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A Comparative Study on Prediction Performance of the Bankruptcy Prediction Models for General Contractors in Korea Construction Industry

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ABSTRACT: The purpose of the present thesis is to develop bankruptcy prediction models capable of being applied to the Korean construction industry and to deduce an optimal model through comparative evaluation of final developed models. A study population was selected as general contractors in the Korean construction industry. In order to ease the sample securing and reliability of data, it was limited to general contractors receiving external audit from the government. The study samples are divided into a bankrupt company group and a non-bankrupt company group. The bankruptcy, insolvency, declaration of insolvency, workout and corporate reorganization were used as selection criteria of a bankrupt company. A company that is not included in the selection criteria of the bankrupt company group was selected as a non-bankrupt company. Accordingly, the study sample is composed of a total of 112 samples and is composed of 48 bankrupt companies and 64 non-bankrupt companies. A financial ratio was used as early predictors for development of an estimation model. A total of 90 financial ratios were used and were divided into growth, profitability, productivity and added value. The MDA (Multivariate Discriminant Analysis) model and BLRA (Binary Logistic Regression Analysis) model were used for development of bankruptcy prediction models. The MDA model is an analysis method often used in the past bankruptcy prediction literature, and the BLRA is an analysis method capable of avoiding equal variance assumption. The stepwise (MDA) and forward stepwise method (BLRA) were used for selection of predictor variables in case of model construction. Twenty two variables were finally used in MDA and BLRA models according to timing of bankruptcy. The ROC-Curve Analysis and Classification Analysis were used for analysis of prediction performance of estimation models. The correct classification rate of an individual bankruptcy prediction model is as follows: 1) one year ago before the event of bankruptcy (MDA: 83.04%, BLRA: 93.75%); 2) two years ago before the event of bankruptcy (MDA: 77.68%, BLRA: 78.57%); 3) 3 years ago before the event of bankruptcy (MDA: 84.82%, BLRA: 91.96%). The AUC (Area Under Curve) of an individual bankruptcy prediction model is as follows. : 1) one year ago before the event of bankruptcy (MDA: 0.933, BLRA: 0.978); 2) two years ago before the event of bankruptcy (MDA: 0.852, BLRA: 0.875); 3) 3 years ago before the event of bankruptcy (MDA: 0.938, BLRA: 0.975). As a result of the present research, accuracy of the BLRA model is higher than the MDA model and its prediction performance is improved.

Keywords: Bankruptcy Prediction Model, Multivariate Discriminant Analysis, Binary Logistic Regression Analysis, Financial ratio, ROC-Curve

1. INTRODUCTION

The construction industry has the industrial structure of a Job-Order-Production type by a client, so it distinguishes itself from the manufacturing industry. The Global Financial Crisis in last 2008 had a big impact on the depression of the domestic construction market so that it generated liquidity shortage of Korean construction companies. Unsold-housing of around 165,599 houses took place in December 2009 according to the decrease of shrinkage of the consumer market and reduction of construction market demand. This is a high value than the case of the past IMF crisis in 1997. The increase of national unsold-housing decreased sale revenue of construction companies and increased expenditure of financial expenses on loans. Accordingly, bankruptcy of construction companies continuously occurred during the year of 2008 so that 130 general contractors and 273 specialty contractors went ultimately bankrupt [3].

In general, it has be shown that the construction industry has a big impact on the national economy. According to the inter-industry relations table analysis of the Bank of Korea, backward linkage effects (Production inducement coefficient, coefficient of employment, value added inducement coefficient) in case of the construction industry appear more highly than an average of the total industry. The bankruptcy of construction companies and insolvency of the construction industry are analyzed as

having a big impact on national economy and it is judged to cause uneasiness of the national labor market. As bankrupt companies due to insolvency of general contractors increase, efforts to predict insolvency and bankruptcy in advance are being carried out, but the effort level is insufficient, compared to other industrial field.

Since a research of Beaver and Altman, various predicting methods are being studied and developed to predict insolvency and bankruptcy of an individual company as a research on bankruptcy prediction. Developed Bankruptcy Prediction Models (BPM) are being actually used by companies, banks, investment companies, creditors and are mainly used for loan assessment, self-diagnosis and assessment of investment adequacy. However, because most BPMs considered only parts that are applied commonly in the overall industrial fields. It has limitation that is difficult to apply to the other field except the corresponding industry [4], [5]. Accordingly, it can be said that development of BPM being divided into region and industry is necessary.

Accordingly, the purpose of this research is to discover insolvency of general contractors or to construct a model capable of predicting by studying bankruptcy prediction methods capable of being applied to the domestic construction industry. This research aims to finally develop BPM applicable to the construction industry by comparatively verifying Prediction performance between Multivariate Discriminant Analysis (MDA) Model and Binary Logistic Regression Analysis (BLRA) Model.

2. THEORITICAL BACKGROUND

2.1 Definition of the Bankruptcy

The bankruptcy is a legal term included in a category of failure and means a state that collides with insolvency due to non-sufficient fund in a checking account owned by a company or dishonour of a bill or a check or that checking transactions are stopped. It is synonymously used as terms such as Liquidation, Composition, Insolvency or Workout according to the legal procedure or the character of a research. The present research included all meanings of insolvency companies, declaration of insolvency, enterprises of workout target and corporate reorganization by extending a concept of existing Bankruptcy to collect samples easily.

2.2 Literature Review of the Business Failure Prediction Model

The corporate executives, investors and creditors often use the financial statement of a company as a decision-making tool, and further, also utilize the summarized information of its financial statement by using its financial ratio. However, they do not know what thing among numerous financial ratios effect a company directly or indirectly, and even if they try to analyze individually, it is an arduous work. The decision-making tools for corporate executives, investors and creditors are being mainly developed by credit rating agency and investment strategy agency. However, because its assessment procedure is complex and the expenses consumed is much, it becomes a burden to an executive of a small-sized company. Accordingly, they are continuing efforts to find out a method that can easily simplify and quantify its procedure.

The BPM using the financial ratio was first suggested by a research of Beaver [6]. Afterward, the theoretical and empirical research on the corporate bankruptcy was widely executed in the financial management and accounting fields. Furthermore, Altman [7] developed financial distressed prediction model by improving the analysis method of Beaver and applying the univariate discriminant model (UDA). This model is often called as a Z-score model. A total of 5 prediction variables (working capital/total assets, retained earnings/total assets, earnings before interest and taxes/total assets, market value of equity/book value of total liabilities, sales/total assets) were used in the model developed by Altman, it showed comparatively high prediction power. For example, it showed 95% before one year of its bankruptcy and 83 % before two years of its bankruptcy. As mentioned above, the BPMs are improving.

The above bankruptcy prediction methods are being improved as an analysis method varying statistical models and a method adding new predictors. Mainly used models among bankruptcy prediction methods are developing from first Univariate Discriminant Analysis of Beaver to Multivariate Discriminant Analysis, Logistic Regression Analysis [8], Artificial Neural Network, Decision-tree Model, Genetic Algorithm, Case-Based Reasoning, Support Vector Machine and Option Model. Recently, bankruptcy prediction methods using time-series analysis are being suggested. Unlike the statistical analysis methodology, importance on prediction variables is being also enhanced. The general analysis methodology using a financial ratio and BPM mixing a non-financial ratio are being developed, and time-series variables like stock price information are being also utilized as prediction variables.

Efforts for bankruptcy prediction of enterprises like this are being carried out across the whole industry, but bankruptcy prediction research targeting the construction industry sector is relatively insufficient.

Recently, researches related to bankruptcy prediction in the construction industry sector are being continuously progressed. Jeffrey S Russell [9] developed a logistic model predicting a bankruptcy possibility of contractors in a project level by carrying out a questionnaire survey targeting 48 projects. Roozbeh Kangari [5] developed a regression model using a financial ratio with the target of the construction-related field (general contractors, operative builders, heavy construction, lumbing, heating and air-conditioning, electrical works, and other specialty trades). He used the following variables in his model: Current ratio, total liabilities to net worth, total assets to revenues, revenues to net working capital, return on total assets, and return on net worth. A characteristic part in his thesis is that he considered on a scale of enterprises. D. Langford [10] verified usability of the Z-model developed by Altman [7] and the existing financial ratio analysis method. He verified two kinds of analysis models mentioned above with the target of 3 failed General Contractors in the thesis of D. Langford [10]. As a result,

he concluded that two methods are difficult to apply to the construction field and has claimed that a specialized model in the construction field is necessary. Besides, researchers such as Jeffrey S. Russell [11], Serdar Kale [12], David Arditi [13], Almula Koksal [14] promoted much research to predict insolvency of general contractors. As mentioned previously in the introduction, usability of BPM falls in other industrial field and region, so it is judged that BPM considering characteristics of an individual region and industry is necessary.

2.3 Multivariate Discriminant and Binary Logistic Regression Analysis

When selecting a BPM, variable's scale (nominal, ratio, etc.) and form (longitudinal section, time-series section), analysis of estimation coefficients and convenience of developed models, etc. should be considered as a whole. Accordingly, the present research aims to develop BPM by selecting MDA being used the most universally on preceding researches and MLRA capable of avoiding statistical supposition.

· Multivariate Discriminant Analysis

The present research used the MDA technique that is the most used in bankruptcy prediction theses. The MDA technique is an analysis method that when the dependent variables are category type variables like a bankrupt or non-bankrupt type and the independent variables are continuous variables, it is used for estimating a function dividing the difference of two groups by using a series of independent variables. The discriminant analysis was achieved by using a statistical computer program (SPSS 17, Excel). The present research has prediction variables(financial ratio) of x_1, x_2, $x_3 \cdots x_p$ and sample companies of n kinds, used the discriminant function like the equation (1) as an estimated equation when the dependent variable (Z) is divided as $Z = 1$, in case of bankrupt companies and is divided as $Z = 0$ in case of non-bankrupt companies.

$$Z_n = d_0 + d_{n1}x_1 + d_{n2}x_2 + d_{n3}x_3 \cdots + d_{np}x_p \qquad (1)$$

Where Z_n is the discriminant score of nth company; and d_0 is the intercept; and d_n is the discriminant weight of independent variable; and x_p is the independent variable.

· Binary Logistic Regression Analysis

A dependent variable of BLRA has a binomial variable like 0 or 1 or a categorical variable and is an analysis method being used when an independent variable is a continuous variable. Because this analysis method doesn't need supposition of equal variance differently from MDA, it is mainly used in the bankruptcy prediction method and social science field. When a dependent variable(Y) is a bankruptcy group, Y=1, and when it is a non-bankruptcy group, it is supposed to be divided by Y=0. So the estimated equation can be displayed as shown in the following equation (2).

$$E\left(\frac{Y_i}{X_i}\right) = \frac{\exp(d_0 + d_{i1}x_1 + d_{i2}x_2 + \cdots + d_{ip}x_p)}{1 + \exp(d_0 + d_{i1}x_1 + d_{i2}x_2 + \cdots + d_{ip}x_p)} = P(X_i) \qquad (2)$$

Here, Y_i : dependent variable of i th company, X_i: estimation value of i th company, $P(X_i)$: probability of i th company, d_0 : intercept, d_{ip} : coefficient on an independent variable, x_p: p pieces of independent variable.

3. POPULATION AND SAMPLE

The construction industry of Korea is largely divided into a general contractor group and a specialty contractor group (subcontractor). The present research is aimed to develop a BPM suitable for a general contractor group rather than handling the total construction industry. The reason is because the general contractor and specialty contractor have a big difference in the size of the company and have different major business portfolios. Also, when the total construction industry is selected as a sample, the characterization of a model is easily deteriotated. The present research selected listed and externally audited company group that is comparatively easy to secure samples and shows high reliability in the financial statement.

A collection period of study samples used in the present research was selected from January 1, 2008 to December 31, 2009 in which samples of bankruptcy companies are crowded the most. Detailed selection criteria of samples of bankruptcy companies are as follows: 1) companies receiving declaration of insolvency from Korea Financial Telecommunications & Clearings Institute [15]; 2) companies listed in a bankruptcy company list published by Construction Guarantee in Korea [16]; 3) companies designated as a workout companies from creditors and Korea government that a corporate reorganization procedure is under progress.

Non-bankrupt companies mean enterprises that are not included basically in the above concept, a company with a similar corporate scale was selected. Samples used in the final research are a total of 112 samples, and it consists of 48 bankrupt companies and 64 non-bankrupt companies.

4. SELECTION METHOD OF THE PREDICTION VARIABLE

4.1 Selecting the Initial Variables from the General Contractors

The present research used financial ratio data for 3 years before bankruptcy timing of bankrupt construction companies for development of an estimation model. A TS2000 program of Korea Listed Companies Association was used for getting initial financial ratio data. The first extracted variable is composed of a total of 152 ratio variables, and is respectively composed of ratios such as

Table 1. Explanation of the Prediction Variables

Category	No	Name of Variable	Explanation	Range of Application
Growth	x1	Tangible Assets Growth Rate	Investment growth rate on fixed assets having detailed form such as a building and machinery & equipment	MDA, BLRA
	x2	Inventories Growth Rate	Increase and decrease rate of products for sale or commodities and raw materials, etc.	MDA, BLRA
	x3	Net Income Growth Rate	Growth rate of net income compared to the previous year	BLRA
Profitability	x4	Net Income to Net Sale	Weight of net income versus sales	MDA, BLRA
	x5	Net Income to Capital Stock	Weight of net income versus capital	MDA, BLRA
	x6	Selling & General Administrative Expenses to Net Sales	Index showing efficiency of sales	MDA, BLRA
	x7	Non-Operating Income to Operating Revenues	Profit and loss being generated in other part excluding major sales activities	MDA, BLRA
	x8	Total Expenses to Total Revenue	Index showing how much management of total costs is efficiently managed	MDA
	x9	Income to Total Capital	Index showing efficiency of operation of total capital of an enterprise	BLRA
	x10	Depreciation Expenses to Total Expenses	Complementary index of total capital's business profit rate (Profitability lowers when it is low)	BLRA
Stability	x11	Current Assets to Total Assets	Weight of current assets that short-term encashment is possible among total assets	BLRA
	x12	Dept to Total Assets	Weight of debt among total assets	MDA, BLRA
	x13	Stockholder's Equity to Capital Stocks	Weight of equity capital in capital	BLRA
	x14	Cash Ratio	Raito of cash being met for repayment of current liabilities	MDA, BLRA
	x15	Current Ratio	Index for judging repayment ability of a company	MDA
	x16	Current Liabilities Ratio	Index for judging excess of current liabilities	MDA, BLRA
	x17	Net Working Capital to Total Assets	Index for judging short-term payment ability of a company	MDA, BLRA
	x18	Total Borrowings & Bond Payable to Total Liability	Weight of short-and long-term loan among total debts	BLRA
	x19	Non-Current Assets to Stockholder's Equity & Non-Current Liabilities	Ratio of fixed assets versus long-term capital	BLRA
Activity	x20	Stockholder's Equity Turnover	Index measuring a good level of equity capital activity	MDA
	x21	Tangible Assets Turnover	Index for judging effective use of tangible assets	MDA
Productivity	x22	Ratio of Value Added to Liabilities & Stockholder's Equity	Index for judging an added value calculated through total capital invested in the present period	BLRA

growth ratio (14 variables), profitability ratio (50 variables), stability ratio (39 variables), activity ratio (21 variables), productivity ratio (12 variables). Collected financial ratio variables should be commonly included to a sample group, so variables including missing values were excluded.

In general, there are many cases that the normal distribution is not formed according to the property of the financial ratio, and there are many cases that the distribution chart also has skewness in a positive (+) direction. A method removing outlier is being mainly used to reduce a biased value, but it can have serious influence on the result value and show arbitrarily manipulated results. Accordingly, the financial ratio used in the present research was normalized as a natural.

The results constructing MDA and BLRA models by using a total of 90 initial prediction variables and 112 estimation samples are the same as in the following table 2. The model is being respectively composed of before one year from bankruptcy timing, two years from bankruptcy timing and three years from bankruptcy timing. Final variables used for the MDA model are two variables of growth ratios, five variables of profitability ratio, five variables of stability ratios and two variables of activity ratios. And final variables used for the BLRA model are three variables of growth ratios, six variables of profitability ratio, eight variables of stability ratios and one piece of activity ratios. The variables were induced closely to the normal distribution using logarithm function transformation.

Ninety variables of initial prediction variables going through the above process were used for development of the respective prediction models (MDA, BLRA). A MDA model was estimated by using a stepwise method. The stepwise method is a method extracting from a variable having the largest difference between groups (bankrupt/non-bankrupt company group). Likewise, the MLRA model also used a forward stepwise method.

5. ESTABLISHMENT OF PREDICTION MODELS

The results constructing MDA and BLRA models by using a total of 90 initial prediction variables and 112 estimation samples are the same as in the following table 2. The model is being respectively composed of before one year from bankruptcy timing, two years from bankruptcy timing and three years from bankruptcy timing. Final variables used for the MDA model are two variables of growth ratios, five variables of profitability ratio, five variables of stability ratios and two variables of activity ratios. And final variables used for the BLRA model are three variables of growth ratios, six variables of profitability ratio, eight variables of stability ratios and one variable of activity ratios.

Table 2. Establishment of the Prediction Model

Year to Period to Bankruptcy	Model	Equation of the Models
1st year before bankruptcy	MDA	$Z_{t-1} = 0.859x_5 + 0.463x_1 - 0.428x_{12} - 0.338x_2 - 0.335x_{20}$
	BLRA	$P_{t-1} = \frac{\exp(-26.097+7.389x_{11}-2.787x_{13}+1.934x_{19}-1.529x_7+1.295x_{16}-0.703x_{11}-0.477x_5+0.425x_2+0.275x_3)}{1+\exp(-26.097+7.389x_{11}-2.787x_{13}+1.934x_{19}-1.529x_7+1.295x_{16}-0.703x_{11}-0.477x_5+0.425x_2+0.275x_3)}$
2nd year before bankruptcy	MDA	$Z_{t-2} = 0.578x_{16} - 0.762x_4 + 0.0.327x_1$
	BLRA	$P_{t-2} = \frac{\exp(-1.552-1.141x_4+0.709x_{16})}{1+\exp(-1.552-1.141x_4+0.709x_{16})}$
3rd year before bankruptcy	MDA	$Z_{t-3} = 1.019x_{15} - 0.915x_{17} + 0.826x_8 - 0.771x_6 + 0.670x_4 + 0.545x_7 + 0.398x_{14} - 0.395x_{21} - 0.278x_1$
	BLRA	$P_{t-3} = \frac{\exp(-342.917+72.897x_6+3.92x_9-2.883x_{22}+2.345x_{12}-1.25x_4-1.1x_{10}+0.978x_{14}+0.972x_{17}+0.613x_{18})}{1+\exp(-342.917+72.897x_6+3.92x_9-2.883x_{22}+2.345x_{12}-1.25x_4-1.1x_{10}+0.978x_{14}+0.972x_{17}+0.613x_{18})}$

The reason that prediction variables showing corporate profitability and stability are much included in the two models can be judged the big difference in profitability and stability between a bankrupt company group and a non-bankrupt company group. Finally developed BPMs are the same as in table 2 and the classification table of individual models are the same as in table 3.

6. PREDICTION PERFORMANCE COMPARISON OF MDA AND BLRA MODEL

Individual classification table's analysis and ROC (Receiver Operating Characteristic) Curve Analysis were carried out to comparatively evaluate prediction performance of the estimated MDA model and BLRA model.

A classification table is that actual bankruptcy generation and the result predicted from a predicted model are composed of tables, so it is used when the accuracy rate, misclassification rate, sensitivity and specificity are calculated. Table 3 is a classification table of results estimated from the above prediction models.

Table 3. Performance of the Prediction Models

Model	Year	Category		Predicted Group		Total
				0(NB)	1(B)	
MDA	1	Actual Group	0(NB)	57	7	64
			1(B)	12	36	48
	2		0(NB)	54	10	64
			1(B)	15	33	48
	3		0(NB)	55	9	64
			1(B)	8	40	48
BLRA	1		0(NB)	59	5	64
			1(B)	2	46	48
	2		0(NB)	56	8	64
			1(B)	16	32	48
	3		0(NB)	60	4	64
			1(B)	5	43	48

NB: Non-Bankrupt group, B: Bankrupt group

Table 4. Performance of the Prediction Models

Model	Category	1st Year before bankruptcy	2nd Year before bankruptcy	3rd Year before bankruptcy
MDA	Accuracy Rate	83.04 %	77.68 %	84.82 %
	Sensitivity	75.00 %	68.75 %	83.33 %
	Specificity	89.06 %	84.38 %	85.94 %
BLRA	Accuracy Rate	93.75 %	78.57 %	91.96 %
	Sensitivity	95.83 %	66.67 %	89.58 %
	Specificity	92.18 %	87.50 %	93.75 %

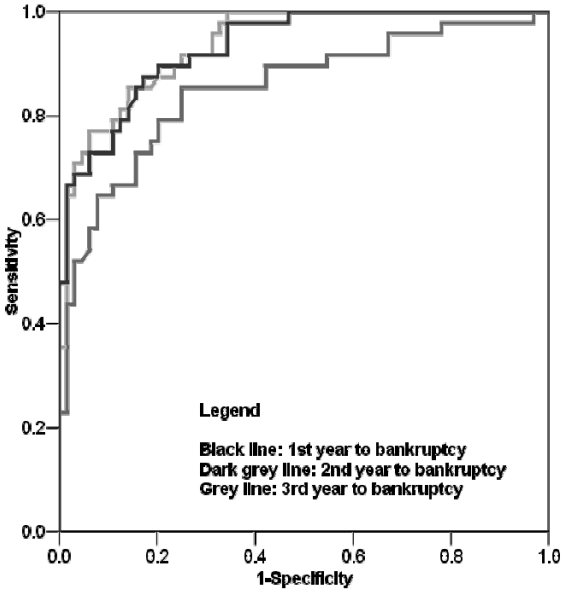
Table 5. AUC of Prediction Models

Model	1st Year before bankruptcy	2nd Year before bankruptcy	3rd Year before bankruptcy
MDA	0.933	0.852	0.938
BLRA	0.978	0.875	0.975

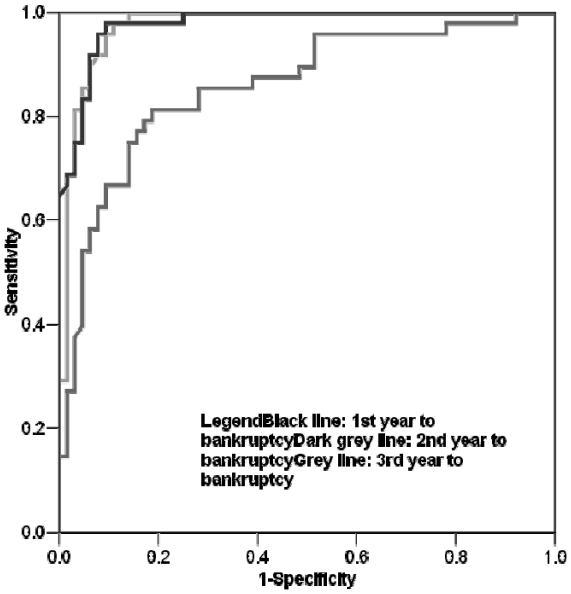
As a result of measuring prediction performance of the respective models, the accuracy rate of MDA appeared as 83.04%, 77.78% and 84.82% from before one year from timing of bankruptcy generation and the sensitivity appeared as 75.00%, 78.75%, and 83.33%. On the other hand, the accuracy rate of BLRA appeared as 93.75%, 78.57% and 91.96% from before one year from timing of bankruptcy generation and the sensitivity appeared as 95.83%, 66.67% and 89.58%.

The ROC Curve Analysis can assess and diagnose prediction performance with a graph outputting a relationship of between misclassification rate and accuracy rate at Cut-off Point (MDA: 0.5, BLRA: 0.5). Accordingly, the ROC Curve Plot according to bankruptcy timing of MDA and BLRA can be expressed as shown in Picture 1 and Picture 2. In general, an

analysis of the ROC-curve uses AUC (Area Under Curve) of suggested plot. It can be analyzed that the larger the AUC is prediction performance of a model is good. As shown in Table 5, the MDA model appeared as AUC: 0.933 before one year ago from bankruptcy timing, AUC: 0.852 before two years ago from bankruptcy timing and AUC: 0.938 before three years ago from bankruptcy timing, but the BLRA showed higher AUC in the same period zone. As a result of comparatively verifying MDA and BLRA models by finally using classification table's analysis and ROC-curve analysis, results of the accuracy rate, sensitivity and specificity of the BLRA model are evaluated as better than the MDA model and the AUC model was also analyzed as being superior.



Picture 1. ROC-Curve Plot of MDA Models



Picture 2. ROC-Curve Plot of BLRA Models

7. CONCLUSION

The present research used the MDA and BLRA models for the purpose of making a model suitable for bankruptcy prediction of domestic General Contractors. Prediction variables used for individual model estimation are mainly composed of profitability and stability ratios. When considering economic situations (Global Financial Crisis) at the time of sample collection, it is judged that the reason is due to the shortage of profitability and stability of bankrupt companies.

The reduction of contract volume of General Contractors due to depression of construction business has a trend that continuously reduces profitability of a construction company. This has a negative impact on numerous profitability ratios, and the profitability decrease like this makes it impossible to get additional loans from banks and related institutions so that it brings in a result that increases the weight of a loan like a company bond issued from non-bank financial institutions. This has a direct impact on corporate stability so that it lowers short-term repayment ability by raising short-term current liabilities. On the other hand, the debt ratio among stability ratios was excluded during a variable selection process of an estimated model. It is judged that the reason is due to general contractors creating profit by using debt capital rather than profit creation through investment of equity capital according to a property of the construction industry.

A variable that estimation of a sign (+, -) is converse or excessively large among coefficient values of the MDA and BLRA models suggested in the present research was discovered. The reason is judged to be closely related to the sample collection period. The sample collection period was a global financial crisis period between from 2008 to 2009, so a characteristic difference between insolvency and bankrupt companies and non-bankrupt companies was insufficient. It is judged that the results like this gives a negative impact on estimation and analysis of models, when a sample analysis is carried out under abnormal economic situations or surrounding conditions.

The MDA and BLRA models developed in the present research were analyzed as what prediction performance of accuracy rate and AUC is comparatively high. The reason is because it was verified with the target of estimation samples used for development of prediction models. According to a property of the Korean construction industry, it was because General Contractors being included in a category of the above bankruptcy companies were just the minimum number. Due to the limited sample collection like this, verification targeting verified samples was not carried out. Accordingly, it is judged that collection of estimation samples and verification samples should be executed under the normal economic situations in the future.

It is thought that development of characteristic variables should be preceded in the research direction on bankruptcy prediction of the construction industry. This is because only the general status of the construction industry can be grasped with the financial ratios being

commonly used presently, and industrial properties are not considered. Accordingly, a research on development and verification of characteristic variables capable of being applied to the construction industry is necessary.

REFERENCES

[1] Roozbeh Kangari, "Business Failure in Construction Industry", *Journal of Construction Engineering and Management*, Vol. 114(2), pp.172-190, 1988.

[2] Mason R. J., Harris, F. C., "Predicting Company Failure in the Construction Industry", *Proceedings Institution of Civil Engineering*, Vol.66, pp.301-307, 1979.

[3] Construction Association of Korea, 2009. "Yearly Bankruptcy Company of General Contractor", *Construction Association of Korea*, Seoul, Korea, 2009.

[4] James O. Horrigan, "Some Empirical Bases of Financial Ratio Analysis", *The Accounting Review*, Vol.40(3), pp.558-568, 1965.

[5] Roozbeh Kangari, Foad Farid, Hesham M. Elgharib, "Financial Performance Analysis for Construction Industry", *Journal of Construction Engineering and Management*, Vol. 118(2), pp.349-361, 1992.

[6] William H. Beaver, "Financial ratios as predictors of failure", *Journal of Accounting Research*, Vol.4, pp.71-111, 1966.

[7] Altman E., "Financial ratio, discriminant analysis and the prediction of corporate bankruptcy", *Journal of finance, American finance association*, pp. 589-609, 1968.

[8] Ohlson J., "Financial Ratios and the Probabilistic Prediction of Bankruptcy", *Journal of Accounting Research*, Vol.18(1), pp.109-131, 1980.

[9] Jeffrey S. Russell, Edward J. Jaselskis, "Predicting Construction Contractor Failure Prior to Contract Award", *Journal of Construction Engineering and Management*, Vol.118(4), pp.791-811, 1992.

[10] Langford, D., Iyagba, R., Komba, D. M., "Prediction of solvency in construction companies", *Construction Management & Economics*, Vol. 11(5), pp. 317-326, 1993.

[11] Jeffrey S. Russell, Huaming Zhai, "Predicting Contractor Failure Using Stochastic Dynamics of Economic and Financial Variables", *Journal of Construction Engineering and Management*, Vol.122(2), pp.183-191, 1996

[12] Serdar Kale, David Arditi, "Age-Dependent business failures in the US construction industry", *Construction Management and Economics*, Vol. 17(4), pp. 493-503, 1999.

[13] David Arditi, Almula Koksal, Serdar Kale, "Business failures in the construction industry", *Engineering, Construction and Architectural Management*, Vol. 7(2), pp. 120-132, 2000.

[14] Almula K. and David A., "Predicting Construction Company Decline" Journal of Construction Engineering and Management, ASCE, 130(6), pp. 799-807. 2004.

[15] Korea Financial Telecommunications & Clearings Institute, "Declaration Company List of Insolvency(1/Jan/2008~31/Dec/2008)", *Korea Financial Telecommunications & Clearings Institute, Seoul, Korea*, 2009.

[16] Construction Guarantee, "Annual Bankruptcy Construction Company List", *Construction Guarantee in Korea*, Seoul, Korea, 2009.