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The Validity of Multinomial Logistic Regression and Artificial Neural Network in Predicting Sukuk Rating: Evidence from Indonesian Stock Exchange

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The Sukuk (shariah bond) market is developing in Indonesia and potentially will capture the global market in the future. It is an attractive investment product and a hot current issue in the capital market. Especially, the problem of predicting an accurate and trustworthy rating. As the Sukuk market developed, the issue of Sukuk rating emerged. As ordinary investors will have difficulty predicting their ratings going forward, this research will provide solutions to the problems above. The objective of this study is to determine the Indonesian Sukuk rating determinants and comparing the Sukuk rating predictive model. This research uses Artificial Neural Network (ANN) and Multinomial Logistic Regression (MLR) as the predictive analysis model. Data in this study are collected by purposive sampling and employing Sukuk rated by PEFINDO, an Indonesian rating agency. Findings in this study are debt, profitability and firm size significantly affecting Sukuk

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rating category and the ANN performs better predictive accuracy than MLR. The implications of the results of the research for the issuer and bondholder are a higher level of credit enhancement, a higher level of profitability, and the bigger size of firm rewarding higher Sukuk rating.

Keywords: Sukuk rating; forecasting models; artificial neural network; multinomial logistic regression.

JEL Classifications: G1, C45, C52, C53

1. Introduction

Indonesian Sukuk market significantly developed from December 2017 to August 2018, the accumulative amount of corporate Sukuk issuance raised from IDR 26,394.90 billion to IDR 30,933.40 billion. Growth during the six-month period recorded at 17.19%, Indonesia's Authority of Financial Service (OJK) stated in its report. Standing Committee for Economic and Commercial Cooperation of the Organization of Islamic Cooperation (COMCEC) stated in its report on Sukuk market development in 2018 that the Indonesian Sukuk market is currently considered as developing market and yet it has a significant potential to capture global Sukuk market share in the future (COMCEC, 2018). Sukuk itself is popularly known as shariah bond, though in fact, both Sukuk and bond is basically and fundamentally different. COMCEC research report explained that Sukuk is not an interest-bearing financial as the way bond is but it possesses a similar function as a financial instrument in the money market (COMCEC, 2018).

According to Giap *et al.* (2018), in spite of the positive development execution of Indonesia in the course of recent decades, concerns have been communicated about whether the nation would be trapped in a middle-income trap. So, this study believes industry financing using Sukuk is a solution so that the country can get out of a middle-income trap.

Moreover, according to Khartabiel *et al.* (2019), companies do not have to worry about issuing Sukuk because, in the postcrisis period (2008), the market reaction for Sukuk is positive and significant, apparently due to new market participants' views, awareness and increased demand for Islamic financial products, whereas the conventional bonds do not have a significant market reaction. This is why discussions about Sukuk are important, especially for Indonesia and other developing countries about how to accurately predict ratings.

Kartiwi *et al.* (2018) stated the development of Sukuk emerged issues on Sukuk rating that shows the issuer's creditworthiness. Indonesia's Rating

Agency (PEFINDO) explained in its release that credit rating is indicating the issuer's capacity to fulfill long-term financial commitment under shariah principles contract. This issue on Sukuk rating is not only about what Sukuk rating one issuer is but also factors that determine the issuer's rating. The later mentioned issue is highly discussed in Sukuk field research mostly in the mature Sukuk market country, Malaysia. The main problem in rating issue is rating agency cannot be widely transparent on what factor people need to know unless the final result, rating. Rating agencies limited access to detailed rating methodology and people found this to be too complicated to understand and according to DeBoskey and Gillett (2011) felt the lack of corporate transparency. Then, Chu *et al.* (2019) noted the results of his research that increased transparency of information can reinforce investment certainty and lead to fewer forecast errors.

This research's objective is to give a better approach toward Sukuk rating understanding for the common investor. A better approach can be provided by using the most popular factors that can be easily recognized. Factors involved will be tested for its significance to build a predictive model of Sukuk rating. The predictive model will be tested in both multinomial logistic regression and artificial neural network than comparing their predictive accuracy. Findings in this study hopefully can provide a better and simplified approach for Indonesian Sukuk investors.

2. Theoretical Framework

2.1. *Sukuk*

Sukuk's origin from the Arabic word "sack" literally means cheque or certificate. As for Borhan and Ahmad (2018), Sukuk is all form of intention as a contract symbol or transferring rights, debt, or money. Ahmed *et al.* (2014) stated that Sukuk is a certificate of equal value that represents an undivided share on ownership of tangible assets, services, a certain project, or investment. As stated before, Sukuk is popularly known as shariah bond. COMCEC reported that Sukuk is a financial instrument in the market as an answer to the needs of shariah compliance instruments that work similarly to a bond (COMCEC, 2018). Shariah compliance instruments must obey shariah principles to avoid *riba, gharar, maysir,* injustice, and the activity of investment must be permitted by shariah (Dusuki, 2012).

There are differences between Sukuk and bond. Mseddi and Naifar (2013) stated Table 1 that bond is a pure debt contract between investor and issuer that issuer uses to finance all kinds of business activity and valued based on

the issuer's credit worthiness. While, Sukuk is a certificate of trust that represent ownership interest, specific assets, specific services, or project that certified by the third party. Sukuk equaling bond's function as it gives return and paid at due. The differences that separate Sukuk and bond fundamentally are the underlying for the contract, the relationship between investors and issuers, and sale price. Bond is based on the loan, while Sukuk must not be based on the loan. Sukuk's underlying must comply with Shariah principles and depends on the type of Sukuk issued. The relationship in the bond is definitely debts relationship, borrowers and lenders. Relationship in Sukuk will depend on its underlying and type of contract, in Mudharabah Sukuk the relationship is a partnership. Then the bond can be sold on premium or discount, while Sukuk must be sold at its fair value.

There are so many Sukuk classifications, yet some literature used the asset-based and asset-backed classification. The Securities Commission Malaysia report stated that this classification is due to its technical and commercial features. The difference between these two types of Sukuk is mainly on how underlying assets treated as Sukuk must have underlying assets. Asset-based Sukuk is occurring when there is no true sale of assets to

Table 1. Sukuk and bond.

Differences	Sukuk	Bond
Ownership	Clearly regulated	Holder rightful of cash flow from pure debt
The contract between issuer and holder	Based on financing or certain business	Purely getting money from money
Underlying asset nature and usage	Shariah compliance	As long as not against the jurisdiction
Operation of sale	Sale of assets, investment, or project	Sale of debt
Expense on assets	Probably stick to Sukuk holders	None
Securitization Price	Based on its underlying assets fair value	Depends on issuer's credit worthiness
Risk and return	Explicit share on risk and return based on profit generated by underlying assets	Holders endure low risk and return based on the coupon
Instrument trading	Depend on underlying assets nature	No prohibition
Shariah compliance	Investment on activity that shariah compliance	No prohibition
Standardization	Lack of standardization	Standardized

Source: Mseddi and Naifar (2013).

investors, which means that the assets remain in the issuer's balance sheet. Whilst-backed Sukuk is occurring when there is true sale. The ownership of assets is legally transferred into investors. Literatures stated that the main different between these two types of Sukuk is significant when default occurs in Herzi (2016) and Rachmawati and Ghani (2015). Asset-backed is preferable at default, this type is more secure than asset-based in these circumstances. Asset-based investors can sell the assets when default. On the other hand, asset-based ultimate recourse at default is the buyback clause. Therefore, asset-based highly considers the issuer's creditworthiness.

Indonesian corporate Sukuk does not vary in the market, though there are so many types of contracts in Sukuk issuance. COMCEC report stated that based on the National Shariah Board (DSN) data on Sukuk issuance in 2016, corporate mainly issued ijarah and mudharabah type of Sukuk (COMCEC, 2018). Indonesian Directorate of Shariah Finance defined Sukuk ijarah as a type of Sukuk that based on the ijarah contract. The underlying of Sukuk ijarah is the asset that its beneficial ownership is sold to investors. The underlying assets will remain in obligor's possession and obligor obliged to pay the investor the rent for the use of underlying assets. Obligor then buys this underlying asset back at its fair value as due. Indonesian Directorate of Shariah Finance stated that Sukuk mudharabah is the type of Sukuk based on the mudharabah contract. The relationship between investors and issuer is a partnership where investor as the capital provider and as the one that works on the investment project. Sukuk mudharabah will divide profit gained from the investment project based on the agreement and loss will be entirely investors exposure.

2.2. *Sukuk rating*

Sukuk rating, aforementioned, is indicating the issuer's capacity to fulfill its long-term financial commitment under shariah contract. PEFINDO rating agency revealed its rating process in its release on securitization that found to be complicated to understand. The release stated the type of analysis in rating Sukuk. In short, the rating methodology analyzes risk, credit enhancement, assets, assets management, and cash flows to classify the issuer's rating. Though the analysis process was briefly described, it remains unclear what should be concerned in rating issues. The rating analysis is as follows:

(1) An industry analysis conducted to investigate the characteristics and risk profile of an industry that relates to assets in many aspects.

(2) Determine "Benchmark Pool", industry analysis result used to determine the benchmark pool that PEFINDO uses to measure risk factors of assets.
(3) Determine "Base Default Frequency (BDF)", purposed to measure expectancy level on loss and credit enhancement for each rating category. The higher the rating, securitization needs higher credit enhancement. Nonperforming Loan (NPL) is a factor to determine the BDF value.
(4) Servicer Evaluation, stage of evaluating the capability of the servicer in managing securitized assets.
(5) Securitized assets analysis, purposed to measure credit enhancement using benchmark pool and BDF.
(6) Securitization structure analysis assessing the risk profile of securitization transaction structure by evaluating security scheme, security agreement analysis, protection on credit risk, legal aspect, and audit result analysis.
(7) Cash flow analysis, measuring cash flow adequacy generated by securitized assets compare to expenses.

2.3. *5C of credit*

Sukuk rating indicates the issuer's capacity that relates to the issuer's creditworthiness. Creditworthiness is also found important in Sukuk, whereas asset-based Sukuk holder relies only on obligor's creditworthiness since the underlying assets remain on obligor's balance sheet. Peprah *et al.* (2017) explained that creditworthiness assessed by 5C principles of credit, as follows:

(1) Character, subjective analysis of borrowers' characteristics. Character analysis mainly investigates borrowers' good will to repay debt.
(2) Capital, very important analysis to measure borrower's capability to endure market and unexpected risk.
(3) Capacity, Sharma and Kalra (2015) capacity is an assessment of borrower's capability to repay debt.
(4) Collateral, purposed to secure financial exposure in case of default.
(5) Condition, analysis of debt purposes, industry, economy, and political environment.

3. Literature Review

Studies on Sukuk have been growing in numbers since the development of the Sukuk market around the globe, though quite a few Sukuk rating

studies. Most studies on Sukuk rating employed in Bursa Malaysia as its Sukuk market considered at a mature stage, as per the COMCEC report. Variables in Sukuk rating studies vary but commonly most studies used financial ratio, macroeconomic factors, and Sukuk itself (COMCEC, 2018). Methodology on Sukuk rating studies also varies though most of the studies used predictive analysis such as multinomial logistic regression and ordered logistic regression.

Arundina and Omar (2009) and Borhan and Ahmad (2018) tried to examine the Sukuk rating determinant in Bursa Malaysia. Analysis of this study is based on multinomial logistic regression findings and resulted in the significance of profitability and guarantee status. The influence of significant factors is all positive toward the Sukuk rating. Firm size is not a significant factor, though Borhan and Ahmad (2018) stated that firm size is the prime factor in the Sukuk rating study. Smaoui and Khawaja (2018) investigated Sukuk's market development determinant. Interest spread, the difference between borrowing and lending rate, found to be negatively influencing Sukuk market development. Elhaj *et al.* (2015) found in their study that board size, financial leverage, profitability, firm size, and Sukuk structure influenced Sukuk's rating. Elhaj *et al.* (2015) found the negative influence of financial leverage represented by debt to total assets ratio (DAR). Arundina *et al.* (2015) compared neural network inferences and multinomial logistic regression in predictive accuracy research on Malaysian Sukuk rating. This study claimed that neural networks better logit predictive accuracy. This study also found return on assets (ROA) and DAR significant. Naifar and Mseddi (2013) showed in their study that Sukuk yield reacts positively toward stock return index.

4. Methodology

4.1. *Data and sample*

Data in this study are secondary data taken from various related sources. Sukuk rated by PEFINDO will be this study's sample and a sample must contain all variables value. Sources in this study are PEFINDO releases on rating, firm's financial statement, Indonesian stock exchange (IDX), and Indonesia's Central Bureau of Statistics (BPS). There are 125 samples collected and filtered by these criteria and issued outlier data and extreme values used become 63 samples.

4.2. *Multinomial logistic regression*

Starkweather and Moske (2011) stated that multinomial logistic regression (MLR) used to predict categorical placement or probability of categorical membership on a dependent variable based on a few independent variables. MLR is a simple development of binary logistic regression that allows more than 2 categories dependent variable. MLR equation is as follows:

$$\log \frac{p(\text{group}j)}{p(\text{group}i)} = \alpha_m + \beta_{i1}X_1 + \beta_{i2}X_2 + \beta_{i3}X_3 + \cdots + \beta_{in}X_n\,.$$

MLR uses maximum likelihood estimation that maximizes the probability of dependent variable occurrence by finding a regression coefficient. MLR assumes the dependent variable category should be independent, multicollinearity test, no extreme values or outlier, and nonperfect separation. There will be two general tests in MLR, the goodness of fit test and significance test. The goodness-of-fit test provided with three indicators which are -2 log-likelihood test, chi-square test, and pseudo R^2. -2 log-likelihood will compare the final model consists of all independent variables against the intercept and only model. The chi-square test indicates the deviation of predictive probability against its observed value. Pseudo R^2 is said to be R^2 and yet it is not real R^2 instead Pseudo R^2 is the measurement of linear convergence between the predictive probability and the observation probability. The significance test will be the partial test and the Wald test. The partial test is indicating the influence of one independent variable toward the dependent variable. Wald test will describe the relationship between the independent variable and the dependent variable's category. This study will do the predictive test which will measure MLR model predictive accuracy.

4.3. *Artificial neural network*

Sena (2017) explains that Artificial Neural Network (ANN) is a nonparametric predictive analysis which imitates the work of human brains. ANN is part of machine learning, artificial intelligence, and also known as a multilayer perceptron. According to Kumar and Haynes (2003), ANN is successfully used in financial fields, such as stock price prediction, portfolio management and selection, and credit rating analysis. Matlab provides types of ANN that produce different output and ANN Pattern Recognition is launched to conduct the predictive analysis. ANN Pattern Recognition's output is categorical that complies with the study objective to predict the rating of Sukuk. ANN in Matlab has three stages of test: training, validation, and test. In the training stage, ANN learned and change weight and bias in

the network. In the Validation stage, ANN will be generalized to its optimum level that there will be no better performance possible to achieve. In the test stage, the model will be tested with no effect that increases ANN performance. Most of the studies using ANN and Matlab indicate that the prime performance indicator extracted from the validation stage. Two main indicators are cross-entropy or error degree and confusion matrix that show predictive accuracy. This study will compare ANN predictive accuracy and MLR predictive accuracy.

5. Hypothesis

This study tries to find determinants of Sukuk rating by plotting financial ratios and macroeconomic factors. Independent variables will be elaborate as follows.

5.1. *DAR* X_1

According to Erica (2018), Gibson (2013) and Gitman and Zutter (2015) that debt to total assets ratio is the measurement of risk but also a financial leverage ratio that shows a potential profit in the future. Elhaj *et al.* (2015), Arundina *et al.* (2015) and February (2016) found DAR significantly affecting Sukuk rating in a negative way. DAR not only represents financial leverage ratio but also capital in 5C, therefore authors believe that DAR will significantly affect Sukuk rating.

H1: DAR significantly affecting Sukuk's rating.

5.2. *ROA* X_2

Erica (2018), Gibson (2013) and Gitman and Zutter (2015) define that return on assets represents profitability that shows the capability to generate profit by the firm's total assets. Borhan and Ahmad (2018), Elhaj *et al.* (2015), Arundina *et al.* (2015) revealed a positive significant influence of ROA toward Sukuk rating. Borhan and Ahmad (2018) stated that higher profitability rewarded by higher Sukuk rating. ROA is also representing capacity in 5C that ensure issuers to pay their liabilities.

H2: ROA significantly affecting Sukuk's rating.

5.3. *Firm size* X_3

Firm size is generally measured by total assets in natural logarithm form. Borhan and Ahmad (2018) stated that there is no significant influence of firm

size, despite firm size being considered as prime factors in Sukuk rating studies. While Elhaj *et al.* (2015) found positive influence by firm size toward Sukuk rating. Firm size can represent character, capital, and collateral of 5C. The character can be represented as firm size measured by total assets that show the value of the firm, the higher value means bigger firm and such big firm will behave as expectedly as explained by Setiadharma and Machali (2017). This reason is also why it can represent capital that shows the capability of risk-bearing and collateral as the big firm has more alternatives to pay liabilities.

H3: Firm size significantly affecting Sukuk rating.

5.4. *Bank Indonesia (BI) rate* X_4

BI rate in this study is BI 7 day repo rate that Bank of Indonesia defined as monetary policy effectively and quickly affects the money market. Smaoui and Khawaja (2018) found interest spread negatively affect Sukuk market development. BI rate is considered a macroeconomic factor and represents the condition of 5C that will significantly affect the Sukuk rating.

H4: BI rate significantly affecting Sukuk rating.

5.5. *JII* X_5

JII stands for Jakarta Islamic Index, JII listed 30 most liquid shariah stock in the market. Sclip *et al.* (2016) found a high volatility relationship between the international stock index and the Sukuk market in the financial crisis. Naifar and Mseddi (2013) stated that Sukuk yield reacted positively against the stock return index in Malaysia. As well as BI rate, JII is also considered as a macroeconomic factor that represents the condition of 5C and will significantly affect Sukuk rating.

H5: JII significantly affecting Sukuk's rating.

5.6. *Predictive accuracy*

Arundina *et al.* (2015) found that Neural Network Inferences better MLR performances in Malaysian Sukuk rating predictive analysis. Kumar and Haynes (2003) found that ANN is better that discriminant analysis in predicting bond rating. ANN is considered a more complex model than MLR and can suit the complexity level of models.

H6: ANN predictive accuracy higher than MLR predictive accuracy.

6. Result and Discussion

6.1. *Introduction*

The objective of this study is to find the determinants of Indonesian Sukuk rating and to decide which method has better predictive accuracy. First, the authors construct the predictive model which only included the significant independent variables as described by Widarjono (2015). All independent variables are continuous variables. While the dependent variable is categorical. The authors divide the Sukuk rating into three categories: 1, 2, and 3. Category 1 is for BBB and below Sukuk rating, Category 2 is for A Sukuk rating, and Category 3 is for AA and AAA Sukuk rating. Model predictive will be selected by launching a stepwise MLR test that enters only the significant variables and excluded nonsignificant variables. This is due to the inability of ANN to figure the effective variables to affect the dependent variables. In order to do so, authors, as aforementioned, conduct stepwise MLR as a more reliable procedure to construct a predictive model.

6.2. *MLR assumption test*

The assumption test is necessary to build a good and reliable MLR model. Therefore, outliers and extreme values in the model must be eliminated. The process of an outlier and extreme values elimination decreased data from 125 to 63 samples. Multicollinearity test indicated in Appendix A (Table A.1) that there is no strong correlation between independent variables in the model. For another assumption of MLR such as independency of dependent variables and nonperfect separation can be done while running the MLR.

Table 2 shows descriptive statistics of all independent variables in the model; it shows that almost all of the variables distributed around their mean values. Dependent variables category distribution is mostly populated

Table 2. Descriptive statistics.

	N	Minimum	Maximum	Mean		Std. Deviation
	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic
X_1 DAR	63	0.3843	0.9100	0.676233	0.0177278	0.1407100
X_2 ROA	63	0.0045	0.1100	0.040595	0.0035679	0.0283191
X_3 Firm size	63	14.4590	19.3997	16.669130	0.1410517	1.1195630
X_4 BI	63	0.0425	0.0975	0.063254	0.0016586	0.0131649
X_5 JII	63	311.2800	759.0700	602.197302	12.789457	101.5131718
Valid *N* (listwise)	63					

Sources: Pefindo (2018); data processed.

in Category 3 (AAA-AA) by 31 samples followed by Category 2 (A) by 29 samples and Category 1 (BBB-D) by 3 samples (see Appendix A, Table A.2).

6.3. *MLR result*

6.3.1. *Stepwise-predictive model*

MLR stepwise results stated that firm size is the most significant variable followed by ROA and DAR. While the BI rate and JII are excluded from the model. The stepwise is using −2 log-likelihood test and chi-square test to determine the significance of the variables. The null hypothesis in this test is independent variable parameters in the model are equal to zero which means having no effect on the dependent variable. We deny the null hypothesis due to p-value < 0.05, which means the independent variable is significantly affecting dependent variables.

Table 3 shows the result of the chi-square test and determined that firm size, ROA, and DAR are all significantly affecting the dependent variable Sukuk rating category. Though the stepwise result does do not provide the necessary explanation on independent variables relationship toward the dependent variable, this result constructs the predictive model and provides proof for H1, H2, and H3.

6.3.2. *Goodness-of-fit*

The goodness-of-fit test indicates the goodness of the model in explaining the dependent variable. The goodness-of-fit is indicated by model fitting information (Table 4), the goodness-of-fit test, and pseudo R^2 test.

Model Fitting Information is also called a global test which shows the significance of all variables in the model. The null hypothesis in this test is all parameters of independent variables equal to zero which means all

Table 3. Stepwise.

			Model Fitting Criteria	Effect Selection Tests		
Model	Action	Effect (s)	−2Log Likelihood	Chi-Square[a]	*df*	Sig.
0		Intercept	107.233	.		
1	Entered	X_3_firmsize	85.908	21.325	2	0.000
2	Entered	X_2_ROA	72.532	13.376	2	0.001
3	Entered	X_1_DAR	59.720	12812	2	0.002
Stepwise Method: Forward Entry						

Note: [a]The chi-square for entry is based on the likelihood ratio test.
Sources: Pefindo (2018); data processed.

Table 4. Model fitting information.

	Model Fitting Criteria	Likelihood Ratio Tests		
Model	−2 Log Likelihood	Chi-Square	*df*	Sig.
Intercept Only	107.233			
Final	59.720	47.513	6	0.000

Sources: Pefindo (2018); data processed.

independent variables have no effect on the model. If p-value < 0.05 then deny the null hypothesis. On the other hand, it means that all variables are significantly affecting dependent variables simultaneously. The sig. equal 0.000 which means the null hypothesis denied and all independent variables simultaneously affecting Sukuk rating. The result also means that the final model consists of all independent variables that can explain the dependent variable better than the intercept only model.

The goodness-of-the-Fittest indicates if the predictive result is large from its observative result. Both Pearson and Deviance show sig. of 1.000 that means the predictive result is not large from the observative result. This result indicates excellent goodness-of-fit (Table 5).

Pseudo R^2 indicates the goodness-of-fit of the model (Table 6). There are two ways of interpretation of pseudo R^2. First, pseudo R^2 is considered as R^2 that means this model can explain the Sukuk rating category by 53%, 64.8%, and 44.3%. Second, pseudo-R^2 is considered as the linear convergence of predictive function and observative function which means that the linear convergence in this model reached 53%, 64.8%, and 44.3%. Specifically, for McFadden pseudo-R^2, the excellent fit shows if pseudo R^2 value is between 0.2 and 0.4 which shows the excellent fit in this model McFadden pseudo-R^2 is 0.443.

Overall, all three indicators of goodness-of-fit are considered MLR model in this study as a proper fit and are reliable to explain the dependent variable Sukuk rating category.

Table 5. Goodness-of-fit.

	Chi-Square	*df*	Sig.
Pearson	71.856	118	1.000
Deviance	59.720	118	1.000

Sources: Pefindo (2018); data processed.

Table 6. Pseudo *R*-square.

Cox and Snell	0.530
Nagelkerke	0.648
McFadden	0.443

Source: Pefindo (2018); data processed.

6.3.3. *Significance test*

The significance test uses the likelihood ratio test and parameter estimate to configure the regression equation. The likelihood ratio test has already been interpreted in the stepwise while constructing the predictive model. It is more important to interpret the parameter estimate that employed the Wald test which indicates the relationship of independent variables toward dependent variables categories.

Table 7 shows the coefficient in the regression equation and the Wald test. The regression equation is as follows:

Logit equation (Category 1/Category 3) Category 1 compared to Category $3 = 10.547 - 34.159\,\text{dar}$.

Logit equation (Category 2/Category 3) Category 2 compared to Category $3 = 43,351 - 58,821\,\text{roa} - 2,358\,\text{firm size}$.

Norton *et al.* (2018) explain that the most important interpretation in parameter estimates is the odds ratio, Exp(B). The odds ratio indicates how powerful independent variables affect the dependent variable but firstly measuring its significance by the Wald test. In Category 1, compared to Category 3, the only significance occurred in DAR variable with odds ratio value equal 1.462×10^{-15} which means every increase in DAR level will

Table 7. Parameter estimates.

Y_sukukrate[a]		*B*	Wald	Sig.	Exp (*B*)
1	Intercept	10.547	0.162	0.687	
	X_1_DAR	−34.159	3.951	0.047	1.462E−15
	X_2_ROA	0.573	0.000	0.988	1.773
	X_3_firmsize	0.356	0.047	0.828	1.428
2	Intercept	43.351	17.009	0.000	
	X_1_DAR	−2.610	0.598	0.440	0.074
	X_2_ROA	−58.821	9.404	0.002	2.847E-26
	X_3_firmsize	−2.358	15.842	0.000	0.095

Note: [a]The reference category is: 3.
Sources: Pefindo (2018); data processed.

decrease the occurrence of Category 1 compared to Category 3 decreased by 1.462×10^{-15} time. In Category 2 compared to Category 3, ROA and firm size found to be significant and increases in both variable values will decrease the occurrence of Category 2 compared to Category 3 by 2.847×10^{-26} and 0.095 times, respectively.

In the overall result, all independent variables are favorable for Category 3. The increase in DAR will rather bring the Sukuk rating toward Category 3 than Category 1. These findings can be understood due to PEFINDO is also considering the credit enhancement and DAR level can confirm the firm's capability of credit enhancement. PEFINDO stated that the higher the credit rating, the higher the credit enhancement needed. While in Category 2 compared to Category 3, increases in firm size and ROA will reward the firm a higher Sukuk rating. Firm size indicating character, capital, and collateral of 5C, the higher the value the better it can represent the 5C mentioned. While ROA represents the capacity, an increase in ROA means a better capacity firm had in creditworthiness.

6.3.4. *Classification table*

Table 8 shows the predictive accuracy of the MLR model. In all samples prediction, MLR predicts correctly 79.4%. Type I error occurred 7 times and type II error occurred 6 times. Type I error is when the predictive rating is higher than the observative rating and type II error is when the predictive rating is lower than the observative rating. Arundina *et al.* (2015) stated that satisfaction of MLR predictive accuracy can be measured by proportion by chance accuracy derived from casing process summary distribution and an increase of 25% in performance. Proportion by-chance accuracy for this model is 56.996% $(1.25(0.048^2 + 0.46^2 + 0.492^2))$. A comparison between the predictive accuracy and proportion by chance accuracy shows that MLR predictive accuracy is satisfying.

Table 8. Classification.

	Predicted			
Observed	1	2	3	Percent Correct (%)
1	2	0	1	66.7
2	0	23	6	79.3
3	0	6	25	80.6
Overall percentage	3.2%	46.0%	50.8%	79.4

Sources: Pefindo (2018); data processed.

6.4. *ANN result*

6.4.1. *How the ANN model is constructed*

The first is to determine the independent variables in the ANN test. Selection of variables based on the previous MLR test. From the MLR test, there are five independent variables determined by the process of *Stepwise Forward Entry* and only 3 that affect the Sukuk rating, namely DAR (X_1), ROA (X_2), and firm size (X_3). Then the three variables will be used in the ANN model.

Next, determine the proportion of the sample to be used at each test stage. Based on the basic Matlab settings, of the 63 samples, 70% were used at the training stage, 15% were used at the validation stage, and the remaining 15% was used at the test stage.

Before entering the training phase it is necessary to first determine the structure of the ANN. At this stage the determination of the number of neurons is only done at the *hidden layer*, the number of neurons can be adjusted or can be changed according to the needs of the model and the expected prediction results.

In the first part in Fig. 1, the *input* consists of 3 neurons namely each independent variable, DAR (X_1), ROA (X_2), and firm size(X_3). In the second part, the *hidden layer* contains 5 neurons that will receive *input* and use the transit transfer function. In the third part, the *output layer* contains 3 neurons according to the number of Sukuk rating categories and uses the transfer function *softmax* to classify the *input* of *hidden layers* into categories. In the fourth part, the *output* shows the predicted results in the form of Sukuk rating from the *input* the given.

On the ANN training results in Fig. 2, it can be seen that the training process was stopped on the 24th iteration. Termination is carried out referring to the validation failure as many as 6 times in a row. At the time of

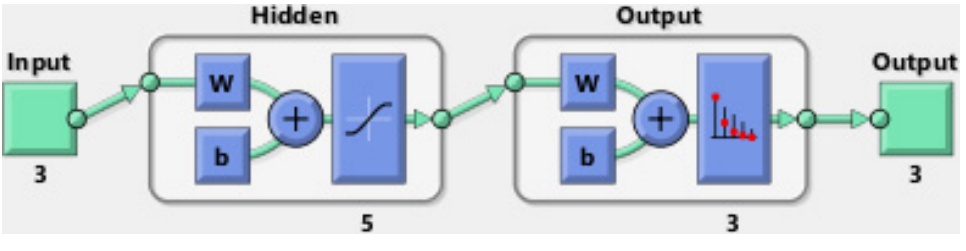

Fig. 1. ANN Matlab structure.

Source: Processed data, 2018.

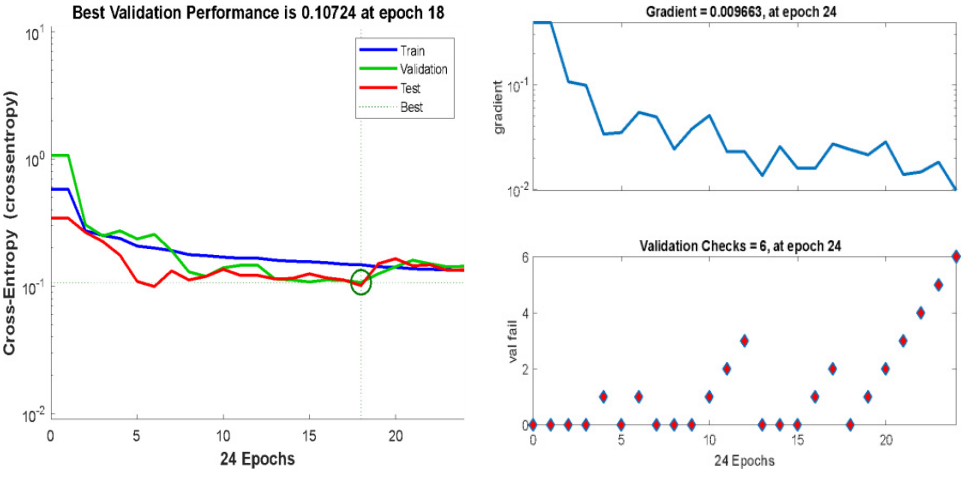

Fig. 2. Training state and performance.

Source: Processed data, 2018.

stopping, the gradient value is 0.009663. Based on the exercise performance curve, you can see the blue line which is the development of the training process until the dismissal. From the blue line, it can be seen that the ANN training process is progressing well with values *cross-entropy* continuing to decline. The best validation performance occurred in the 18th iteration with a *cross-entropy value of* 0.10724.

From the training, the process has been generated bias values and weights at each *layer* (Tables 9 and 10).

At the validation and test, there are two different stages. At the validation stage, the trained network is measured at the level of generalization and stops the training stage when the increase in network generalization stops. Meanwhile, at the test stage, it will not change the network being trained or after experiencing a measurement of the level of generalization at the validation

Table 9. Bias and weight of hidden layer.

Neuron Hidden Layer (NHL)	Biased *Hidden Layer* ($b_{1.i}$)	W_iX_1	W_iX_2	W_iX_3
NHL_1	1.1604	0.7611	0.2052	−3.3136
NHL_2	−1.0849	1.9927	1.4795	1.4795 1.9830
NHL_3	−1.6654	−1.7067	−0.9887	3.0644
NHL_4	−2.1825	−0.8273	−2.2592	−1.1171
NHL_5	−1.9930	−1.5798	2.3628	−1.3847

Source: Processed data, 2018.

Table 10. Bias and weight of *output layer*.

Neuron Output Layer (NOL)	Bias Output Layer ($b_{2.i}$)	W_iNHL$_1$	W_iNHL$_2$	W_iNHL$_3$	W_iNHL$_4$	W_iNHL$_5$
ZERO$_1$	0.0293	0.9987	−0.3458	0.4306	2.1291	1.5837
ZERO$_1$	−1.33967	1.1107	−0.44897	−2.4234	1.3865	−1.3796
ZERO$_1$	2.3576	−0.6981	1.5311	0.8611	−2.1507	0.4422

Source: Data processed, 2018.

stage. At the test stage, the network will be tested independently to measure the performance of the network that has been trained and validated.

At the training stage in Fig. 3 (see also Appendix A, Table A.3), ANN correctly predicts 1 of 2 samples in Category 1 used in the training phase or

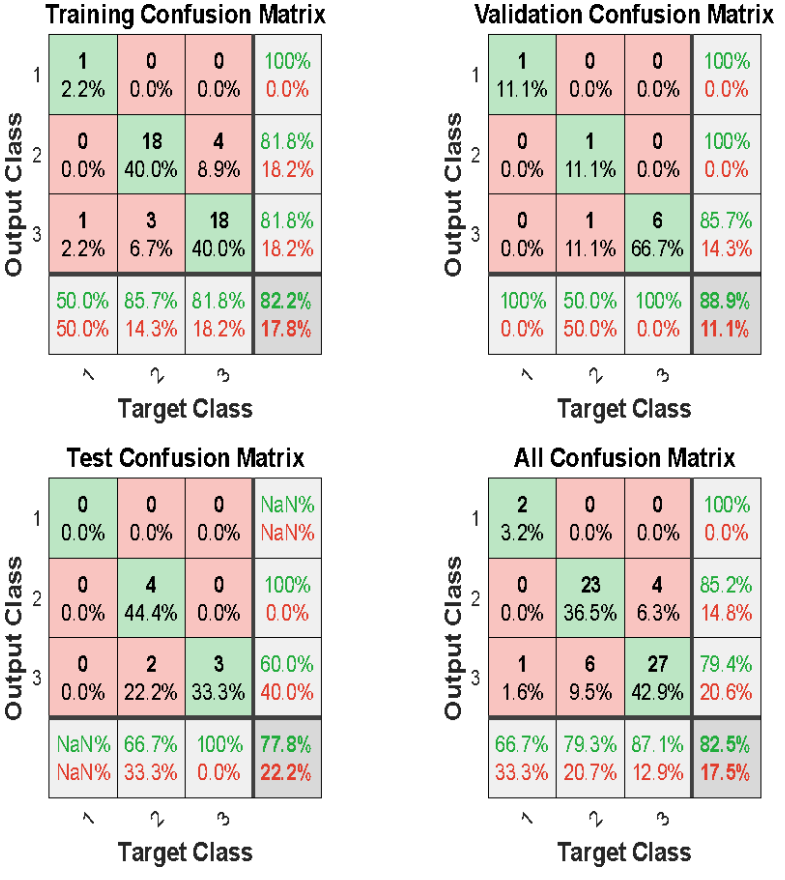

Fig. 3. Confusion matrix.

Source: Processed data, 2018.

by 50%, In Category 2, ANN successfully predicts 18 out of 21 samples or 85, 7% of all samples in Category 2. In Category 3, ANN managed to predict 18 out of 22 samples or 81.8% of all samples in Category 2. Overall the training phase, ANN managed to predict 37 out of 45 samples or 82.2% of all samples used in the training phase.

In the matrix, it *confusion* validation can be seen in Fig. 3 that ANN successfully predicts 1 in 1 sample in Category 1 that was tested at the validation stage or ANN has a 100% prediction accuracy rate in samples from Category 1 that were tested at the validation stage. ANN successfully predicted exactly 1 of 2 samples that were members of Category 2 or 50% of all samples in Category 2 that were tested at the validation stage. ANN successfully predicted exactly 6 of the 6 samples that were members of Category 3 or 100% of all samples in Category 3 that were tested at the validation stage. Overall, ANN can correctly predict 8 out of 9 samples or 88.9% of all samples tested at the validation stage.

At the test stage in Fig. 3, ANN does not have a sample of category 1 members tested so the level of accuracy is unknown. In Category 2, the accuracy of ANN prediction is 66.7% or managed to predict 4 of the 6 samples tested. In Category 3, the accuracy of ANN prediction is 100% or 3 of the 3 samples tested. Overall the test phase, ANN has a prediction accuracy of 77.8% or true in 7 of the 9 samples tested at the test stage.

The results of the three steps are summarized in one matrix *confusion* final in Fig. 3 that shows ANN performance in all test samples. In Category 1, ANN managed to predict 2 out of 3 samples or an accuracy rate of 66.7%. In Category 2, ANN managed to predict 23 out of 29 samples or an accuracy rate of 79.3%. In Category 3, ANN succeeded in predicting 27 of 31 samples or a prediction accuracy of 87.1%. Overall, ANN successfully predicted 52 out of 63 samples and an accuracy rate of 82.5%. From all stages, there were 7 *errors Type I* and 4 *errors Type II*.

6.4.2. *The accuracy of the ANN model*

ANN is used as the predictive model to perform rating prediction. There are four predictive accuracy results that represent each of the three stages and all stages of summary. This study will use the indicators in the validation stage, as previous studies did, and all stages summary as authors argue as more proper comparison by sample numbers. Matrix confusion is showing the predictive accuracy, validation stages recorded 88.9% accuracy from all nine samples tested in this stage. As for all stages summary: training,

validation, and test, the predictive accuracy is 82.5%. In all stage summary, there are 7 types I errors and 4 types II errors.

6.5. *Predictive accuracy*

In the last stage of this study's analysis, predictive accuracy comparison between MLR model and ANN model is conducted to determine which method performs better predictive accuracy. MLR predictive accuracy is 79.4% of all samples and having 7 types I errors and 6 types II errors. While ANN validation test predictive accuracy is 88.9% and has only 1 type I error. The all stages summary of ANN predictive accuracy is 82.5% and having 7 types I error and 6 type II error. Comparing MLR to ANN both validation and all stages summary produce the same result that ANN performs better predictive accuracy than MLR, H6 is proven. As stated before, this finding is also supported by previous studies that ANN performs better than methods compared to it. It is because ANN is a more complex method and can manage to adapt to all levels of problems.

7. Conclusion

The issue of Sukuk rating emerged as the Sukuk market developed. This study investigates the determinants of Indonesian Sukuk rating and plot predictive analysis comparing the ANN and MLR model. MLR stepwise used to build a predictive model that results in DAR, ROA, and firm size as a determinant of Sukuk rating. The predictive analysis results in ANN predictive accuracy better MLR's. Findings in this study confirmed that higher credit enhancement, higher profitability, and a bigger size of firms relate to higher Sukuk rating.

8. Recommendation

Authors recommendation for the inventor and issuer to conduct an independent valuation to Sukuk rating using DAR (debt), ROA (profitability), and firm size. Sukuk issuer can benefit from this study to perform better on those significant variables to gain a higher Sukuk rating. Recommendation for upcoming studies, researchers can further investigate more characteristic of Sukuk itself in the Indonesian Sukuk market, such as Sukuk type, guarantee status, other macroeconomic factors, and may include another financial ratio.

The results of this study with the model offered are highly recommended for use in other places such as Southeast Asia, South Asia, the Middle East,

Europe, especially in the UK. In these regions, the development of Sukuk is quite fast.

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Appendix A

Table A.1. Table correlation.

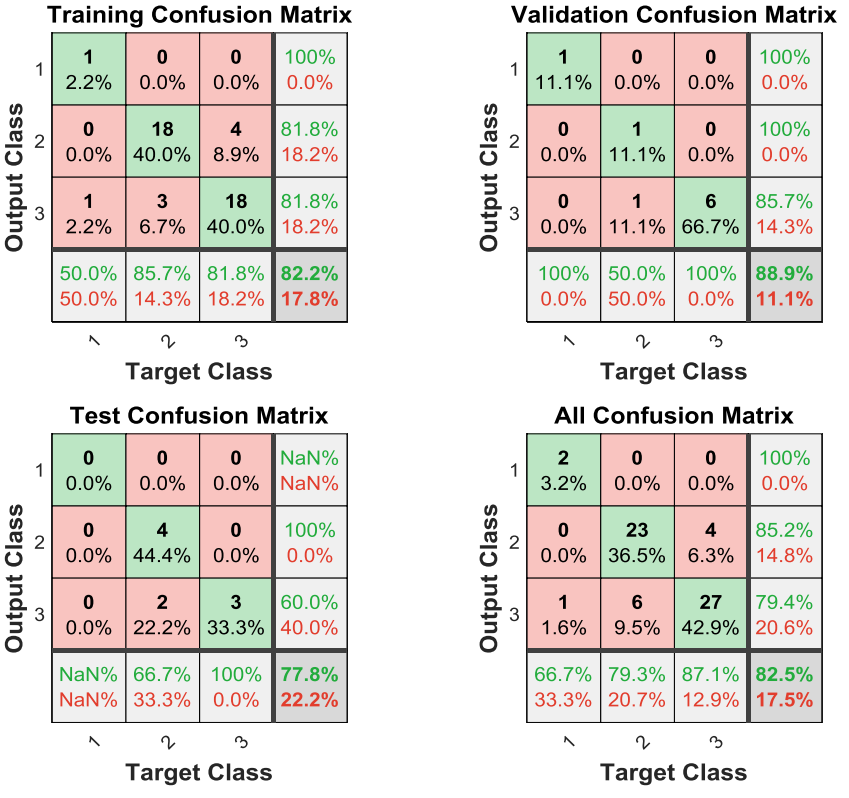
		X_1_DAR	X_2_ROA	X_3_firmsize	X_4_BI	X_5_JII
X_1_DAR	Pearson Correlation	1	−0.320*	0.452**	0.074	0.116
	Sig. (two-tailed)		0.010	0.000	0.565	0.367
	N	63	63	63	63	63
X_2_ROA	Pearson Correlation	−0.320*	1	−0.600**	0.162	−0.155
	Sig. (two-tailed)	0.010		0.000	0.204	0.226
	N	63	63	63	63	63
X_3_firmsize	Pearson Correlation	0.452**	−0.600**	1	−0.244	0.440**
	Sig. (two-tailed)	0.000	0.000		0.054	0.000
	N	63	63	63	63	63
X_4_BI	Pearson Correlation	0.074	0.162	−0.244	1	−0.548**
	Sig. (two-tailed)	0.565	0.204	0.054		0.000
	N	63	63	63	63	63
X_5_JII	Pearson Correlation	0.116	−0.155	0.440**	−0.548**	1
	Sig. (two-tailed)	0.367	0.226	0.000	0.000	
	N	63	63	63	63	63

Note. ** and * denote significance at 1% and 5%, respectively.

Table A.2. Table case processing summary.

		N	Marginal Percentage (%)
Y_sukukrate	1 (BBB-D)	3	4.8
	2 (A)	29	46.0
	3 (AAA-AA)	31	49.2
Valid		63	100.0
Missing		0	
Total		63	
Subpopulation		63[a]	

Table A.3. Table confusion matrix.



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