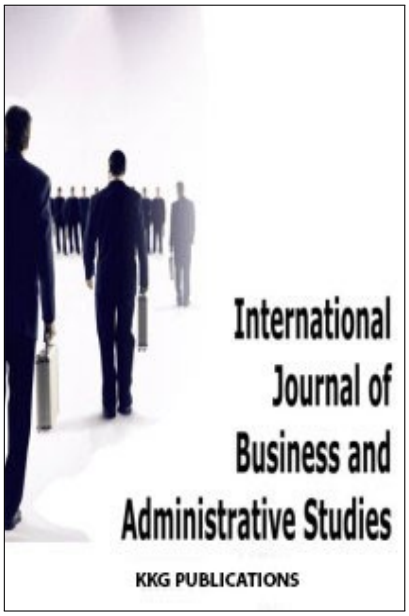


Key Knowledge Generation
Publication details, including instructions for author and subscription information:
http://kkgpublications.com/business/

The Implementation of Fuzzy Logic to Predict the Bankruptcy of Company in Indonesia

EDNAWATI RAINARLI [1], AURELIUS AARON [2]

[1, 2] University Of Computer Indonesia, Bandung, Indonesia

Published online: 05 December 2015

To cite this article: Rainarli, E., & Aaron, A. (2015). The implementation of fuzzy logic to predict the bankruptcy of company in Indonesia. *International Journal of Business and Administrative Studies, 1*(4), 147-154.
DOI: https://dx.doi.org/10.20469/ijbas.10003-4

To link to this article: http://kkgpublications.com/wp-content/uploads/2015/12/IJBAS10003-4.pdf

PLEASE SCROLL DOWN FOR ARTICLE

International Journal of Business and Administrative Studies
2015, 1(3), 147-154
IJBAS

THE IMPLEMENTATION OF FUZZY LOGIC TO PREDICT THE BANKRUPTCY OF COMPANY IN INDONESIA

EDNAWATI RAINARLI [1], AURELIUS AARON [2] *

[1, 2] University of Computer Indonesia, Bandung, Indonesia

Keywords:
Fuzzy Logic
Mamdani Method
Company Predictions of Bankruptcy
Soft Computing

Received: 03 March 2015
Accepted: 20 May 2015
Published: 05 December 2015

Abstract. Prediction of company bankruptcy is generally used to determine the risk of harm caused by the inability of debtors in basic payment of its debt, interest rate, or both. This research will be built on fuzzy model to predict the company's bankruptcy based on the company's characteristics. The data used would be obtained from the financial reports of public companies taken from the Indonesian Stock Exchange to do a correlation test. After a correlation test would be conducted, it would be found that the financial ratios influence one year before bankruptcy and two years before the bankruptcy. Those ratios are used as parameter input of the fuzzy model. The output of defuzzification of the fuzzy model is a prediction of bankruptcy for each company. After conducting testing, we saw that the fuzzy model could predict the bankruptcy of 65 public companies to the year before bankruptcy and two years before the bankruptcy, with the accuracy for each being 81,54% and 83,85%. Based on these results, fuzzy logic can be used as an alternative to predict events in the future with a high degree of uncertainty, especially for the characteristic of the companies' conditions in Indonesia.

INTRODUCTION

The measurement of the company performance can be seen in various ways, one of them is by analyzing financial reports. From the financial reports, we can discover information about bankruptcy predictions of a company. The bankruptcy information predictions can be used by parties such as a creditor, investors, accountant, the government or the management to produce strategic decisions.

In Indonesia, a very complex and dynamic country, the environmental conditions in which the uncertainty level is high affect the determination of input data to be used in prediction of bankruptcy of a company (Himmelstein, Thorne, Warren, & Woolhandler, 2009).

Three models can be used to predict bankruptcy, which are statistical models, soft computing technique models, and the theoretical models. Practically, the most widely used model is statistical model, this is shown from the research conducted by (Adnan Azis & Dar, 2004; Armour & Cumming, 2008; Araujo, Ferreira, & Funchal, 2012) that as much as 64% of research study is completed using statistical model.

With the advent of the times and business environmental change becoming more complex and dynamic, statistical assumptions such as normality, homogeneity, independence, and additive properties are increasingly getting difficult to be fulfilled. This has resulted in the effectiveness of the statistics no better than model built using a soft computing technique. Besides that, there are differences between learning dataset assumptions commonly used in many literatures with the actual economic conditions. On the assumption learning dataset commonly used the proportion of 50: 50, while in fact the bankrupt public company is busted far lesser than the one that is not bankrupt.

Soft computing is the method that can process uncertainty, imprecision data and is able to be implemented at a cheap cost. Some methods of this category are fuzzy logic, artificial neural network, and probabilistic reasoning. Based on research conducted by Korol (Korol, 2012) it was proven that the effectiveness in forecasting bankruptcy of company using statistical model is 77,77% for one year before bankruptcy and 64,81% for two years before bankruptcy.

While the effectiveness of fuzzy logic model is 87,03% for one year before bankruptcy and 83,33% for two years before bankruptcy. It can be concluded that in the effectiveness, the fuzzy logic model can be used to predict the bankruptcy of company. In this research, it will be built on a fuzzy model with regards to characteristics of companies in Indonesia.

As for the purpose to be reached in this research, effectiveness of that model will be tested that has been constructed to predict bankruptcy of company with a fuzzy logic implementation in Indonesia.

*Corresponding author: Aurelius Aaron
†Email: Home.aureliusst@gmail.com

LITERATURE REVIEW

Corporate Bankruptcy

Bankruptcy is a condition when the company experiences the inadequacy of funds to run its business. According to the Bankruptcy Law No. 4 in 1998, debtors who have two or more creditors and do not pay at least one debt on due date and can be billed, can be declared bankrupt by the court ruling authorities, both on their own, or at the request of one or more creditors. A failing public company that is incapable of paying its liability to lenders which have no affiliation should submit reports of loans including the amount of principal and interest, with a loan period , the name of lenders , the use of their loans and the reason of failure or inability to the capital market supervisory board (BAPEPAM) and a stock exchange where a public company has been registered as soon as possible, at least by the end of the second day since issuers undergo failure (Yani & Widjaja, 2004).

Failure is to be defined in some ways and failure should not cause collapse. Economical Failure means that the company's earnings are unable to cover its own costs. While financial failure means that the company is unable to meet obligations in time to be protected, although its total liability is more than its total asset. (Fred & Brigham, 2000). According to Agus Sartono (Sartono, 1994), there are three types of failure faced by the companies:

$$S(x;\alpha,\gamma)=\begin{cases}0 & x\le\alpha\\ 2((x-\alpha)/(\gamma-\alpha))^2 & \alpha\le x\le\frac{\alpha+\gamma}{2}\\ 1-2((\gamma-x)/(\gamma-\alpha))^2 & \frac{\alpha+\gamma}{2}\le x\le\gamma\\ 1 & x\ge\gamma\end{cases} \quad (1)$$

$$S(x;\alpha,\gamma)=\begin{cases}1 & x\le\alpha\\ 1-2((x-\alpha)/(\gamma-\alpha))^2 & \alpha\le x\le\frac{\alpha+\gamma}{2}\\ 2((\gamma-x)/(\gamma-\alpha))^2 & \frac{\alpha+\gamma}{2}\le x\le\gamma\\ 0 & x\ge\gamma\end{cases} \quad (2)$$

a. Company is technically insolvent, if a company is unable to fulfill its obligations immediately, but the value of companys assets is higher than the loan.

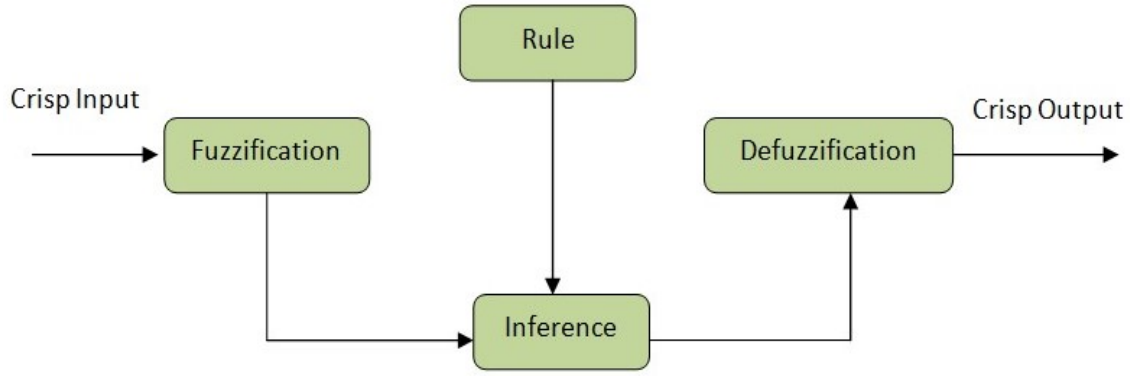
b. Company is legally insolvent, if the value of the company's assets is lower than the value of corporate debt.

c. The company faces bankruptcy if it cannot pay the loan and is declared bankrupt by a court.

Fuzzy Inference System

There are three stages used in building a fuzzy model (Kusumadewi & Purnomo, 2010). This phase is shown in Figure 1. First is the process whereby fuzzification is done to calculate degrees of membership of the crisp input. In this paper it is used as membership sigmoid function. Sigmoid-right function is shown in equation 1 and sigmoid-left function is shown in equation 2.

FIGURE 1
Basic Configuration of Fuzzy Inference System



Second phase is fuzzy inference process; fuzzy inference is the process of formulating the mapping from a given input to an output using fuzzy logic. The aim of this process is mapping the degree of membership value from parameters that were observed to be output in fuzzy logic. For development of this fuzzy model, the inference process used a Mamdani method. Mamdani method is one kind of fuzzy inference where the set of fuzzy logic that is the consequence of each rule is combined using operator aggregation and yields the set of fuzzy logic which then generates fuzzy logic to produce certain output of a system. Mamdani method can be used to input data that is singleton (only consisting of one input), as well as data input which is the fuzzy set (Kusumadewi & Purnomo, 2010).

The last step in the fuzzy process is defuzzification. Fuzziness

helps us to evaluate the rules, but the final output of a fuzzy system has to be a crisp number. The input for the defuzzification process is the aggregate output of the fuzzy set and the output is a single number (crisp output).

RESEARCH METODOLOGY

The research methodology executed is as follows:

a. Collecting information about fuzzy logic theory, mamdani inference system, a theory about bankruptcy company through the literature study, collectingthe data set and testing the data set taken from the financial statements at the Indonesian Stock Exchange (BEI) .

b. Doing analysis of input parameter. At this stage, testing is done to determine parameter that has the most influence on the determination of bankruptcy of the company based on characteristic companies in Indonesia. Correlation analysis is used to test the influence of parameter. Parameter that is most influential will be used as parameter input in the fuzzy model.

c. Fuzzy modelling is built after conducting the problem analysis, creating rules on fuzzy inference and the determination of output of fuzzy model.

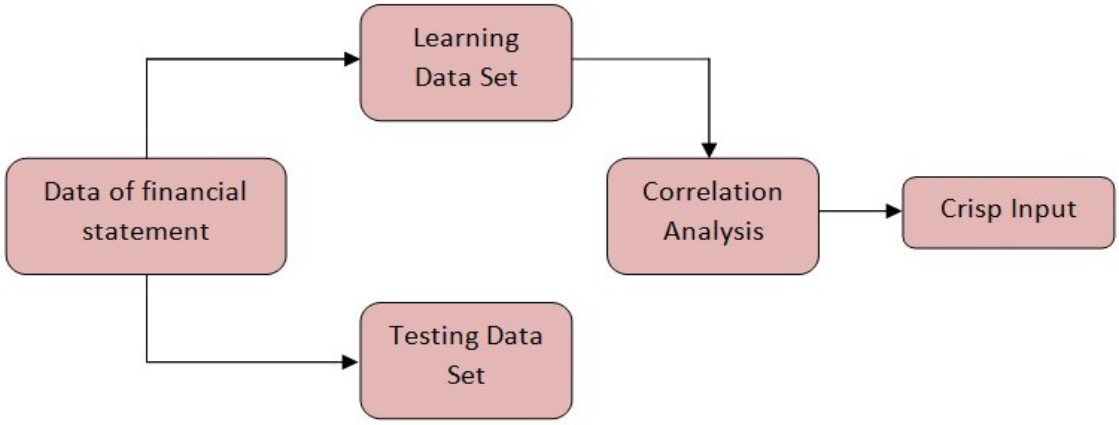
d. Testing fuzzy model and creating a simulator to find out how well the model made can predict bankruptcy of the company based on existing data.

e. The conclusions of the research; at the end of the research obtained conclusions and recommendations pertaining to the accuracy of fuzzy model in forecasting bankruptcy of the company.

Analysis of Input Data

In this research, input data comes from the financial statements of 65 public companies that are listed in the Indonesian Stock Exchange (BEI) from the various sectors of industry, consumable goods industry, basic industry and chemical, infrastructure, utility, transportation, services and trade and investment since 2006-2011. Here is the analysis process of this research that can be seen in figure 2.

FIGURE 2
Analysis Process of Input Data



Based on the sample, it is known that there are 17 issuers who went bankrupt and 48 issuers who did not decline. The sample is then categorized as follows:

a. Learning data set, dataset that is used for development model. The contents of this dataset are 15 insolvent issuers and 15 of the issuers who are not insolvent. These thirty issuers will come from various sectors and subsector such as infrastructure, utility, transportation, trade and investment services, and manufacturing industries.

b. Testing dataset, dataset used for testing model has been made .The dataset is all the sample issuers (17 went bankrupt and 48 issuers not bankrupt) to the year before bankruptcy and two years before bankruptcy , so that the number of records on dataset were 130 in this case.

After categorizing the sample, the next step is conducted as a correlation analysis of all financial ratios outlined in Table 1 to obtain input data according to those of public companies characteristic in Indonesia. Having calculated financial ratios described in Table 1, a correlation analysis is performed. The aim of this test is to choose financial ratio that is significant to score of issuers. The results of correlation analysis that were taken for one year prior bankruptcy are return on assets $(X1_1)$, current liabilities to total assets $(X9_1)$, gross profit to current liabilities $(X11_1)$ and log of total assets $(X19_1)$. For two years prior bankruptcy the ratios that were taken are operating margin $(X2_2)$, current liabilities to total assets $(X9_2)$, gross profit to current liabilities $(X11_2)$, fixed asset turn over $(X17_2)$ and log of total assets $(X19_2)$.

TABLE 1
Financial Ratios

Symbol	Nama Rasio	Jenis Rasio
X1	Return on Assets	Profitability Ratio
X2	Operating Margin	
X3	Profit Margin	
X4	Return on Net Worth	
X5	Current Ratio	Liquidity Ratio
X6	Acid-Test Ratio	
X7	Working Capital to Total Assets	
X8	Current to Total Liabilities	
X9	Current Liabilities to Total Assets	Debt Ratio
X10	Shareholder Equity Ratio	
X11	Gross Profit to Current Liabilities	
X12	(Stockholders Equity + Long Term Liabilities) / Fixed Assets	
X13	Debt Equity Ratio	
X14	Long Term Liabilities to Total Equity	
X15	Total Asset to Equity Ratio	
X16	Operating Cost to Short Term Liabilities	Activity Ratio
X17	Fixed Assets Turn Over	
X18	Current Liabilities Turn Over	
X19	Log of Total Assets Other Ratio	

Fuzzy Inference System

Modeling fuzzy started with the determination of the parameters of function membership used in process of fuzzification. The following ratios were taken into threshold value of membership function, these values are presented in Table 2. The values in Table 2 are obtained from first and third quartile and median value for "good" or "bad" companies. These threshold values would be used in membership function equation shown by equation 1 and 2. The second process is creating the set of rules. These rules used by fuzzy decision model contain 16 rules for analysis of companies one year prior to bankruptcy and 32 rules for two years prior to bankruptcy. The details of these rules is shown by Table 3 and Table 4. After obtaining the result, it will be found to be composed of the results of rules using the max, and the last step to do is to do defuzzification.

Defuzzification were conducted based on a method of centroid (composite moment) for continuous variables (Ross, 2010). Defuzzification results of this research will range from 0 to 1. 0 means that the company went bankrupt and 1 means the company didn't go bankrupt.

Once the value of the results obtained through defuzzification process will be calculated the average value of defuzzification process proceeds to the issuers going bankrupt. Then the value will be used as a criterion for determining whether or not the issuer went bankrupt, if the value of the results of the process of defuzzification is less than the average value then the issuer is predicted to be bankrupt in accordance with the model used, but if the value of the results of defuzzification process is more than the average value the predicted issuers will not be bankrupt. In this study the average value for the model year before the bankruptcy was 0.433 and the average value for the model two years before the bankruptcy was 0.483. Average value is the result - average of Z * from issuers who have experienced bankruptcy.

TABLE 2
The Threshold Value for Membership Function

Ratio Symbol	Not Bankrupt		Bankrupt	
	Q1=α	Q3=γ	Q1=α	Q3=γ
One year prior to bankruptcy				
$X1_1$	0.019481706	0.087740788	-0.118222031	0.007089883
$X9_1$	0.161354705	0.279244722	0.107467845	0.709684321
$X11_1$	0.312698853	1.596466358	0.000369623	0.726664081
$X19_1$	13.4129182	15.66376898	11.53909842	13.25777399
Two years prior to bankruptcy				
$X2_2$	0.051376114	0.123995802	-1.861273006	-0.014192867
$X9_2$	0.126181308	0.271108491	0.08633396	0.503385973
$X11_2$	0.441002443	1.842702356	0.005716627	0.686762547
$X17_2$	0.624380378	1.023336002	0.036380093	0.980448737
$X19_2$	13.39883544	15.37950982	11.90496478	13.1739931

TABLE 3
The Set Decision Rule of One Year Prior to Bankruptcy

If $X1_1$	**If** $X9_1$	**If** $X11_1$	**If** $X19_1$	**Then**
Low	Low	Low	Low	Bankruptcy
Low	Low	Low	High	Bankruptcy
Low	Low	High	High	Bankruptcy
Low	High	High	High	Not Bankruptcy
High	High	High	High	Not Bankruptcy
High	High	High	Low	Not Bankruptcy
High	High	Low	Low	Not Bankruptcy
High	Low	Low	Low	Bankruptcy
Low	High	Low	Low	Bankruptcy
Low	Low	High	Low	Bankruptcy
Low	High	High	Low	Bankruptcy
High	Low	High	High	Not Bankruptcy
High	High	Low	High	Not Bankruptcy
High	Low	Low	High	Bankruptcy
High	Low	High	Low	Bankruptcy
Low	High	Low	High	Bankruptcy

TABLE 4
The Set Decision Rule of Two Years Prior to Bankruptcy

If $X2_2$	**If** $X9_2$	**If** $X11_2$	**If** $X17_2$	**If** $X19_2$	**Then**
Low	Low	Low	Low	Low	Bankruptcy
Low	Low	Low	Low	High	Bankruptcy
Low	Low	Low	High	Low	Bankruptcy
Low	Low	High	Low	Low	Bankruptcy
Low	High	Low	Low	Low	Bankruptcy
High	High	Low	Low	Low	Bankruptcy
High	Low	High	Low	Low	Bankruptcy
High	Low	Low	High	Low	Bankruptcy
High	Low	Low	Low	High	Bankruptcy
Low	High	Low	Low	High	Bankruptcy
Low	Low	High	Low	High	Bankruptcy
Low	Low	Low	High	High	Bankruptcy
Low	High	High	Low	Low	Bankruptcy
Low	Low	High	High	Low	Bankruptcy
Low	Low	High	Low	High	Bankruptcy
Low	High	Low	High	Low	Bankruptcy
High	High	High	Low	Low	Not Bankruptcy
High	High	Low	High	Low	Not Bankruptcy
High	High	Low	Low	High	Not Bankruptcy
High	Low	High	High	Low	Not Bankruptcy
High	Low	High	Low	High	Not Bankruptcy
High	Low	Low	High	High	Not Bankruptcy
Low	High	High	High	Low	Not Bankruptcy
Low	High	High	Low	High	Not Bankruptcy
Low	High	Low	High	High	Not Bankruptcy
Low	Low	High	High	High	Not Bankruptcy
Low	High	High	High	High	Not Bankruptcy
High	Low	High	High	High	Not Bankruptcy
High	High	Low	High	High	Not Bankruptcy
High	High	High	Low	High	Not Bankruptcy
High	High	High	High	Low	Not Bankruptcy
High	High	High	High	High	Not Bankruptcy

MODEL TESTING For testing, a simulator is needed that can generate value of the effectiveness of the model. The interface of the simulator is shown in Figure 3. Testing the model is intended to look at the effectiveness of the model that has been built. In this study two models will be tested that have been built as bankruptcy prediction model for one year earlier and bankruptcy prediction model for two years earlier than the time when bankruptcy actually takes place. Both models are constructed using fuzzy logic sigmoid membership functions and Mamdani inference method.

In this study, input data are sourced from financial statements of 65 companies (issuer) that are listed in the Indonesia Stock Exchange (BEI) in various sectors of industry, consumer goods industry, basic industry and chemicals, infrastructure, utilities, transportation, and trade in services and investment since 2006-2011. The test is conducted for the dataset used for testing models that have been created. Contents of this dataset are the entire sample (17 companies that went bankrupt and 48 companies that did not go bankrupt) for the year before bankruptcy and two years before the bankruptcy, so the number of records in the dataset totaled 130 cases. Summary results of the testing that has been done can be seen in Table 5.

Based on the test results in Table 5 to provide a more detailed overview, results will be evaluated based on two types of error and the overall effectiveness of the model, namely:

1. Error type I that is a model error in classifying the bankrupt company into the category of companies that are not bankrupt. This type of error is calculated based on the number of companies that are incorrectly classified divided by the number of companies that went bankrupt in the testing dataset.
2. Error type II that is a model error in classifying companies into categories that do not go bankrupt. This type of

FIGURE 3
The Interface Simulator to View The Effectiveness of Model

SISTEM PREDIKSI KEBANGKRUTAN PERUSAHAAN | Lihat Efektivitas Model | Senin, 20 Juli 2015 | Setting

Model Prediksi Kebangkrutan Setahun Sebelumnya

Kode LK	Hasil Prediksi	Fakta
ADES10	Tidak Bangkrut	Tidak Bangkrut
ADES11	Tidak Bangkrut	Tidak Bangkrut
ADMG11	Tidak Bangkrut	Tidak Bangkrut
AISA10	Tidak Bangkrut	Tidak Bangkrut
AISA11	Tidak Bangkrut	Tidak Bangkrut
AKKU10	Bangkrut	Tidak Bangkrut
AKKU11	Bangkrut	Tidak Bangkrut
AKPI10	Tidak Bangkrut	Tidak Bangkrut
ALFA08	Tidak Bangkrut	Tidak Bangkrut
ALFA09	Tidak Bangkrut	Bangkrut
APLI10	Tidak Bangkrut	Tidak Bangkrut
APLI11	Tidak Bangkrut	Tidak Bangkrut
ARGO10	Tidak Bangkrut	Tidak Bangkrut
ARGO11	Tidak Bangkrut	Tidak Bangkrut
ASIA11	Bangkrut	Tidak Bangkrut

Model Prediksi Kebangkrutan Dua Tahun Sebelumnya

Kode LK	Hasil Prediksi	Fakta
ADES10	Tidak Bangkrut	Tidak Bangkrut
ADES11	Tidak Bangkrut	Tidak Bangkrut
ADMG10	Tidak Bangkrut	Tidak Bangkrut
ADMG11	Tidak Bangkrut	Tidak Bangkrut
AISA10	Tidak Bangkrut	Tidak Bangkrut
AISA11	Tidak Bangkrut	Tidak Bangkrut
AKKU10	Bangkrut	Tidak Bangkrut
AKKU11	Bangkrut	Tidak Bangkrut
AKPI10	Tidak Bangkrut	Tidak Bangkrut
AKPI11	Tidak Bangkrut	Tidak Bangkrut
ALFA08	Tidak Bangkrut	Bangkrut
ALFA09	Tidak Bangkrut	Tidak Bangkrut
APLI10	Tidak Bangkrut	Tidak Bangkrut
APLI11	Tidak Bangkrut	Tidak Bangkrut
ARGO10	Tidak Bangkrut	Tidak Bangkrut

Tingkat Keefektifan Model untuk Prediksi Kebangkrutan Setahun Sebelumnya

Error Tipe I	58.82%	10 Kasus
Error Tipe II	12.39%	14 Kasus
S	81.54%	24 Kasus

Tingkat Keefektifan Model untuk Prediksi Kebangkrutan Dua Tahun Sebelumnya

Error Tipe I	70.59%	9 Kasus
Error Tipe II	7.96%	12 Kasus
S	83.85%	21 Kasus

Keterangan :

Error Tipe I :	Kesalahan model dalam memprediksi perusahaan yang bangkrut
Error Tipe II :	Kesalahan model dalam memprediksi perusahaan yang tidak bangkrut
S :	Tingkat efektivitas model secara keseluruhan

TABLE 5
Summary of Model Evaluation

Prediction of One Year Prior to Bankruptcy			
The Fact	**Bankrupt**	**Not Bankrupt**	**Total**
Bankrupt	7	10	17
Not Bankrupt	14	99	113
Total	21	109	130
Prediction of Two Years Prior to Bankruptcy			
The Fact	Bankrupt	Not Bankrupt	Total
Bankrupt	8	9	17
Not Bankrupt	12	101	113
Total	20	110	130

error is calculated based on the number of companies that are classified divided by the number of companies that do not go bankrupt in the testing dataset. 3. The effectiveness of the overall model (S) is a model of success rates in classifying the bankrupt company in the category of companies that go bankrupt and the companies that do not go bankrupt in the category of companies that are not bankrupt. To calculate the value of the overall effectiveness is done by dividing the number of cases of type I error and type II error by the total number of companies that are tested on the test dataset.

The level of effectiveness for bankruptcy prediction model for one previous year and two previous years can be seen in Table 6 and Table 7.

TABLE 6
The Effectiveness of one Year Prior to Corporate Bankruptcy Model

Error Type I	58,82% (10 Cases)
Error Type II	12,39% (14 Cases)
S	81,54% (24 Cases)

TABLE 7
The Effectiveness of two Year Prior to Corporate Bankruptcy Model

Error Type I	70,59% (12 Cases)
Error Type II	7,96% (9 Cases)
S	83,85% (21 Cases)

Based on Table 6 and Table 7 the value of effectiveness for bankruptcy prediction model for two years earlier is better than bankruptcy prediction model year earlier by a margin of 2.31%. If seen from its error types, bankruptcy prediction model two years earlier was also better than the previous year bankruptcy prediction model for type II error, otherwise for type I error bankruptcy prediction model for a year earlier is better.There are several possibilities that could explain why the level of effectiveness of the model for predicting bankruptcy two years earlier is better than the previous year bankruptcy prediction model and also an explanation is there for why the model for the prediction of bankruptcy a year earlier is better in type I error, such as:

1. The number of input variables used by the model for the prediction of bankruptcy two years earlier is five, which means that more than one variable models for the prediction of bankruptcy a year earlier. This resulted in a growing number of parameters used in predicting corporate bankruptcies.

2. Based on the time period (time horizon), an uncertainty would be more assured if the time period is getting close to the occurrence of an event, the longer the period of time between a prediction of the time when the event will occur, the higher the 3. uncertainty. This explains that the ideal model for the prediction of corporate bankruptcy a year earlier is better for type I error when compared with the bankruptcy prediction model for the company two years earlier.

This also explains why the models for the prediction of corporate bankruptcy two years earlier is better for type II error when compared with the bankruptcy prediction model for the company a year earlier.

CONCLUSION

Based on test results that have been made to the bankruptcy prediction model for the previous year and the model for the prediction of bankruptcy for previous two years, its conclusions are as follows:

The level of effectiveness of bankruptcy prediction model for the previous year was 81.54% with type I error of 58.82% and type II error of 12.39%. The effectiveness of the model for predicting bankruptcy two years earlier was 83.85% with type I error of 70.59% and type II error of 7.96%. Based on the

level of effectiveness of the two models, it is known that the effectiveness of the model for predicting bankruptcy two years earlier is better than bankruptcy prediction model for the previous year, but the type I error of prediction model for bankruptcy two years earlier was higher by 11.77%. This indicates that the uncertainties would be more assured if the time period is getting close to the occurrence of an event.

Of all the results that have been achieved so far, of course, there are still shortcomings that must be corrected or added in order to get better results, while the suggestions in this study are as follows:

1. Use all ratios of financial statement as an input but use other method to classify the company such as Support Vector Machine (SVM) method.
2. Study the use of different function membership to count degrees of membership and their influence on the accuracy of a model.

REFERENCES

Armour, J., & Cumming, D. (2008). Bankruptcy law and entrepreneurship. *American Law and Economics Review, 10*(2), 303-350.

Araujo, A. P., Ferreira, R. V., & Funchal, B. (2012). The Brazilian bankruptcy law experience. *Journal of Corporate Finance, 18*(4), 994-1004.

Adnan Aziz, M., & Dar, H. A. (2006). Predicting corporate bankruptcy: where we stand? *Corporate Governance: The International Journal of Business in Society, 6*(1), 18-33.

Fred, W. J., & Brigham, E. F. (2000). *Fendamental of financial management.* Jakarta, Indonesia: Erlangga.

Himmelstein, D. U., Thorne, D., Warren, E., & Woolhandler, S. (2009). Medical bankruptcy in the United States, 2007: Results of a national study. *The American Journal of Nedicine, 122*(8), 741-746.

Korol, T. (2012). *Fuzzy logic-Emerging technologies and applications.* Rijeka: InTech.

Korol, T. (2013). Early warning models against bankruptcy risk for Central European and Latin American enterprises. *Economic Modelling, 31,* 22-30.

Kusumadewi, A., & Purnomo, H. (2010). *Fuzzy logic applications for decision support.* Yogyakarta, Indonesia: Graha Ilmu.

Ross, T. J. (2010). *Fuzzy logic with engineering applications.* New York, NY: A John Wiley and Son Ltd.

Sartono, A. (1994). *Financial management theory and applications.* Yogyakarta, Indonesia: BPFE.

Yani, A., & Widjaja, G. (2004). *Business bankruptcy law series.* Jakarta, Indonesia: PT Raja Grafindo Persada.

— This article does not have any appendix. —