is rated to be able to repay debts.

6. Some Recommendations for Commercial Banks

6.1. For Non-Financial Factors

First, when grading non-financial factors, banks need to establish a Council of Experts and the score is the score of the whole Council, not the individual

Secondly, when grading, it is necessary to comply with the scale and proportion of each element

Thirdly, when grading, it must be based on specific data evidence, not on the subjective feelings of the graders

Fourth, when there are some abnormal changing factors, it is necessary to re-grade and credit rating for corporate customers

6.2. For Financial Factors

Firstly, the Z-Score Model has utilized the multi-factor differential analysis method to quantify the probability of default of borrowers, which has overcome the disadvantages of the qualitative model, thus contributing positively to credit risk control at commercial banks. However, the model depends entirely on the quality of the data. Therefore, commercial banks need to ensure the accuracy of the information on the financial statements provided by the enterprise.

Secondly, when analyzing five indicators X1, X2, X3, X4, and X5, if there are abnormal findings, we need to clearly understand the reasons to know the cause of the increase or decrease of those indicators.

Third, commercial banks, when applying the model, need to recalculate the Z-score to capture changes in the company's financial situation, thereby taking timely measures.

Fourth, when the Z-score falls into an uncertain range, banks need to consider more non-financial factors such as credit history, management scale, management level, number of years of establishment, etc., to make decisions in the safest way.

7. Conclusion

Credit risk has significant consequences for banks. However, confronting it is unavoidable for every bank, especially in today's fiercely competitive environment. The results of this paper can assist bank managers in having an additional tool to analyze and identify customers at risk of insolvency, while also identifying factors that strongly influence credit risk, enabling managers to implement appropriate focused policies. However, the aforementioned results are only effective when the analysis data is based on standard actual data.

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