APPLICATION OF QUANTITATIVE MODELS IN EARLY CREDIT RISK WARNING SYSTEMS FOR CORPORATE CLIENTS AT COMMERCIAL BANKS IN VIETNAM

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Abstract: ***Credit activities are the main activities of commercial banks, so credit risk is also the most common risk. One of the measures to manage credit risk is to provide early warning of credit risks in order to have appropriate prevention and handling measures. This study uses the Logit model with data from 257 corporate customers at 10 Vietnamese commercial banks in the period 2020-2023 to provide early warning of credit risks. The model's forecast results compared to the actual credit risk of customers have an accuracy rate of 94.9%. The author recommends that quantitative models such as the Logit model should be used more widely in Vietnamese commercial banks because of its objectivity and effectiveness.***

• Keywords: *credit risk, early warning systems, quantitative model, logit model.*

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1. Introduction

Credit activities of Vietnamese commercial banks are developing in the direction of increasing scale and growth rate, however, with adverse fluctuations of the economy, credit quality is unstable.

The current situation of credit risk management at Vietnamese commercial banks mainly focuses on handling credit risk without paying due attention to credit risk prevention, especially credit monitoring after lending to detect credit risk at an early stage in order to have appropriate risk prevention measures, minimizing possible credit losses. Due to limitations in early warning of credit risk, credit risk is often only detected when the loan has become overdue debt or bad debt, making credit risk management measures not as effective as expected. Many commercial banks have not yet built a credit risk early warning system as the basic requirement of Circular 41.

During the period of restructuring and efforts to achieve safety standards according to international practices, to improve the operational efficiency as well as the position of Vietnamese commercial banks in the region and the world, the construction of an early warning system for credit risks by quantitative models plays a vital role in the operations of Vietnamese commercial banks.

2. Literature review and research methodology

The research hypothesis can be stated as below:

H1: X1-The short-term liquidity ratio (Current Assets/Current Liabilities) negatively correlates the probability of corporate insolvency.

Operating efficiency is a very important factor that directly affects the risk of corporate bankruptcy (Altman, 2000 and (Hoang Tung, 2011). This factor in the topic is represented by four variables: ROA, ROE, basic earning power ratio (EPS) and Total asset turnover. In this topic, the variable X2 (ROA) = Profit after tax / Total assets. X3 (ROE) = Profit after tax / Owner's equity. X4 (basic earning power ratio) = Earnings before tax and interest (EBIT) / Total assets. X5 (Total asset turnover) = Net revenue / Total assets. X6 (Profit rate on revenue) = EBIT / Net revenue.

These ratios are particularly suitable for studies related to corporate bankruptcy, as the ultimate survival of a company depends on its operational effectiveness. The hypothesis proposed is as below:

H2: "The company's operational performance is negatively correlated with the probability of corporate bankruptcy".

The independent variable financial leverage or capital structure is represented by the ratio of total debt to total assets (Beaver, 1966, Sori and Karbhari, 2004). For the financial leverage ratio, this study will use X7=Total debt/Total assets.

H3: "The ratio of total debt to total assets positively correlates the probability of a business's risk of bankruptcy" (Altman, 2000; Zang et al., 2007). Given

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the unique characteristics of the Vietnamese economy and for the convenience of data collection, this study uses two variables to represent growth: X8 = the rate of revenue growth and X9 = the rate of total asset growth. A company that exhibits positive revenue and asset growth typically indicates that the company is performing well operationally, and vice versa. Additionally, it is important to note that companies with excessively high growth rates may sometimes experience the opposite effect (increased bankruptcy risk); therefore, caution is needed when analyzing the results. The research hypothesis is temporarily stated as follows:

H4: "Normal growth of a company has a negative effect on the probability of corporate bankruptcy."

For non-financial factors, the research uses X10= age of the company to represent industry experience because Lussier (2005) found that it affects the prediction of business success or failure, especially in emerging markets like Vietnam. Hypothesis for this non-financial variable:

H5: "The number of years of operation negatively correlates the probability of corporate bankruptcy".

And the research also adds another variable, X11= Company listing status, which is a non-financial variable. The listing status implies that a publicly listed company, with a larger scale, tends to have a lower probability of bankruptcy compared to a privately held company. Hypothesis

H6: "Listed enterprises have a lower risk of bankruptcy than unlisted enterprises".

The author also chooses the variable: X12= Loan utilization ratio calculated by log (Actual debt ratio/Credit limit) within 3 months of the enterprise representing the loan characteristics. Hypothesis

H7: "The ratio of loan utilization positively correlates the probability of default of the borrowing enterprise.

The study uses two control variables, X13 - Current Debt/Total Debt and X14 - Current assets/Total assets.

3. Data collection

The data used in this study is provided from the database of corporate customers borrowing capital from commercial banks in Vietnam. First, the author sent the information sheet to be collected about the borrowing enterprises to the directors of commercial banks in Vietnam. The researcher collected data from 385 corporate customers from 10 commercial banks. However, after reviewing the database, the author found that for some customers, important information was omitted; Therefore, the sample selected for model development includes 257 enterprises borrowing capital from 10 commercial banks in Vietnam.

The dependent variable is the customer's ability to repay debt, which takes the value of 1 if the customer has overdue debt as defined above (bad customer) and takes the value of 0 if the debt repayment status is good (good customer).

With that perspective, the sample selected for research includes 77 bad customers and 180 good customers.

First, the author conducted a basic quality check of the data sample, tested for multicollinearity, and built an early warning model for credit risk based on the Logit regression model on SPSS 20 software. The results of the model will be analyzed in the next section.

4. Model results

4.1. Descriptive statistics

Table 2: Descriptive statistics of variables

	N (number of observations)	Minimum (minimum value)	Maximum (maximum value)	Mean	Std. Deviation
X1	257	.00300	17.81200	1.1225175	1.44286582
X2	257	-6.460	4.172	-.01414	.781365
X3	257	-.17	7.97	7.3405	.86201
X4	257	-.492	5.469	.11571	.449409
X5	257	.0260	24.9434	2.587964	2.6402370
X6	257	-24.6	1.0	.449	2.7610
X7	257	.017	2.041	.56722	.275117
X8	257	-.999	24.351	.30575	1.885963
X9	257	-.999	1.901	.13465	.366750
X10	257	1	64	15.72	14.951
X11	257	.000	1.000	.52128	.500406
X12	257	.00045	.94572	.3082320	.23160453
X13	257	.187	1.000	.84433	.205181
X14	257	.017	.959	.45087	.237871

Source: Author's calculation

The descriptive statistics table shows significant differences among firms in terms of performance and short-term liquidity, reflecting the challenging economic conditions. Control variables related to financial leverage and growth are also included in the analysis.

4.2. Multicollinearity test

We need to check the VIF coefficient of the variables. The results show that the VIF of all variables is less than 10, so there is no multicollinearity between the variables in the model.

Table 3: Multicollinearity test

Coefficient								
Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	.457	.273		1.671	.096		
	X1	-.065	.020	-.206	-3.206	.002	.553	1.808
	X2	-.065	.037	-.110	-1.731	.085	.564	1.773
	X3	-.063	.028	-.119	-2.219	.027	.797	1.254
	X4	.126	.077	.123	1.634	.104	.401	2.491
	X5	.003	.009	.015	.280	.779	.794	1.259
	X6	-.020	.009	-.123	-2.310	.022	.805	1.242
	X7	.806	.175	.483	4.611	.000	.207	4.828
	X8	-.001	.012	-.005	-.109	.913	.977	1.024
	X9	-.076	.063	-.060	-1.199	.232	.897	1.115
	X10	-.012	.002	-.381	-7.477	.000	.876	1.142
	X11	.036	.046	.039	.782	.435	.919	1.088
	X12	-.512	.112	-.259	-4.556	.000	.707	1.415
	X13	.734	.160	.328	4.573	.000	.442	2.260
	X14	-.835	.219	-.433	-3.808	.000	.176	5.668

a. Dependent Variable: Y

Source: Author's calculation

4.3. Multivariate logit regression

The Case Processing Summary table gives us information about the data entered into the binary regression analysis. Specifically, there are 257 observations (Included in Analysis), no observations are missing data: 0 (Missing Cases), no observations are not selected: 0 (Unselected Cases).

Table 4: Summary of regression analysis data information

		N (Number of observations)	Rate (%)
Selected Model	Analysis sample	257	100,0
	Sample missing data	0	.0
	Total	**257**	**100,0**
Model not selected		0	.0
Total		**257**	**100,0**

Source: Author's calculation

The Dependent Variable Encoding table for the dependent variable has 2 values as follows:

Y = 1: Bankruptcy risk (Unable to repay debt), encoded as 1

Y = 0: Able to repay debt, encoded as 0

Table 5: Coding of dependent variables

Dependent Variable Encoding	
Original Value	Internal Value
0	0
1	1

Source: Author's calculation

The first step in running the Logit model analyzes thThe Chi-square and Sig. columns show the results of the Chi-square test, which is a test to see if the regression coefficients of the independent variables are simultaneously equal to 0 or not. Because the selected method is Enter, the three values of Step, Block, and Model are the same. In this case, the Sig. of all three indices is 0.000 < 0.1 (90% confidence level), so the regression model is statistically significant with a confidence level of 90%.

Table 6: Analysis of model coefficients

		Chi-square	df	Sig.
Step 1	Step	239.266	14	.000
	Block	239.266	14	.000
	Model	239.266	14	.000

Source: Author's calculation

Nagelkerke R Square = 0.859 means that the model can explain the risk of default (bankruptcy) of 85.9%

Table 7: Model summary

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	74.549	.606	.859

Source: Author's calculation

The Hosmer and Lemeshow test table for the appropriate model. Here Sig. = 0.947 > 0.1: appropriate model.

Table 8: Hosmer and Lemeshow test

Step	Chi-square	df	Sig.
1	2.785	8	.947

Source: Author's calculation

In 180 (175+5) observed cases with the ability to repay the debt, there are 175 cases where the model predicted correctly, the correct prediction rate is 175/180 = 97.2%

In 77 (8+69) observed cases of inability to repay debt, there were 69 cases where the model predicted correctly, the correct prediction rate was 69/77 = 89.6

Thus, the average correct prediction rate is 94.9%.

Table 9: Regression model results

		B	SE	Wald	Df	Sig.	Exp(B)	90% CIfor EXP(B)	
							Lower	Upper	
Step 1a	X1	-1.675	.567	8.733	1	.003	.187	.074	.476
	X2	-5.077	2.258	5.058	1	.025	.006	.000	.256
	X3	-6.245	2.829	4.873	1	.027	.002	.000	.204
	X4	-5.691	3.525	2.607	1	.106	.003	.000	1.113
	X5	-.264	.224	1.386	1	.239	.768	.532	1.110
	X6	-4.119	1.721	5.730	1	.017	.016	.001	.276
	X7	25.725	6.869	14.028	1	.000	148721688766.163	1844219.340	11993226742987974.000
	X8	-.389	.677	.331	1	.565	.677	.223	2.063
	X9	-.363	.759	.228	1	.633	.696	.200	2.427
	X10	-.599	.122	24.288	1	.000	.549	.450	.671
	X11	.716	.685	1.092	1	.296	2.046	.663	6.313
	X12	-6.367	1.918	11.024	1	.001	.002	.000	.040
	X13	25.410	6.167	16.975	1	.000	108540716705.858	4264810.483	276239406902235 6.000
	X14	-30.090	7.714	15.217	1	.000	.000	.000	.000
	Constant	36.327	20.431	3.162	1	.075	5981440955588875.000		

a. Variable(s) entered on step 1: X1, X2, X3, X4, X5, X6, X7, X8, X9, X10, X11, X12, X13, X14.

Source: Author's calculation

The "Variables in the Equation" table provides information on the regression model. The Sig. column from the Wald test indicates the statistical significance of the independent variables. In this dataset, variables with Sig. values below 0.1 (corresponding to a 90% confidence level) are considered to have an impact on the probability of default or debt repayment. The results show that variables X4, X5, X8, X9, and X11 are not statistically significant, while the remaining variables are.

The B column represents the regression coefficients, indicating whether the independent variables have a positive or negative influence on the dependent variable.

X1 - Short-term Liquidity Ratio:

This variable has a negative impact on the likelihood of bankruptcy, which is consistent with the initial hypothesis. A higher liquidity ratio is associated with lower bankruptcy risk. However, during periods of economic downturn, excessive allocation of resources to short-term liquidity at the expense of profitable investment opportunities may reduce overall performance, thereby increasing bankruptcy risk. Despite the legal importance of this ratio in Vietnam, some empirical studies suggest it is not statistically significant.

X2 (ROA), X3 (ROE), X6 (EBIT/Revenue): These variables all exhibit negative relationships with bankruptcy probability indicating that higher profitability reduces bankruptcy risk. The findings align with the research hypothesis and are supported by the literature reviewed.

X7 - Financial Leverage: This variable has a positive and statistically significant coefficient, suggesting that higher financial leverage increases the probability of bankruptcy.

X10 - Firm Age: This variable has a statistically significant and negative effect on bankruptcy risk, implying that older firms are less likely to go bankrupt.

X12 - Debt Utilization Ratio (Debt/Credit Limit): A positive relationship with bankruptcy risk is observed. Higher levels of debt utilization serve as early warning indicators of credit risk.

Control Variables - Debt Structure (X13) and Asset Structure (X14):

An increase in the proportion of short-term debt raises bankruptcy risk, while a higher share of short-term assets reduces it. Imbalances such as using short-term debt to finance long-term assets can weaken liquidity and heighten bankruptcy risk.

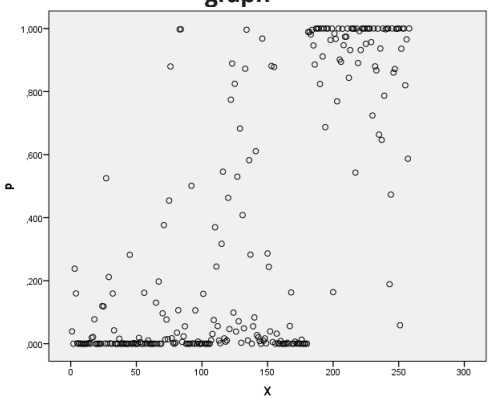
With the above results, substituting into the Logit regression equation we have:

log[y/(1-p)] = -1.675*X1 - 5.077*X2 - 6.245*X3 - 4.119*X6 + 25.725*X7 - 0.599*X10 - 6.367*X12 + 25.410*X13 - 30.090*X14 + 36.327

From there we can calculate the probability p as follows:

$$P = \frac{e^{-1,675*X1 - 5,077*X2 - 6,245*X3 - 4,119*X6 + 25,725*X7 - 0,599*X10 - 6,367*X12 + 25,410*X13 - 30,090*X14 + 36,327}}{1+e^{-1,675*X1 - 5,077*X2 - 6,245*X3 - 4,119*X6 + 25,725*X7 - 0,599*X10 - 6,367*X12 + 25,410*X13 - 30,090*X14 + 36,327}}$$

Figure 1: Debt repayment probability distribution graph



5. Conclusion and recommendations

From the distribution graph, the author found that the Pi values are not distributed evenly, so the author does not build a Credit risk ranking table according to debt repayment ability with equal distances but proposes a classification table suitable for the distribution properties as Table 10.

Consequently, the application of the Logit model to early warning of Credit risk for corporate customers with the database of enterprises borrowing capital at Vietnamese commercial banks was carried out in the period 2015-2018. With the selected variables having statistical significance and using the Logit regression method, the study has shown the factors affecting the probability of default of borrowers, the direction of impact and the specific level of impact by quantitative method. The forecast results of the model compared with the actual risk of customers have a high hit rate.

Table 10: Proposed Credit risk warning level

Pi	Classify	Proposed Credit risk early warning level
0.95 - 1	AAA	Low risk
0.9-0.95	AA	
0.8-0.9	A	
0.7-0.8	BBB	Medium risk
0.6-0.7	BB	
0.4-0.6	B	
0.2-0.4	CCC	High risk
0.1-0.2	CC	
0.05-0.1	C	
0.00-0.05	D	Insolvency

Source: Author's suggestion

Through the study of the Logit model above, the author found that the model has many advantages such as: customer credit rating is more objective and accurate... Meanwhile, most Vietnamese commercial banks are still using qualitative models to rate customers and give early warnings of credit risk. This method depends a lot on the subjective views of credit staff, so banks face many risks because the staff's appraisal skills are limited, staff can collude with customers to upgrade credit ratings...

Therefore, the author proposes that quantitative models such as the Logit model should be used more widely because of its objectivity and effectiveness. Vietnamese commercial banks should continue to research and experiment with their databases to build models that best suit their customer segments and business environments.

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