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Developing a Credit Risk Early Warning Model using Regression Model. A Case Study in Vietnam

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Abstract: ***In this paper, the author has conducted researches and investigations about risk management in Vietnamese commercial banking system. 210 observations from companies were collected by survey and SPSS software was used to perform Maddala's Binary logistics regression model (1984) to find out individual impacting factors that affects the loan repayment ability of corporate customers. Results from above process were aligned by affecting power for better evaluation thus supports banking mangers in disbursement decision making, reduces credit risks.***

Keywords: warning models; credit risk; logistics model; financial factor; loan repayment ability; corporate customers; credit risk management

1. Introduction

Credit is the major activities of the commercial banks. Therefore, credit risk is the biggest risk that these banks has to be faced, especially in the severe competition background in the field of currency trading like nowadays. There are many reasons which lead to the credit risk, and one of the most common reason come from borrower. Previously, lots of studies with models focused on credit risk, credit risk management. For example, Merton model (1972) shown loan repayment abilityof a company based on calculating the value of that company's assets at a given time [1] Z point model (Altman, 1968) calculates the customer' loan repayment ability based on historical data of the affecting factors. This model used multi-factor differential analysis method to quantify the customer's bankrupcy probability to surmount the disadvantages of the qualitative model, thus contributed positively credit risk managements at commercial banks [2]. CreditMetrics model was introduced by JP Morgan in 1997 which became commonly used in modern. This model is considered to be derived from the Merton model. However there is a fundamental difference between CreditMetrics model with Merton model that the bankruptcy threshold in the CreditMetrics model is determined from credit ratings rather than from debts. Therefore, this model allows managers to determine both the bankruptcy credit decline probability [3]. In addition, Meyer and Douglas W (1996) used quantitative methods to support credit risk management [4]

InVietnam, building and applying mathematical models to credit risk management in commercial banks is limited, especially in private joint-stock commercial banks. They mostly rely on credit rating system to make loan decisions. Therefore, result from this research proposes a credit risk warning model to support commercial banks to limit the risk in making lending decisions for corporate customers.

2. Method and Data

2.1. Method

Through the process of survey and research, the author has set out the set of factors affecting the loan repayment ability of customers who are bank borrowers. The model consists of 7 elements, as follows:

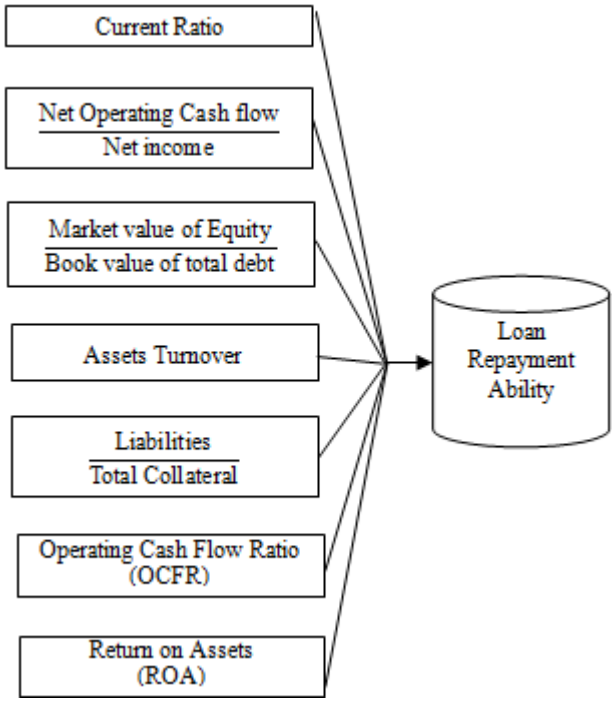

Figure 1: Credit risk warning model

2.2 Method of variable selection

The model's basis of variable selection is based on Altman's Z score model published in 1968 with 5 factors (for joint stock companies) and Piotroski Scorecard developed and introduced by Joseph D.Piotroski first public appearance in 2002 with 9 factors [5].

Table 1: Relationship between z-score model, Piotroski scorecard and the proposed model

Ordinal numbers	*Z-score – 5 factors (Altman-1968)*	*Piotroski scorecard – 9factors (Piotroski-2002)*	*Proposals model – 7 factors*
1	$\frac{\text{Working capital}}{\text{Total Assets}}$	Quality of Earnings	$\frac{\text{Net Operating Cash flow}}{\text{Net income}}$
2	$\frac{\text{Retained Earnings}}{\text{Total Assets}}$	Return on Assets (ROA)	Return on Assets (ROA)
3	$\frac{\text{Earnings before interest and Taxes}}{\text{Total Assets}}$	$\frac{\text{Long-term Debt}}{\text{Total Assets}}$	$\frac{\text{Liabilities}}{\text{Total Collateral}}$
4	$\frac{\text{Market value of Equity}}{\text{Book value of total debt}}$	Share Outstanding	$\frac{\text{Market value of Equity}}{\text{Book value of total debt}}$
5	$\frac{\text{Sales}}{\text{Total Assets}}$	Assets Turnover	Assets Turnover
6		Net Operating Cash flow(OCF)	Operating Cash Flow Ratio(OCFR)
7		Current Ratio	Current Ratio
8		Gross margin	
9		Net income	

2.2.1 Explain the variables

- *Current Ratio*: is the ratio of current assets and current liabilities, measuring the ability of short-term loan repayment by current assets of enterprises. This coefficient is higher, the loan repayment ability of enterprises is higher. This is a good factor to assess the loan repayment ability of businesses. However, It is necessary to carefully consider the amount of inventory and receivable from customers.

- *Net Operating Cash Flow /Net Income:* Net income ratio is a very important factor to assess business efficiency as well as the loan repayment ability of businesses. Therefore, the Net income ratio can be beautified by enterprises such as early declaration of revenue or declaration of cost reduction.So, when considering the Net income ratio, we should consider in relation to the Net operating Cash Flow (OCF). If OCF is greater than Net income, it is confirmed that the enterprise has good loan repayment ability, if OCF is smaller than Net income, we should reconsider the honesty of the enterprise when calculating the Net income ratio.

- *Market value of equity/Book value of total debt:* The market value of equity is the total value measured by the market value of all shares of stock, while debt includes both current and long-term obligations. The measure shows how much the firm's assets can decline in value (measured by market value of equity plus debt) before the liabilities exceeds the assets and the firm becomes insolvent. The higher this ratio,the more loan repayment ability of enterprises. For un-equitized companies, the market value of shares will be replaced by book value of equity to book value of total debt.

$$= \frac{\text{Market value of shares} * \text{Amount of shares}}{\text{Current liabilities}}$$

According to some authors, they only use OCF indicator. However, OCFR can measure enterprise's loan repayment ability in cash in the short term. Using cash flow in relation to income will sometimes give us more accurate information about loan repayment ability of enterprise, simply because bills are usually paid in cash.

- *Assets Turnover*: is an indicator assesses efficient company's management is at using its assets to generate earnings, which shows how much net revenue a enterprise earns from its operating activities perdollar of assets. The higher the asset turnover ratio, the better the company is performing, since higher ratios imply that the company is generating more revenue per dollar of assets as well as good loan repayment capability of enterprises.

$$\text{Assets Turnover} = \frac{\text{Net Revenue}}{\text{Average Total Assets}}$$

- *Liabilities/ Total Collateral*:According to some authors, they only use long-term debt ratio to total assets. However, when considering the loan repayment ability of interprises for the bank's loan, we should use the debt to total collateral coefficient.The smaller this ratio, the more loan repayment ability of the enterprises.

$$\text{Collateral} = \text{Total assets} - \text{Invisible assets} + \text{Lan use book}$$

- *Operating Cash Flow Ratio (OCFR):* The Operating Cash Flow Ratio, a liquidity ratio, is a measure of how well a company can pay off its current liabilities with the cash flow generated from core business operations. In other words, the operating cash flow ratio shows how much a company earns from its operating activities per dollar of current liabilities. Since earnings involve accruals and can be manipulated by management, the operating cash flow ratio is considered a more accurate measure of a company's short-term liquidity.

$$\text{OCFR} = \frac{\text{OCF}}{\text{Current liabilities}}$$

$$\text{OCF} = \text{EBIT} + \text{Depreciation} - \text{Tax}$$

- *Return on Assets (ROA):*Indicate the efficiency of using assets of enterprises, in particular, how much Net income a enterprise earns from its operating activities per dolla of assets. This is an important indicator to assess loan repayment ability of enterprise.

$$\text{ROA} = \frac{\text{Net Income}}{\text{Average Total Assets}}$$

2.2.2 Method to build and run the model

After collecting, calculating indicators, the author uses Binary logistic regression published in 1983 by Maddala [6] which is a quantitative model in which the dependent variable is a dummy variable, receiving only 2 values of 0 or 1. This model is widely applied in economic analysis in general and credit risk in particular. More specifically, this model can support the Banks determine customers can brings credit risk to bank (dependent variable) on the basis of using factors that affect customers (independent variables). To support data processing, the author uses IBM SPSS version 20 software [7]

General research model:

$Z = B_0 + B_1X_1 + B_2X_2 + B_3X_3 + B_4X_4 + B_5X_5 + B_6X_6 + B_7X_7 \Rightarrow z \in (-\infty; +\infty)$

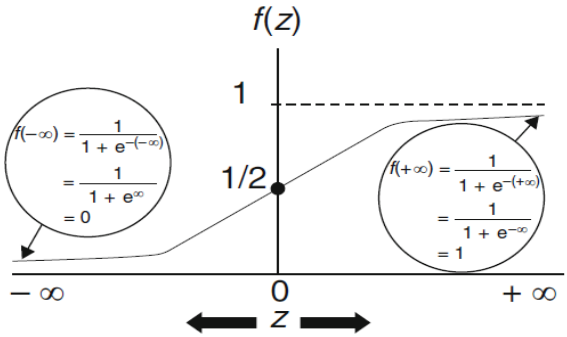

Figure 2: General research model

- independent variables

Table 2: Assumptions and sign variables

ordinal numbers	*Variables's name*	*Assumptions*	*Sign*
1	Current ratio	+	X_1
2	Net Operating Cash flow / Net income	+	X_2
3	Market value of Equity / Book value of total debt	+	X_3
4	Assets Turnover	+	X_4
5	Liabilities / Total Collateral	-	X_5
6	Operating Cash Flow Ratio (OCFR)	+	X_6
7	Return on Assets (ROA)	+	X_7

- Dependent Variable

Z: Loan repayment

Z = 1: Enterprise have loan repayment ability

Z = 0: Enterprise don't have loan repayment ability

2.2. Data

The article using dataset of 210 observations is the information's calculated based on the data collected from the financial statements of enterprise. Formula to calculate sample size for multivariate regression: $n \geq 50 + 8p$. Where, p is the number of independent variables [Tabachnick and Fidell (1996)] [8]. With p = 7, we need a sample size of at least 106. So, article using dataset of 210 observations is absolutely guaranteed.

3. Results and Discussion

3.1. Credit risk warning model

Performing Binary logistic regression analysis by SPSS (Sig <0.05), we get the following results:

Table 3: Variables in the equation

Independent variable names	*B*	*S.E.*	*Wald*	*df*	*Sig.*	*Exp(B)*
Current ratio	3.032	1.252	5.870	1	0.015	20.744
Net Operating Cash Flow /Net Income	2.082	0.810	6.606	1	0.010	8.019
Market value of equity/Book value of total debt	1.182	0.569	4.314	1	0.038	3.260
Assets Turnover	0.581	0.273	4.535	1	0.033	1.788
Liabilities/ Total Collateral	-3.659	1.180	9.620	1	0.002	0.026
Operating Cash Flow Ratio (OCFR)	5.119	2.035	6.327	1	0.012	167.116
Return on Assets (ROA)	0.156	0.066	5.532	1	0.019	1.168
Constant	-8.935	2.880	9.628	1	0.002	.000

General form of the logistic regression equation:

$Ln(odds) = B_0 + B_1X_1 + B_2X_2 + B_3X_3 + B_4X_4 + B_5X_5 + B_6X_6 + B_7X_7$

From the logistic regression analysis table, we can write the logistic equation in the economic direction as follows:

Ln(odds) = -8.935+ 3.032*X1 + 2.082*X2 + 1.182*X3 + 0.581*X4 -3.659*X5 +5.119*X6 + 0.156*X7

3.2. Model test

- Wald test

From the results of Logistics regression analysis in Table 3, we see that "sig." of the all of independent variables are less than 0.05. So, all of them in the Binary logistics regression model have a correlation with the dependent variable. The statistical significance level of the above regression coefficients has a reliability of over 95%, the symbols of the regression coefficients is consistent with the initial hypothesis

-Omnibus Test

Table 4: Omnibus Tests of model coefficients

	Chi-square	*df*	*Sig.*
Step	140.262	7	.000
Block	140.262	7	.000
Model	140.262	7	.000

Based on the results of omnibus test of the model, we have sig <0.05 so the general model shows the correlation between the dependent variable and the independent variables in model are statistically significant with confidence interval over 99%.

-Testing the explanation level of model

Table 5. Model Summary

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	52.158[a]	0.487	0.812

Explanatory coefficient of model: R2 Nagelkerke = 0.812. This means that 81.2% variation of the dependent variable is explained by seven independent variables in model, the rest for other factors.

- *Testing the level of accurate prediction of model*

Table 6: Classification table[a]

Observed		Predicted		
		Loan repayment ability		Percentage Correct
		Inability to pay debts	Ability to pay debts	
Loan repayment ability	Inability to pay debts	31	5	86.1
	Ability to pay debts	5	169	97.1
Overall Percentage				95.2

a. The cut value is 0,5

- In 36 respondents forindividuals are inability to pay debts, the model is accurate forecasting 31 cases, model's correct rate is 86.1%
- In 174 respondents for individuals are ability to pay debts, model is the accurate forecasting 169 cases, model's correct rate is 97.1%.

The accurate forecast rate of overall model is 95.2%

- *Testing the multicollinearity phenomenon*

The article is based on variance inflation factor (VIF) to detect multicollinearity phenomenon.

Table 7: Coefficients[a]

Model	*Unstandardized Coefficients*		*standardized Coefficients*	*t*	*Sig.*	*Collinearity Statistics*	
	B	*Std.Error*	*Beta*			*Tolerance*	*VIF*
(Constant)	0.225	0.106		2.125	0.035		
Current ratio	0.095	0.046	0.131	2.060	0.041	0.514	1.947
Net Operating Cash Flow /Net Income	0.089	0.038	0.138	2.342	0.020	0.600	1.668
Market value of equity/Book value of total debt	0.073	0.025	0.139	2.919	0.004	0.923	1.084
Assets Turnover	0.052	0.014	0.183	3.814	0.000	0.901	1.110
Liabilities/ Total Collateral	-0.479	0.053	-0.491	-9.011	0.000	0.700	1.429
Operating Cash Flow Ratio (OCFR)	0.382	0.109	0.181	3.517	0.001	0.781	1.280
Return on Assets (ROA)	0.007	0.002	0.210	3.644	0.000	0.627	1.595

a. Dependent Variable: Loan repayment

Looking at the table 7, we see that the variance inflation factor (VIF) of variables are< 2, so there is no multicollinearity phenomenon.

3.3. Discussion

-*Current ratio*

B_1= 3.032, P_0 =10%, $e^{B_1} = e^{3.032} = 20.744$

$$P_1 = \frac{P_0 \times e^{B_1}}{1-P_0(1-e^{B_1})} = \frac{0.1 \times 20.744}{1-0.1(1-20.744)} = \frac{2.0744}{2.9744} = 0.6974$$

If the initially probability of repayment is 10%, when all other factors are unchanged, if the Current ratio of enterprise increases by 1 unit, the probability of repayment debt of that enterprise is 69.74% (increased to 59.74% compared to the initial probability of 10%).

-*Net Operating Cash Flow /Net Income*

B_2= 2.082, P_0 =10%, $e^{B_2} = e^{2.082} = 8.019$

$$P_1 = \frac{P_0 \times e^{B_2}}{1-P_0(1-e^{B_2})} = \frac{0.1 \times 8.019}{1-0.1(1-8.019)} = \frac{0.8019}{1.7019} = 0.4712$$

If the initially probability of repayment is 10%, when all other factors are unchanged, if the *Net Operating Cash Flow / Net Income of enterprise* increases by 1 unit, the probability of repayment debt of that enterprise is 47.12 % (increased to 37.12% compared to the initial probability of 10%)

-*Market value of equity/Book value of total debt*

B_3= 1.182, P_0 =10%, $e^{B_3} = e^{1.182} = 3.260$

$$P_1 = \frac{P_0 \times e^{B_3}}{1-P_0(1-e^{B_3})} = \frac{0.1 \times 3.260}{1-0.1(1-3.260)} = \frac{0.3260}{1.226} = 0.2659$$

If the initially probability of repayment is 10%, when all other factors are unchanged, if the *Market value of equity/Book value of total debt* of enterprise increases by 1 unit, the probability of repayment debt of that enterprise is 26.59% (increased to 37.12% compared to the initial probability of 10%).

-*Assets Turnover*

B_4= 0.581, P_0 =10%, $e^{B_4} = e^{0.581} = 1.788$

$$P_1 = \frac{P_0 \times e^{B_4}}{1-P_0(1-e^{B_4})} = \frac{0.1 \times 1.788}{1-0.1(1-1.788)} = \frac{0.1788}{1.0788} = 0.1657$$

If the initially probability of repayment is 10%, when all other factors are unchanged, if the*Assets Turnover* of enterprise increases by 1 unit, the probability of repayment debt of that enterprise is16.57% (increased to 37.12% compared to the initial probability of 10%).

-*Liabilities/ Total Collateral*

B_5= -3.659, P_0 =10%, $\boldsymbol{e^{B_5}} = \boldsymbol{e^{-3.659}} = 0.026$

$$P_1 = \frac{\boldsymbol{P_0 \times e^{B_5}}}{\boldsymbol{1-P_0(1-e^{B_5})}} = \frac{\boldsymbol{0.1} \times 0.026}{\boldsymbol{1-0.1}(1-0.026)} = \frac{\boldsymbol{0.0026}}{\boldsymbol{0.9026}} = 0.0029$$

If the initially probability of repayment is 10%, when all other factors are unchanged, if the*Debt Ratio/ Total Collateral* of enterprise increases by 1 unit, the probability of repayment debt of that enterprise is 0.29% (decrease to 9.71% compared to the initial probability of 10%).

-Operating Cash Flow Ratio (OCFR)

B_6= 5.119, P_0 =10%, $e^{B6} = e^{5.119} = 167.116$

$$P_1 = \frac{P_0 \times e^{B6}}{1-P_0(1-e^{B6})} = \frac{0.1 \times 167.116}{1-0.1(1-167.116)} = \frac{16.7116}{17.6116} = 0.9489$$

If the initially probability of repayment is 10%, when all other factors are unchanged, if the *OCFR*of enterprise increases by 1 unit, the probability of repayment debt of that enterprise is 94.89% (increased to84.89% compared to the initial probability of 10%).

-Return on Assets (ROA)

B_7= 0.156, P_0 =10%, $e^{B7} = e^{0.156} = 1.168$

$$P_1 = \frac{P_0 \times e^{B7}}{1-P_0(1-e^{B7})} = \frac{0.1 \times 1.168}{1-0.1(1-1.168)} = \frac{0.1168}{1.0168} = 0.1149$$

If the initially probability of repayment is 10%, when all other factors are unchanged, if the ROAof enterprise increases by 1 unit, the probability of repayment debt of that enterprise is 11.49% (increased to 1.49% compared to the initial probability of 10%).

-Determining the influence of independent variables to loan repayment (Dependent)

Table 8: Influence level of independent variables to loan repayment (Dependent)

Ordinal numbers	*variable names*	*B*	*EXP(B)*	*Initially probability* $P_0 = 10\%$ P_1	*Increase speed (Decrease) %*	*Infulence level*
1	Current ratio	3.032	20.744	69.74	59.74	2
2	Net Operating Cash Flow /Net Income	2.082	8.019	47.12	37.12	3
3	Market value of equity/Book value of total debt	1.182	3.260	26.59	16.59	4
4	Assets Turnover	0.581	1.788	16.57	6.57	6
5	Liabilities/ Total Collateral	-3.659	0.026	0.29	-9.71	5
6	Operating Cash Flow Ratio (OCFR)	5.119	167.116	94.89	84.89	1
7	Return on Assets (ROA)	0.156	1.168	11.49	1.49	7

4. Conclusion

Credit risk is the first prioritized factors to commercial banking systems. Therefore, building a suitable risk management standard will give competitive advantages to bank manager in the industry.

From results in this research, a credit risk warning model were suggested for managers based on financial impacting factors. In fact, the new model will focus and point out whether the corporate customers can maintain their solvency or not. Moreover, from the research, the most impacting factor to customer' loan repayment ability will be revealed for the consideration of banking managerial leaders.

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