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Model Combination of Activation Functions in Neural Network Algorithms (Case: Retail State Sukuk by Group)

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Abstract

This study aims to maximize the activation function used in backpropogation networks in finding the best architectural model. The case study used is the sale of state retail sukuk based on professional groups. The combination of activation functions used for training and testing is tansig-tansig, tansig-purelin and tansig logsig. The architectural model used is the architectural model 6-2-1 and 6-5-1. The evaluation parameters used are epoch, MSE training, MSE testing and accuracy level of truth. Data processing is assisted by using Matlab software. The results showed that the tansig-logsig activation function had more stable results than tansig-tansig and tansig-purelin.

Keywords: *Activation Function, Artificial Neural Network, Backpropogation, State Retail Sukuk, Combination*

1. Introduction

Artificial Neural Networks have a positive impact on the progress of current information technology [1]. One method of artificial neural networks used to make predictions is backpropogation [2], [3]. Backpropagation is a type of artificial neural network that uses the supervised learning method used to train ANN until the desired weight is obtained. If the output gives the wrong result, the weigher is corrected so that the error can be minimized and the prediction of the next ANN is expected to be close to the correct value [4]. In this case the process of the activation function to the hidden layer has an effect on the weight learning function on backpropogation [5]. the activation function used must meet the requirements, namely: continuous, easily differentiated and is a function that does not go down. One of the functions that meets these criteria is the binary sigmoid activation function that has a range (0, 1). Therefore, this function is often used because it has an output value located in the interval 0-1 [6]. The purpose of this study is to analyze the extent of accuracy of the combination of activation functions in producing a prediction of training and testing data. In this study, the case used was a study conducted by Solikhun et al. 2017 [7] with the topic "Artificial Neural Networks in Predicting Retail State Sukuk Based on Professional Groups with Backpropogation in Encouraging the Rate of Economic Growth". The results of the study mention data from the Ministry of Finance through the website www.djppr.kemenkeu.go.id. The data is the sales data of sukuk with series 001 - 007. The activation functions used are "logsig" and "tansig". Using the data from previous research [7], the researcher conducted a combination of activation functions where the results of the study will be able to provide maximum information on the use of a series of activation functions.

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2. Rudimentary

2.1. Artificial Neural Network (ANN)

ANN is compiled by processing elements that are in the related layers and given weights where ANN is an artificial representation of the human brain that always tries to simulate the learning process in the human brain [3].

2.2. Backpropogation

ANN is compiled by processing elements that are in the related layers and given weights where ANN is an artificial representation of the human brain that always tries to simulate the learning process in the human brain [2], [5], [7].

2.3. Activation Function

The activation function functions to bridge the comparison between the sum of the values of all the weights that will come with the input value with a certain threshold value for each neuron. there are 3 activation functions, namely: (1) linear function (identity / purelin), (2) binary sigmoid function (logsig), (3) sigmoid function bipolar (tansig) [6].

3. Research Methodology

The research methodology is the stages in conducting a research to collect data or information that will be used in finding a solution of the problems that have been found.

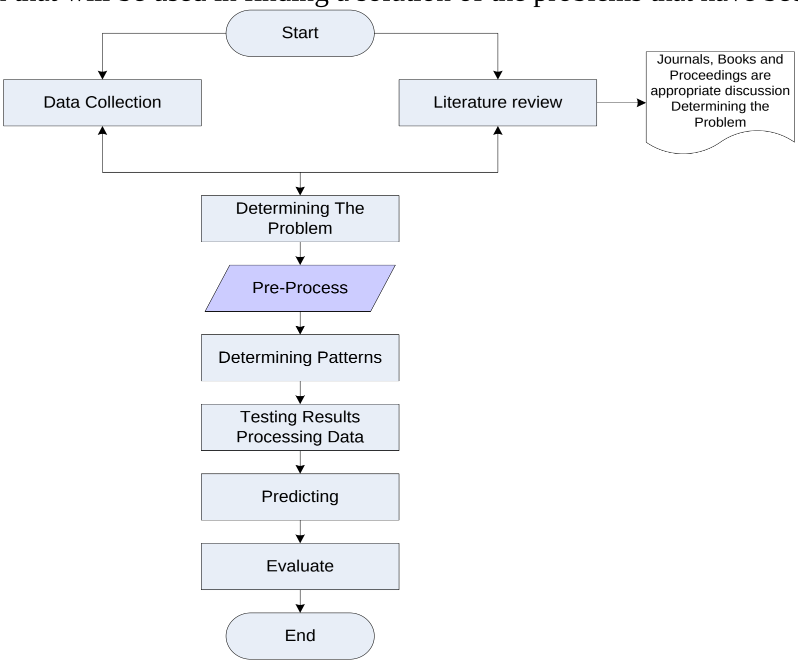

Figure 1. Research Framework

4. Results and Discussion

4.1. Input Data

In the case: retail state sukuk based on professional groups to determine the best combination of a series of activation functions using the backpropogation algorithm, where data input is a professional group consisting of civil servants (X1), private employees (X2), housewives (X3), entrepreneurs (X4), military / police (X5) and others (X6) [7].

4.2. Ouput Data

The output data is the number of state retail sukuk investors based on professional groups [7].

4.3. Data processing

In this study, the data used to maximize the use of the activation function in the backpropogation algorithm is data from research conducted by Solikhun, et al. (2017) on predictions of state retail sukuk based on professional groups. The process is divided into 2, namely the training stage and the testing phase. The research data is retail state sukuk data based on professional groups with 7 sales samples from SR001 to SR007 from 2009 to 2016. The activation function used is sigmoid binary (logsig) whose range is from 0 to 1. So that training data and testing in sukuk cases are obtained state retail based on professional groups such as the following:

Table 1. Research data

No	Name	Variable						Target
		X1	X2	X3	X4	X5	X6	
1	SR-001	1577	5578	1560	2420	40	3121	14295
2	SR-002	4099	3801	3427	3274	79	2550	17231
3	SR-003	3553	3677	2847	2956	63	2391	15487
4	SR-004	5074	3643	2849	3505	56	2479	17606
5	SR-005	814	5075	2956	4437	350	4151	17783
6	SR-006	2713	9509	5894	7934	496	8146	34692
7	SR-007	2097	7629	4806	8980	214	5980	29706

Table 2. Data that has been transformed

No	Name	Variabel						Target
		X1	X2	X3	X4	X5	X6	
1	SR-001	0,1355	0,2279	0,1351	0,1549	0,1000	0,1711	0,4291
2	SR-002	0,1937	0,1868	0,1782	0,1747	0,1009	0,1580	0,4969
3	SR-003	0,1811	0,1840	0,1648	0,1673	0,1005	0,1543	0,4566
4	SR-004	0,2162	0,1832	0,1648	0,1800	0,1004	0,1563	0,5055
5	SR-005	0,1179	0,2162	0,1673	0,2015	0,1072	0,1949	0,5096
6	SR-006	0,1617	0,3186	0,2352	0,2822	0,1105	0,2871	0,9000
7	SR-007	0,1475	0,2752	0,2100	0,3064	0,1040	0,2371	0,7849

In table 2, it can be explained that the transformation process is based on table 1 because the activation function used is binary (0-1). In this case, training and testing data use the same data. The training process and testing of data are assisted by using the help of Matlab 5.3 software.

4.4. Combination of Activation Functions

Before entering the training step and testing artificial neural networks with backpropogation, the authors performed several combinations of activation functions to find the best network architecture model by looking at the error value. The smaller the error value, the better the recommended network architecture model. The following is a combination of activation functions in the case of state retail sukuk based on professional groups.

Table 3. Combination of Activation Functions

Input Combination Model	Type of architecture	Activation Function	Learning Function Weight
Combination 1	6-2-1 and 6-5-1	*Tansig and Logsig*	*traingd*
		Tansig and Purelin	
		Tansig and Tansig	

Based on table 3, the training and testing process is carried out using the help of Matlab software with the following parameters:

code *Training*	code *Testing*
>> net=newff(minmax(P),[hidden layer,output layer],{'Activation Function 1',' 'Activation Function 2'},'traingd'); *>> net.IW{1,1};* *>> net.b{1};* *>> net.LW{2,1};* *>> net.b{2};* *>> net.trainParam.epochs= 2500000;* *>> net.trainParam.goal = 0.001;* *>> net.trainParam.Lr = 0.1;* *>> net.trainParam.show = 500;* *>> net=train(net,P,T)* *[a,Pf,Af,e,Perf]=sim(net,P,[],[],T)*	*>> PP=[input test data]* *>> TT=[test output]* *[a,Pf,Af,e,Perf]=sim(net,PP,[],[],TT)*

4.5. Combination Architecture Model 1

The following are the results of training and testing on the 6-2-1 and 6-5-1 architectural models on combination 1 (according to table 3) seen in the epoch, MSE training, MSE testing and accuracy of truth as shown in the following figure and table:

6-2-1 (tansig – tansig)

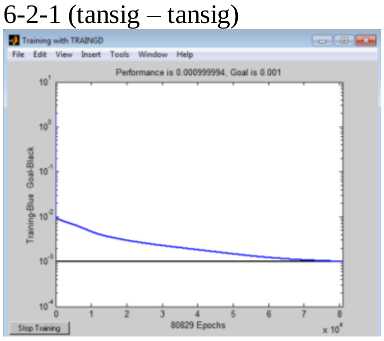

Figure 2. Goal (tansig – tansig)

6-2-1 (tansig – logsig)

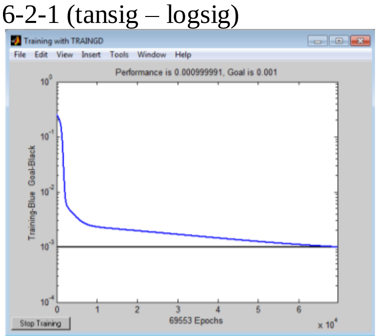

Figure 3. Goal (tansig – logsig)

6-2-1 (tansig – purelin)

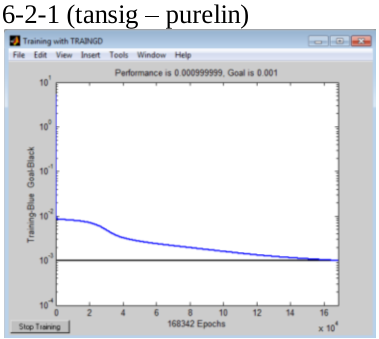

Figure 4. Goal (tansig – purelin)

6-5-1 (tansig – tansig)

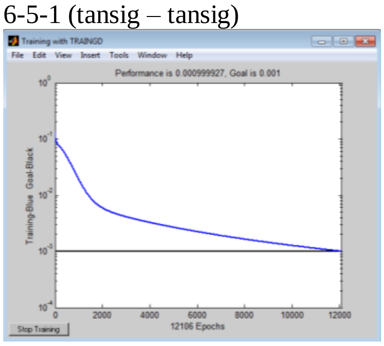

Figure 5. Goal (tansig – tansig)

6-5-1 (tansig – logsig)

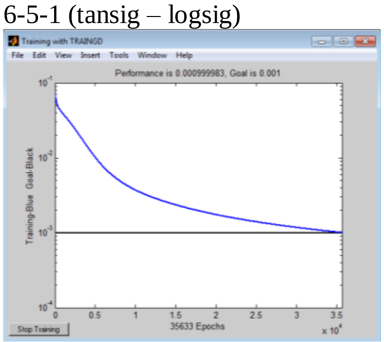

Figure 6. Goal (tansig – logsig)

6-5-1 (tansig – purelin)

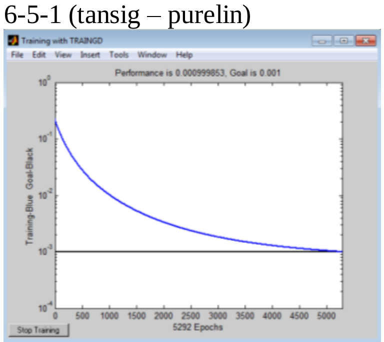

Figure 7. Goal (tansig – purelin)

In Figures 2 to 7, it can be explained that the backpropogation process that achieves goals = 0.001 based on the activation function with the architectural model 6-2-1 and 6-5-1. The following are the complete results of training and testing data for the architectural model in combination 1.

Table 4. Architectural Training and Testing 6-2-1 (tansig – tansig)

Tansig and Tansig									
Training Data					Testing Data				
No	**Target**	**Output**	**Error**	**SSE**	**No**	**Target**	**Output**	**Error**	**SSE**
1	0,4291	0,4404	-0,0113	0,0001276805	1	0,4291	0,4404	-0,0113	0,0001276805
2	0,4969	0,5288	-0,0319	0,0010186953	2	0,4969	0,5288	-0,0319	0,0010186953
3	0,4566	0,4201	0,0365	0,0013336940	3	0,4566	0,4201	0,0365	0,0013336940
4	0,5055	0,5413	-0,0358	0,0012787411	4	0,5055	0,5413	-0,0358	0,0012787411
5	0,5096	0,4985	0,0111	0,0001238069	5	0,5096	0,4985	0,0111	0,0001238069
6	0,9000	0,9258	-0,0258	0,0006656400	6	0,9000	0,9258	-0,0258	0,0006656400
7	0,7849	0,7353	0,0496	0,0024591358	7	0,7849	0,7353	0,0496	0,0024591358
Total				0,0070073937	Total				0,0070073937
Means Square Error (MSE)				**0,0010010562**	Means Square Error (MSE)				**0,0010010562**
					Truth Accuracy (%)				**100%**

Table 5. Architectural Training and Testing 6-2-1 (tansig – purelin)

Tansig and Purelin									
Training Data					Testing Data				
No	**Target**	**Output**	**Error**	**SSE**	**No**	**Target**	**Output**	**Error**	**SSE**
1	0,4291	0,4307	-0,0016	0,0000025587	1	0,4291	0,4307	-0,0016	0,0000025587
2	0,4969	0,5310	-0,0341	0,0011639701	2	0,4969	0,5310	-0,0341	0,0011639701
3	0,4566	0,4370	0,0196	0,0003849356	3	0,4566	0,4370	0,0196	0,0003849356
4	0,5055	0,5431	-0,0376	0,0014107153	4	0,5055	0,5431	-0,0376	0,0014107153
5	0,5096	0,4917	0,0179	0,0003213722	5	0,5096	0,4917	0,0179	0,0003213722
6	0,9000	0,9212	-0,0212	0,0004494400	6	0,9000	0,9212	-0,0212	0,0004494400
7	0,7849	0,7277	0,0572	0,0032706589	7	0,7849	0,7277	0,0572	0,0032706589
Total				0,0070036507	Total				0,0070036507
Means Square Error (MSE)				0,0010005215	Means Square Error (MSE)				0,0010005215
					Truth Accuracy (%)				**86%**

Table 6. Architectural Training and Testing 6-2-1 (tansig – logsig)

Tansig and Logsig									
Training Data					Testing Data				
No	**Target**	**Output**	**Error**	**SSE**	**No**	**Target**	**Output**	**Error**	**SSE**
1	0,4291	0,4360	-0,0069	0,0000476042	1	0,4291	0,4360	-0,0069	0,0000476042
2	0,4969	0,5304	-0,0335	0,0011233897	2	0,4969	0,5304	-0,0335	0,0011233897
3	0,4566	0,4307	0,0259	0,0006718348	3	0,4566	0,4307	0,0259	0,0006718348
4	0,5055	0,5410	-0,0355	0,0012573754	4	0,5055	0,5410	-0,0355	0,0012573754
5	0,5096	0,4911	0,0185	0,0003432444	5	0,5096	0,4911	0,0185	0,0003432444
6	0,9000	0,9322	-0,0322	0,0010368400	6	0,9000	0,9322	-0,0322	0,0010368400
7	0,7849	0,7347	0,0502	0,0025190034	7	0,7849	0,7347	0,0502	0,0025190034
Total				0,0069992920	Total				0,0069992920
Means Square Error (MSE)				**0,0009998989**	Means Square Error (MSE)				**0,0009998989**
					Truth Accuracy (%)				**100%**

In tables 4 to 6 is the process of training and testing data in the architectural model 6-2-1 with tansig-tansig activation functions (table 4), tansig-purelin (table 5) and tansig-logsig (table 6). The results obtained are different for each activation function. Evaluation parameters seen from Epoch, MSE training, MSE testing and accuracy level of truth. The following are the complete results of the 6-2-1 architectural model.

Table 7. Recapitulation of Training and Testing data on Architecture 6-2-1

Combination of Activation Functions	tansig-tansig	tansig-purelin	tansig-logsig
Architectural 6-2-1			
Epoch	80825	168342	69553
MSE Training	0,001001056	0,001000522	0,000999899
MSE Testing	0,001001056	0,001000522	0,000999899
Truth Accuracy (%)	100%	86%	100%

Table 8. Architectural Training and Testing 6-5-1 (tansig – tansig)

Tansig and Tansig									
Training Data					Testing Data				
No	**Target**	**Output**	**Error**	**SSE**	**No**	**Target**	**Output**	**Error**	**SSE**
1	0,4291	0,4067	0,0224	0,0005017788	1	0,4291	0,4067	0,0224	0,0005017788
2	0,4969	0,5519	-0,0550	0,0030268709	2	0,4969	0,5519	-0,0550	0,0030268709
3	0,4566	0,4675	-0,0109	0,0001183793	3	0,4566	0,4675	-0,0109	0,0001183793
4	0,5055	0,4649	0,0406	0,0016516510	4	0,5055	0,4649	0,0406	0,0016516510
5	0,5096	0,5206	-0,0110	0,0001204099	5	0,5096	0,5206	-0,0110	0,0001204099
6	0,9000	0,8603	0,0397	0,0015760900	6	0,9000	0,8603	0,0397	0,0015760900
7	0,7849	0,7849	0,0000	0,0000000001	7	0,7849	0,7849	0,0000	0,0000000001
Total				0,0069951800	Total				0,0069951800
Means Square Error (MSE)				**0,0009993114**	Means Square Error (MSE)				**0,0009993114**
					Truth Accuracy (%)				**86%**

Table 9. Architectural Training and Testing 6-5-1 (tansig – purelin)

Tansig and Purelin									
Training Data					Testing Data				
No	**Target**	**Output**	**Error**	**SSE**	**No**	**Target**	**Output**	**Error**	**SSE**
1	0,4291	0,4041	0,0250	0,0006250210	1	0,4291	0,4041	0,0250	0,0006250210
2	0,4969	0,5539	-0,0570	0,0032509389	2	0,4969	0,5539	-0,0570	0,0032509389
3	0,4566	0,4742	-0,0176	0,0003090643	3	0,4566	0,4742	-0,0176	0,0003090643
4	0,5055	0,4552	0,0503	0,0025341669	4	0,5055	0,4552	0,0503	0,0025341669
5	0,5096	0,5208	-0,0112	0,0001248391	5	0,5096	0,5208	-0,0112	0,0001248391
6	0,9000	0,8901	0,0099	0,0000980100	6	0,9000	0,8901	0,0099	0,0000980100
7	0,7849	0,7773	0,0076	0,0000576032	7	0,7849	0,7773	0,0076	0,0000576032
Total				0,0069996434	Total				0,0069996434
Means Square Error (MSE)				0,0009999491	Means Square Error (MSE)				0,0009999491
					Truth Accuracy (%)				**86%**

Table 10. Architectural Training and Testing 6-5-1 (tansig – logsig)

Tansig and Logsig									
Training Data					Testing Data				
No	**Target**	**Output**	**Error**	**SSE**	**No**	**Target**	**Output**	**Error**	**SSE**
1	0,4291	0,4302	-0,0011	0,0000012091	1	0,4291	0,4302	-0,0011	0,0000012091
2	0,4969	0,5490	-0,0521	0,0027161823	2	0,4969	0,5490	-0,0521	0,0027161823
3	0,4566	0,4582	-0,0016	0,0000024971	3	0,4566	0,4582	-0,0016	0,0000024971
4	0,5055	0,4444	0,0611	0,0037381619	4	0,5055	0,4444	0,0611	0,0037381619
5	0,5096	0,5187	-0,0091	0,0000823219	5	0,5096	0,5187	-0,0091	0,0000823219
6	0,9000	0,8784	0,0216	0,0004665600	6	0,9000	0,8784	0,0216	0,0004665600
7	0,7849	0,7868	-0,0019	0,0000036493	7	0,7849	0,7868	-0,0019	0,0000036493
Total				0,0070105817	Total				0,0070105817
Means Square Error (MSE)				**0,0010015117**	Means Square Error (MSE)				**0,0010015117**
					Truth Accuracy (%)				**100%**

In tables 8 to 10 is the process of training and testing data in the architectural model 6-5-1 with tansig-tansig activation functions (table 8), tansig-purelin (table 9) and tansig-logsig (table 10). The results obtained are different for each activation function. Evaluation parameters seen from Epoch, MSE training, MSE testing and accuracy level of truth. Calculation process for architectural models 6-5-1 with tansig-tansig, tansig-purelin and tansig-logsig activation functions using matltab software. The following are the complete results of the 6-5-1 architectural model.

Table 11. Recapitulation of Training and Testing data on Architecture 6-5-1

Combination of Activation Functions	tansig-tansig	tansig-purelin	tansig-logsig
Architectural 6-5-1			
Epoch	12106	5292	35633
MSE Training	0,000999311	0,000999949	0,001001512
MSE Testing	0,000999311	0,000999949	0,001001512
Truth Accuracy (%)	86%	86%	100%

5. Conclusion

In choosing the best architectural model by combining several activation functions (tansig-tansig, tansig-purelin and tansig-logsig) for architectural models 6-2-1 and 6-5-1 have different results. In the activation function (tansig-purelin), the training process tends to be fast and find goals. This is indicated by the smallest epoch of several activation functions performed. Test results with activation functions (tansig-purelin) tend to be unstable in the prediction process. It can be concluded that a small epoch does not guarantee the results of high predictive accuracy. Likewise with the activation function (tansig-tansig), it has a poor level of accuracy. This hall can be seen from the results of training and testing on the Matlab software trial. For the activation function (tansig-tansig), it has a small MSE Training level, but the MSE Test is not stable. Of the three activation functions, the activation function (tansig-logsig) has more stable results seen from training and testing data. Of the 2 architectural models used (6-2-1 and 6-5-1), the activation function (tansig-logsig) is better than the other two activation functions (tansig-tansig; tansig-logsig).

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