ANN : PREDICTING OF STATE RETAIL SUKUK BASED ON REGION IN INDONESIA

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Abstract. Retail Sukuk is a product of State Sharia Securities (Sukuk) issued by the Government of the Republic of Indonesia in this case the Ministry of Finance and sold to individuals or individuals of Indonesian Citizens through Selling Agents in the domestic Primary Market. This research contributes to the government and the Bank to be able to do the maximum promotion for the next sukuk issuance. The data used is data from the Ministry of Finance. These data are sukuk sales data with series 002-010 based on regional groups. The algorithm used in this study is Artificial Neural Network with Backpropogation method. Variabel masukan yang digunakan adalah kelompok wilayah bagian barat selain Jakarta (X1), kelompok Jakarta (X2), kelompok Indonesia Bagian Tengah(X3), dan kelompok Indonesia Bagian Timur (X4) dengan model arsitektur pelatihan dan pengujian sebanyak 4 arsitektur yakni 4-2-1, 4-3-1, 4-2-3-1 dan 4-3-2-1. The best architectural model is 4-3-1 with epoch 266, MSE 0.009918 and 100% accuracy rate. From this model, predictions of retail country sukuk will be made by region.

1. Introduction
Retail Sukuk is a product of State Sharia Securities (Sukuk) issued by the Government of the Republic of Indonesia in this case the Ministry of Finance and sold to individuals or individuals of Indonesian Citizens through Selling Agents in the domestic Primary Market. Purchase orders for Retail State Sukuk can only be made by individual Indonesian citizens as evidenced by a valid Identity Card, with the minimum number of purchases set by the Government based on the Information Memorandum issued every Issuance of Retail State Sukuk.

There are 4 groups of retail country sukuk sales. The region consists of western regions other than Jakarta, the Jakarta group, the Central Indonesia group, and the Eastern Indonesia group. The government needs a prediction data on regional retail sukuk based on the region to take the marketing policy for the future retail country sukuk.
To overcome this situation, it is necessary to have a study that can predict the number of investors and the purchase volume of Retail State Sukuk in the future based on the region which can later determine the market of the region category. This model is expected to be an input to the Islamic or Conventional Banks that are trusted in selling Retail State Sukuk to market these instruments by region. So that the Bank can maximize the sale of State Retail Sukuk to the society so that the future of the community can participate in the construction of monumental projects that benefit the State through investment in Retail State Sukuk.

2. Rudimentary

2.1. Artificial Intelligence

Artificial Intelligence is one area that is quite reliable in solving problems such as prediction (forecasting) [1]. AI is a very important discipline and it includes a number of well recognized and mature areas including Neural Network [2]–[4]. Artificial Intelligence (AI) is a general term that implies the use of a computer to model intelligent behavior with minimal human intervention. AI is generally accepted as having started with the invention of robots. The term derives from the Czech word robota, meaning biosynthetic machines used as forced labor [5].

2.2. Artificial Neural Network

Artificial Neural Network (ANN) is one of the studies of Artificial Intelligence and is a new computing technology in the field of computer science study. Neural networks mostly used for problem-solving in pattern recognition, data analysis, control and clustering [6][7]. Initially ANN were developed in the field of artificial intelligence and were first introduced for image recognition. The central concept was inspired by knowledge of the nervous system, especially the human brain with its closely connected neurons [8][9].

2.3. Backpropagation Neural Network

Backpropagation (BP) algorithm was used to develop the ANN model [10][11]. The typical topology of BPANN (Backpropagation Artificial Neural Network) involves three layers: input layer, where the data are introduced to the network; hidden layer, where the data are processed; and output layer, where the results of the given input are produced [12]–[14]. A backpropagation algorithm was used for training. It is a convenient and simple iterative algorithm that usually performs well, even with complex data. Unlike other learning algorithms (like Bayesian learning) it has good computational properties when dealing with large-scale data [15][16].

2.4. Arsitektur Backpropagation

The back-propagation learning algorithm (BPLA) has become famous learning algorithms among ANNs. In the learning process, to reduce the inaccuracy of ANNs, BPLAs use the gradient-decent search method to adjust the connection weights. The structure of a back-propagation ANN is shown in Figure 2. The output of each neuron is the aggregation of the numbers of neurons of the 3 previous level multiplied by its corresponding weights. The input values are converted into output signals with the calculations of activation functions. Backpropagation ANNs have been widely and successfully applied in diverse applications, such as pattern recognition, location selection and performance evaluations [17][18].

3. Results and Discussion

3.1. Design of the system

3.1.1. Defining Input and Target

State Sukuk data based on the following regions will be processed by the Artificial Neural Network with the backpropagation method. Data must be represented in numerical form between 0 to 1, both variables and contents which are input data of the State Retail Sukuk by region as pattern recognition and output which is a prediction of purchase of State Retail Sukuk by region. This is because the network uses the binary sigmoid activation function (logsig) whose range is from 0 to 1.
3.1.2. Pendefinisian Input

Variable State Retail Sukuk based on region is a criterion that becomes a reference in making decisions on assessments using Artificial Neural Networks. Variables are determined by looking at data dependence on research conducted. The list of variables in predicting State Retail Sukuk by region consists of:

1. Western region other than Jakarta (X1)
2. Jakarta Group (X2)
3. Central Indonesian Group (X3)
4. Eastern Indonesia Group (X4)

Input data is obtained from the Ministry of Finance's website regarding the sale of the State Retail Sukuk. The results of the State Retail Sukuk Sales will be recorded at PT. Indonesia stock exchange. State Retail Sukuk Sales consist of several groups namely geography, profession and age category. The sample data used were the sales of SR002 up to SR0010 State Retail Sukuk based on regions consisting of western regions other than Jakarta, Jakarta groups, Central Indonesia groups, and Eastern Indonesia groups which consists of 9 data and each data has 4 variables and 1 target. This data will later be transformed into a data between 0 to 1 before training and testing with formulas:

\[ x' = \frac{0.8(x - a)}{b - a} + 0.1 \]

3.1.3. Defining Target

The target data is the number of State Retail Sukuk investors by region.

3.2. Data processing

Data processing is done with the help of Matlab 6.1 software. Data samples are the number of State Retail Sukuk investors by region. This data will be used in training data and test data. Samples of data that have been processed and transformed are as follows.

### Tabel 1. Samples of raw Retail State Sukuk data based on region

| Number | Name   | Variable | Target       |
|--------|--------|----------|--------------|
| 1      | SR-002 | X1 4.203.315.552.000 | X2 3.550.162.734.000 | X3 195.222.798.000 | X4 85.158.916.000 | 8.033.860.000.000 |
| 2      | SR-003 | X1 4.067.141.140.000 | X2 2.960.790.653.000 | X3 780.000.000.000 | 194.680.000.000 | 7.341.410.000.000 |
| 3      | SR-004 | X1 5.980.000.000.000 | X2 5.850.000.000.000 | X3 390.000.000.000 | 13.000.000.000.000 |
| 4      | SR-005 | X1 6.585.920.000.000 | X2 7.334.320.000.000 | X3 149.480.000.000 | 14.968.000.000.000 |
| 5      | SR-006 | X1 7.696.488.313.500 | X2 9.791.138.911.500 | X3 131.398.746.000 | 19.323.345.000.000 |
| 6      | SR-007 | X1 8.541.780.000.000 | X2 11.148.145.000.000 | X3 88.545.000.000 | 21.965.035.000.000 |
| 7      | SR-008 | X1 12.136.950.000.000 | X2 15.847.650.000.000 | X3 667.800.000.000 | 31.500.000.000.000 |
| 8      | SR-009 | X1 7.313.438.510.000 | X2 5.732.837.404.000 | X3 77.205.205.000 | 14.037.310.000.000 |
| 9      | SR-010 | X1 4.267.217.106.000 | X2 3.320.633.952.000 | X3 48.932.106.000 | 8.436.570.000.000 |

Source : Ministry of Finance

### Table 2. Sampel dari data yang telah ditransformasikan

| Number | Name   | Variable | Target |
|--------|--------|----------|--------|
| 1      | SR-002 | X1 0.205672 | X2 0.189058 | X3 0.103721 | X4 0.100921 | 0.303107 |
| 2      | SR-003 | X1 0.202209 | X2 0.174067 | X3 0.104301 | X4 0.101183 | 0.285494 |
| 3      | SR-004 | X1 0.250865 | X2 0.247558 | X3 0.118596 | X4 0.108676 | 0.429428 |
| 4      | SR-005 | X1 0.266277 | X2 0.285314 | X3 0.121599 | X4 0.102563 | 0.479486 |
3.3. Design of Artificial Neural Network Architecture

The network used to predict Retail State Sukuk is based on the region with backpropagation with feedforward learning steps. This network has several layers, namely the input layer, layer family and several hidden layers. The hidden layer helps the network to recognize more input patterns compared to networks that do not have hidden layers. The parameters in the formation of backpropagation network use 4 input variables, 1 or more hidden layers and 1 output layer. The existing architectural models are 4-2-1, 4-3-1, 4-2-3-1 and 4-3-2-1.

The neural network that will be built is the backpropagation algorithm with the Sigmoid activation function. Activation function in Artificial Neural Networks is used to calculate the actual value of the output in the hidden layer and calculate the actual value of the output in the output layer.

3.4. Defining Output

The expected result at this stage is the pattern detection determines the best value to predict the Retail State Sukuk based on the region. The test results are as follows:

a. To determine the prediction of Retail State Sukuk based on age category, of course, it is based on the sale of Retail State Sukuk. The output of this prediction is the best architectural pattern in predicting Retail State Sukuk by region by seeing a minimum error.

b. Categorization Training output and testing The category for output is determined by the minimum error level of the target. The limit of this category is for the true category the minimum error is between 0.05 - 0.001 and the wrong category is > 0.05.

3.5. Design of Artificial Neural Network Architecture

Designing Artificial Neural Network architecture for training and testing data, 4 input variables were used, namely the western region other than Jakarta (X1), the Jakarta group (X2), the Central Indonesia group (X3), and the Eastern Indonesia Group (X4).

The following stages will be performed in the user of the back propagation algorithm with the sigmoid activation function. The steps that must be done are as follows:

1. Initialization, is the stage where the value variables will be set or defined first, for example, such as: input data value, weight, expected output value, learning rate and other data values.
2. Activation, is the process of calculating the actual value of the output in the hidden layer and calculating the actual output value in the output layer.
3. Weight Training, is the process of calculating the gradient error value in the output layer and calculating the value of the gradient error in the hidden layer.
4. Iteration, is the final stage in testing, where if there is still a minimum error that is expected not to be found then return to the activation stage.

3.5.1. Architectural Training and Testing 4-2-1

Following are the results of testing with 9 test data with a 4-2-1 test pattern. Test results and training data can be seen in the table as follows:

| Number | Name   | X1     | X2     | X3     | X4     | Target     |
|--------|--------|--------|--------|--------|--------|------------|
| 5      | SR-006 | 0.294526 | 0.347806 | 0.142107 | 0.102098 | 0.590270   |
| 6      | SR-007 | 0.316027 | 0.382323 | 0.154374 | 0.101008 | 0.657465   |
| 7      | SR-008 | 0.407475 | 0.501862 | 0.171188 | 0.115742 | 0.900000   |
| 8      | SR-009 | 0.284782 | 0.244578 | 0.122000 | 0.100719 | 0.455813   |
| 9      | SR-010 | 0.207298 | 0.183220 | 0.119099 | 0.100000 | 0.313351   |

Source: Ministry of Finance
Architectural Training and Testing 4-3-1

Following are the results of testing with 9 test data with a 4-3-1 test pattern. Test results and training data can be seen in the table as follows:

**Table 4. Training and Testing Results with Model 4-3-1**

| Number | Target  | Output ANN | Error   | SSE  | Number | Target  | Output ANN | Error   | SSE  |
|--------|---------|------------|---------|------|--------|---------|------------|---------|------|
| 1      | 0.3031  | 0.412916   | -0.109809 | 0.0120579851 | 1      | 0.3031  | 0.412916   | -0.109809 | 0.0120579851 |
| 2      | 0.2855  | 0.414626   | -0.129132 | 0.0166751329 | 2      | 0.2855  | 0.414626   | -0.129132 | 0.0166751329 |
| 3      | 0.4294  | 0.420784   | 0.008644  | 0.00000747191| 3      | 0.4294  | 0.420784   | 0.008644  | 0.00000747191|
| 4      | 0.4795  | 0.430147   | 0.049339  | 0.0024343751 | 4      | 0.4795  | 0.430147   | 0.049339  | 0.0024343751 |
| 5      | 0.5903  | 0.466445   | 0.123825  | 0.0153326159 | 5      | 0.5903  | 0.466445   | 0.123825  | 0.0153326159 |
| 6      | 0.6575  | 0.483372   | 0.174093  | 0.0303084017 | 6      | 0.6575  | 0.483372   | 0.174093  | 0.0303084017 |
| 7      | 0.9000  | 0.957386   | -0.057386 | 0.0032931789 | 7      | 0.9000  | 0.957386   | -0.057386 | 0.0032931789 |
| 8      | 0.4558  | 0.450639   | 0.005174  | 0.0000267671 | 8      | 0.4558  | 0.450639   | 0.005174  | 0.0000267671 |
| 9      | 0.3134  | 0.412192   | -0.098841 | 0.0097696150 | 9      | 0.3134  | 0.412192   | -0.098841 | 0.0097696150 |
| Total  |         |            |          | 0.089973    |         |         |            |          | 0.089973    |
| MSE    |         |            |          | 0.009997    |         |         |            |          | 0.009997    |
| Accuracy (%) |       |            |          | 100          |       |         |            |          | 100          |

3.5.3. Architectural Training and Testing 4-2-3-1

Following are the results of testing with 9 test data with a 4-2-3-2 test pattern. Test results and training data can be seen in the table as follows:

**Table 5. Training and Testing Results with Model 4-2-3-1**

| Number | Target  | Output ANN | Error   | SSE  | Number | Target  | Output ANN | Error   | SSE  |
|--------|---------|------------|---------|------|--------|---------|------------|---------|------|
| 1      | 0.3031  | 0.361873   | -0.05876  | 0.0034534665 | 1      | 0.3031  | 0.361873   | -0.05876  | 0.0034534665 |
| 2      | 0.2855  | 0.324228   | -0.038734 | 0.0015003190 | 2      | 0.2855  | 0.324228   | -0.038734 | 0.0015003190 |
| 3      | 0.4294  | 0.486147   | -0.056719 | 0.0032170004 | 3      | 0.4294  | 0.486147   | -0.056719 | 0.0032170004 |
| 4      | 0.4795  | 0.544230   | -0.064744 | 0.0041917716 | 4      | 0.4795  | 0.544230   | -0.064744 | 0.0041917716 |
| 5      | 0.5903  | 0.555027   | 0.035243  | 0.0012420360 | 5      | 0.5903  | 0.555027   | 0.035243  | 0.0012420360 |
| 6      | 0.6575  | 0.570543   | 0.086922  | 0.0075554960 | 6      | 0.6575  | 0.570543   | 0.086922  | 0.0075554960 |
3.5.4. Architectural Training and Testing 4-3-2-1

Following are the results of testing with 9 test data with a 4-3-2-1 test pattern. Test results and training data can be seen in the table as follows:

| Number | Target | Output ANN | Error | SSE     | Number | Target | Output JST | Error | SSE     |
|--------|--------|------------|-------|---------|--------|--------|------------|-------|---------|
| 1      | 0.3031 | 0.412916   | 0.109809 | 0.0120579851 | 1      | 0.3031 | 0.412916   | 0.109809 | 0.0120579851 |
| 2      | 0.2855 | 0.414626   | 0.129132 | 0.0166751329 | 2      | 0.2855 | 0.414626   | 0.129132 | 0.0166751329 |
| 3      | 0.4294 | 0.420784   | 0.008644 | 0.0000741919 | 3      | 0.4294 | 0.420784   | 0.008644 | 0.0000741919 |
| 4      | 0.4795 | 0.430147   | 0.049339 | 0.0024343751 | 4      | 0.4795 | 0.430147   | 0.049339 | 0.0024343751 |
| 5      | 0.5903 | 0.466445   | 0.123825 | 0.0153326159 | 5      | 0.5903 | 0.466445   | 0.123825 | 0.0153326159 |
| 6      | 0.6575 | 0.483372   | 0.174093 | 0.0303084017 | 6      | 0.6575 | 0.483372   | 0.174093 | 0.0303084017 |
| 7      | 0.9000 | 0.957386   | 0.057386 | 0.0032931789 | 7      | 0.9000 | 0.957386   | 0.057386 | 0.0032931789 |
| 8      | 0.4558 | 0.450639   | 0.005174 | 0.0000267671 | 8      | 0.4558 | 0.450639   | 0.005174 | 0.0000267671 |
| 9      | 0.3134 | 0.412192   | 0.098841 | 0.0097696150 | 9      | 0.3134 | 0.412192   | 0.098841 | 0.0097696150 |
| Total  |        |            |        | 0.089973  |        |        |            |        | 0.089973 |
| MSE    |        |            |        | 0.009997  |        |        |            |        | 0.009997 |
| Accuracy (%) |      |            |        | 89%       |        |        |            |        | 100%     |

From table 7 it can be seen that the best architectural models that will be used to make predictions from a series of model trials are 4-3-1 with epoch 266, MSE 0.009918 and 100% accuracy rate.

3.5.5. Selection of the best architectural neural network

The results of the Matlab 6.1 application software used for 4-2-1 architectural models, 4-3-1 architecture, 4-2-3-1 architecture and 4-3-2-1 architecture are obtaining the best architectural patterns. From this pattern, it will be used to predict which region will be dominant in the State Retail Sukuk. The best assessment of architectural models is seen from several aspects such as epoch, minimum error and accuracy of truth. For more details can be seen in the following:

| Model  | 4-2-1 | 4-3-1 | 4-2-3-1 | 4-3-2-1 |
|--------|-------|-------|---------|---------|
| Epochs | 947   | 266   | 2216    | 891     |
| MSE    | 0.009999 | 0.009918 | 0.009992 | 0.009997 |
| Accuracy | 100% | 100% | 89% | 100% |

From table 7 it can be seen that the best architectural models that will be used to make predictions from a series of model trials are 4-3-1 with epoch 266, MSE 0.009918 and 100% accuracy rate.

4. Conclusion

Based on the results and discussion above, the writer can draw the following conclusions:
1. From the results of the study obtained the best architecture to predict the Retail State Sukuk based on the region in Indonesia which is divided into 4 regions, namely: the western region other than Jakarta, the Jakarta area, the Central Indonesia region, and Eastern Indonesia.

2. With the best architectural model 4-3-1, can predict the Retail State Sukuk based on region by showing 100% performance with an average error rate of 0.009918.

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