INFLATION FORECASTS IN AMBON USING NEURAL NETWORK APPLICATIONS BACKPROPAGATION

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Abstract. *An artificial Neural Network is the processing of information systems on certain characteristics which are artificial representations based on human neural networks. Artificial Neural Networks can be applied to various fields in human life, one of which is the economic field. In this study, the Artificial Neural Network is used to predict the inflation rate using the Backpropagation method. The data used in this study is 144 data, with 100 data as training data and 44 data as test data taken from the Central Statistics Agency of Maluku Province from 2008-2019. The best prediction accuracy level is obtained by using learning rate (a) = 0.1, Target Error = 0.000001, Maximum epoch = 500, network architecture 11-1, and 70% training data sharing scheme and 30% test data. The average absolute error percentage (MAPE) is 85.21%.*

Keywords: artificial neural networks, backpropagation, inflation rate.

https://ojs3.unpatti.ac.id/index.php/barekeng/   barekeng.math@yahoo.com

1. INTRODUCTION

Economic development is essentially a series of policy efforts aimed at improving people's living standards, expanding job opportunities and directing the distribution of income evenly. A country is seen as successful or not in solving its own country's economic problems, it can be seen from the country's macro and micro economies. Macroeconomics is the study of activities that discuss the economy of a country. One of the macroeconomic indicators used to see/measure the stability of a country's economy is inflation [1].

Inflation is one of the macroeconomic indicators that often occurs in a country's economy [2]. An increase in prices that occurs in one or two goods cannot be said to be inflation unless the increase affects an increase in the price of other goods. The inflation rate that continuously increases will have a negative impact on the country's economy, namely causing a decrease in the real income of the community, will create uncertainty for economic actors in making decisions, and pressure on currency value [3].

Inflation occurs because it is influenced by several factors such as the Consumer Price Index (CPI), Wholesale Price Index (IHPB) and Gross Domestic Product (Bank Indonesia, 2018). The largest inflation occurred in December at 1.20%, and the lowest inflation occurred in July at -1.45%. Compared to the highest national inflation data that also occurred in December of 0.62%, Ambon City has the highest inflation percentage twice the national highest inflation [4].

The instability of the percentage of inflation that has occurred until now is still a major problem for the economy of Ambon City [5]. Therefore, it is necessary to forecast inflation as a consideration in making decisions and policies for the Ambon City government. Many methods have been used to predict Ambon City and National inflation. However, the search for more accurate prediction or forecasting methods is still an interesting topic.

Artificial Neural Network (ANN) is an information system processing on certain characteristics which is an artificial representation based on human neural network. Starting from a simple ANN introduced by Waffen McCulloch and Walter Pitts in 1943, by several experts, ANN continues to be developed as an application of existing ANN models to help solve problems in the real word [6]. One of the forecasting methods in ANN is the Backpropagation.

Method Backpropagation is a supervised learning algorithm and is usually used by perceptrons with many layers to change the weights associated with the neurons in the hidden layer. Algorithm Backpropagation uses error output to change its weight values in the backward direction. To get error , the forward propagation stage must be done first [7]. Forecasting with this method can be used in the economic field. Not only that, when compared with the method used by previous researchers, namely Kondo Lembang 2017 with the ARIMA method, the backpropagation method is superior because the ARIMA method if there is additional data, the previous model cannot be used. but the backpropagation method does not require a method change or in other words if there is additional data, the previous model can still be used.

Thus, this study will use the Backpropagation Artificial Neural Network (ANN) method to predict the inflation rate in Ambon City.

2. RESEARCH METHODS

2.1. Definition of Artificial Neural Networks

Artificial Neural Networks (ANN) is one of the artificial representations of the human brain which always tries to simulate the learning process of the human brain [8]. ANN was created as a generalized mathematical model of human cognition which is based on the assumption that information processing occurs in simple elements called neurons, signals flow between cells nerve through a connecting link, each connecting link has an appropriate weight, and each cell nerve will be an activation function of the weighted summation signal that enters it to determine the output signal [9]. ANN is determined by 3 things:

1. The pattern of relationships between neurons (called network architecture).
2. Method for determining the weight of the link.
3. Activation function.
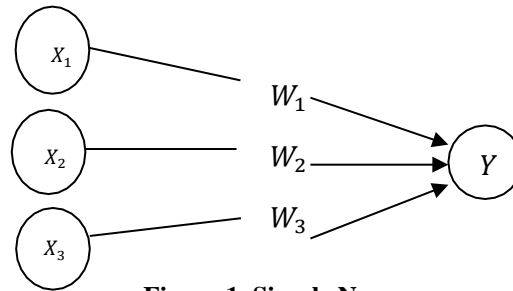
As an example, consider neuron Y in Figure 1.

Figure 1. Simple Neurons

Y receive input from neurons x_1, x_2, x_3 and weighs each relationship is w_1, w_2, w_3. . The three existing neural impulses are added up, namely net $= x_1 w_1 + x_2 w_2 + x_3 w_3$. The magnitude of the impulse received by Y follows the activation function $y = f(net)$. If the value of the activation function is strong enough, the signal will be forwarded. The value of the activation function (network model output) can also be used as a basis for changing the weights.

2.2. The basic concepts of neural artificial network artificial

In Neural networks, the basic concept that must be understood is that every pattern of input and output information given to the ANN is processed in neurons. These neurons are collected in layers called neuron layers. The layers that make up the ANN can be divided into 3, namely:

1. Input layer, the units in the layer are input called input units. These input units receive data patterns from the outside that describe a problem.

2. Hidden layers, the units in the hidden layer are called hidden units. Where the output cannot be directly observed.

3. Output layer, the units in the layer are output called output units. The output of this layer is an ANN solution to a problem.

2.3. Artificial Neural Network Architecture

ANN is one of the artificial representations of the human brain that always trying to simulate the learning process of the human brain [10] ANN has several network architectures that are often used in various applications. The ANN architecture, among others:

1. Single Layer Network

A network with a single layer consist layer and 1 output layer. Every neuron in the input layer is always connected to every neuron in the output layer. This network only accepts input then it will directly process it into output without having to go to through the hidden layer.
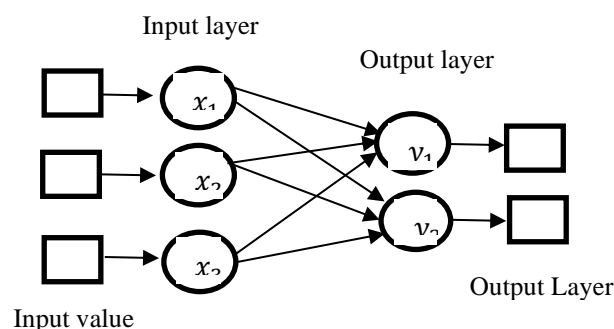

Figure 2. Single Layer Architectur

2. Multilayer Net

A network with multiple layers has a particular characteristic which has 3 types of layer: the input

layer, an output layer and a hidden layer. Networks with multiple layers can solve more complex problems than networks with single layers. However, the training process often takes a long time. Examples of ANN algorithms that use this method are MADALINE, backpropagation, and Neocognitron.
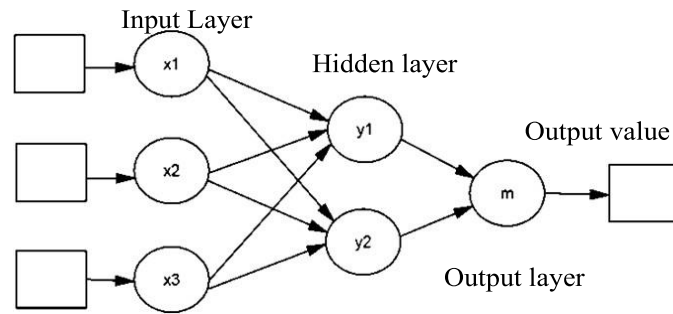

Figure 3. Multilayer Architecture

3. Competitive Layer

In this network a set of neurons compete for the right to be active. An example of an algorithm that uses this network is LVQ.
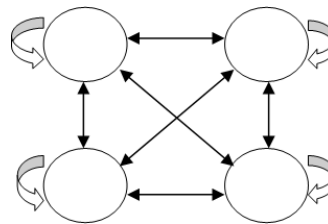
Figure 4. Competitive Layer Architecture

4. Backpropagation Activation Function

In backpropagation, the activation function used must meet several requirements, namely: continuous, easily differentiated and is a function that does not descend. [11]One of the functions that meet these three conditions so that it is often used is the binary sigmoid function which has a *range* (0.1). Given $f(x) = \frac{1}{1+e^{-x}}$ with the derivative $f(x) = f(x)(1 - f(x))$.

The graph of this function is shown in Figure 5

Figure 5. Binary Sigmoid Activation

Another function that is often used is the bipolar sigmoid function whose form is similar to the binary sigmoid function, but with a range (-1.1). Given $f(x) = \frac{2}{1+e^{-x}} - 1$ with the derivative $\frac{(1+f(x))(1-f(x))}{2}$

Figure 6. Bipolar Sigmoid Activation Function

The sigmoid function has a maximum value = 1. So for patterns with more than 1 target, the input and output patterns must first be transfo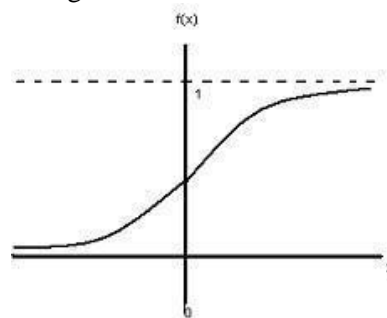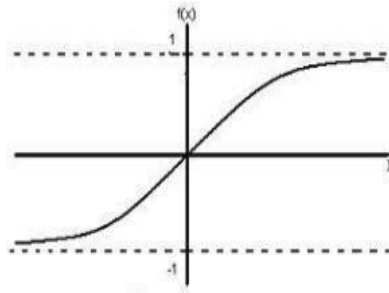rmed so that all patterns have the same range as the sigmoid function used. Another alternative is to use the sigmoid activation function only on layers that are not output layers. In the output layer, the activation function used is the identity function $f(x) = x$.

Algorithm Training Backpropagation

The backpropagation training is as follows [12] :

Step 0 : Initialize the weight value with a small random value.

Step 1 : As long as the stop condition is still not met, do steps 2 - 9.

Step 2 : For each training pair $(s: t)$, do steps 3 - 8.

Feedforward:

Step 3 : Each input $(X_i, i = 1, ... , n)$ receives the input Xi and propagates the signal to all units on the layer (hidden layer).

Step 4 : Each unit in $(Z_j, j = 1, ... , p)$ the calculation of the input value using its weight value.

$$Z_{in_j} = v_{0j} + \sum_{t=1}^{n} x_i v_{ij}$$

Next, calculate the output using the selected activation function.

$$Z_j = f\left(Z_{in_j}\right) = \frac{1}{1 + e^{-Z_{in_j}}}$$

The results of the function are sent to all units in the layer units output.
Step 5 unit output $(Y_k, k = 1, ... , m)$ calculate the input using its weighted value

$$y_{in_k} = W_{0k} + \sum_{j=1}^{p} Z_j W_{jk}$$

Then calculate the output using the

$$Y_k = f(y_{in_k}) = \frac{1}{1 + e^{-y_{in_k}}}$$

Backpropagation of Error

Step 6 unit output $(Y_k, k = 1, ... , m)$ receives a target pattern that corresponds to the input and then calculates the error information

$$\delta_k = (t_k - y_k)f(y_{in_k})$$

Then calculate the correction of the weight value that will be used to update the weight value:

$$\Delta w_{jk} = \alpha \delta_k z_j$$

Calculate the correction of the bias value that will be used to update the value of w_{0k}:

$$\Delta w_{0k} = \alpha \delta_k$$

and the value is sent to the unit in the layer.

Step 7 every unit in $(Z_j, j = 1, \dots, p)$ delta count input comes from the unit in the layer above it:

$$\delta_{in\,j} = \sum_{k=1}^{m} \delta_j w_{jk}$$

Then that value is multiplied by the derivative value of the activation function to calculate the error information:

$$\delta_j = \delta_{in\,j} f'(z_{in\,j})$$

Calculate the weighted correction value which is then used to update the value v_{ij}

$$\Delta v_{ji} = \alpha \delta_j x_i$$

and calculate the bias correction value which is then used to update weights biases v_{0j}:

$$\Delta v_{0j} = \alpha \delta_j$$

Step 8 : Each unit of output $(Y_k, k = 1, \dots, m)$ update bias and weights $(j = 0, \dots, p)$

$$w_{kj}(new) = w_{kj}(old) + \Delta w_{kj}$$

Each unit of hidden $(Z_j, j = 1, \dots, p)$ update bias and weights $(i = 0, \dots, n)$

Step 9 : Optimality test: Are the stopping conditions met?

In some cases the training carried out requires many iteration so that the training process takes a long time. To speed up iteration, you can set parameters α or learning rate. The value α lies between 0 and 1 ($0 \leq \alpha \leq 1$). If the value α is greater, then fewer iterations are used but cause the correct pattern to be damaged so that understanding becomes slow. To find out when the training process will stop, it can be done by limiting the number of iterations or determining the Mean Square Error (MSE) value between the target output that must be achieved (t_k) and the network output (y_k). If there is a lot of training data, then to calculate the Mean Square Error (MSE) the following equation is used [13] :

$$MSE = \frac{\sum_{i=1}^{m}(t_k - y_k)^2}{m}$$

And because MSE is used to produce moderate errors which are preferred by a forecast which usually produces smaller errors but sometimes produces a very large error. Meanwhile, Mean Absolute Percent Error (MAPE) is used if the size of the forecasting variable is an important factor in evaluating the accuracy of the forecast. MAPE provides an indication of how big the forecast error is compared to the actual value of the series [14].

Therefore, in this study, the method of calculating the accuracy value to be used is MAPE with the following equation [15]:

$$MAPE = \frac{\sum_{i=1}^{m}|PE_i|}{n}$$

$$MAPE = \frac{1}{n}\sum_{i=1}^{m}|PE_i|$$

$$MAPE = \frac{1}{n}\sum_{i=1}^{m}\frac{|x_{origin} - x_{output}|}{x_{origin}} \times 100\%$$

3.   RESULTS AND DISCUSSION

3.1. Research Variable

In this study, the variable used is the amount of inflation in Ambon City obtained from the Central Statistics Agency of Maluku Province, each data is a monthly recapitulation for the last 12 years from 2008-2019. The following presents the data obtained:

Table 1. Ambon City inflation data for 2008-2019

NO	Month	Years											
		2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
1	January	3.9	1.22	3.23	-0.83	1.62	1.81	0.81	2.37	0.28	0.28	0.63	0.48
2	February	1.83	0.71	-0.65	0.04	1.31	-2.29	0.85	1.03	0.18	-0.74	0.67	0.15
3	March	-2.73	0.32	0.27	-0.46	1.33	0.79	0.64	0.44	-0.36	1.13	-0.14	0.86
4	April	1.82	0.4	-0.51	0.09	0.79	0.27	0.92	0.33	-1.07	-0.76	-0.53	-0.16
5	May	3.38	-0.11	-0.07	1.66	0.06	2.25	0.4	1.06	1.64	0.2	1.19	1.46
6	June	1.76	-2.7	0.85	3.76	2.39	-0.15	0.18	-0.25	0.23	2.91	0.94	0.42
7	July	1.85	1.1	1.28	-1.2	1.7	4.03	0.14	1.03	0.5	0.86	-1.45	-0.03
8	August	2.31	1.27	2.4	0.83	0.19	4.79	0.12	-1.77	0.43	-2.08	0.15	-0.18
9	September	0.82	-0.55	0.95	-0.4	-1.87	-0.92	-0.26	0.38	-0.11	-0.23	-0.45	-0.05
10	October	-1.63	0.76	-0.29	-0.67	-2.44	-3.82	0.15	1.02	0.53	-1.28	0.45	0.28
11	November	-1.4	0.5	-0.24	-0.34	0.63	0.53	0.82	-0.44	0.48	-0.59	0.85	-0.83
12	December	-1.84	3.49	1.3	0.43	0.94	1.51	1.85	0.62	0.53	0.34	1.2	-0.33

Source: Central Statistics Agency 2019

Based on the data on the amount of inflation above which will then be normalized into a weighted form so that it can be used in the process of testing and training data with the Backpropagation method. This stage is the stage of preparation of data where the data is normalized by using the formula, as follows [16] :

$$x_{new} = \frac{0.8(x - x\_min)}{x_{min} - x_{max}} + 0.1$$

From the above equation can be shown the results of calculations using Microsoft Excel software as in the following Table 2:

Table 2. Normalization Results

NO	Month	2008	2009	2010	2011	2012	2013
1	January	0.9	0.62228	0.83057	0.409845	0.663731	0.68342
2	February	0.685492	0.56943	0.428497	0.5	0.631606	0.258549
3	March	0.212953	0.529016	0.523834	0.448187	0.633679	0.57772
4	April	0.684456	0.537306	0.443005	0.505181	0.57772	0.523834
5	May	0.846114	0.484456	0.488601	0.667876	0.502073	0.729016
6	June	0.678238	0.216062	0.583938	0.885492	0.743523	0.480311
7	July	0.687565	0.609845	0.628497	0.371503	0.672021	0.913472
8	August	0.735233	0.627461	0.74456	0.581865	0.515544	0.992228
9	September	0.580829	0.43886	0.594301	0.454404	0.302073	0.400518
10	October	0.326943	0.574611	0.465803	0.426425	0.243005	0.1
11	November	0.350777	0.547668	0.470984	0.460622	0.56114	0.550777
12	December	0.305181	0.857513	0.63057	0.540415	0.593264	0.652332

NO	Month	2014	2015	2016	2017	2018	2019
1	January	0.579793	0.741451	0.52487	0.52487	0.56114	0.545596
2	February	0.583938	0.602591	0.514508	0.419171	0.565285	0.511399
3	March	0.562176	0.541451	0.458549	0.612953	0.481347	0.584974
4	April	0.591192	0.530052	0.384974	0.417098	0.440933	0.479275
5	May	0.537306	0.605699	0.665803	0.51658	0.619171	0.64715
6	June	0.514508	0.469948	0.519689	0.797409	0.593264	0.539378
7	July	0.510363	0.602591	0.547668	0.584974	0.345596	0.492746
8	August	0.50829	0.312435	0.540415	0.280311	0.511399	0.477202
9	September	0.468912	0.535233	0.484456	0.472021	0.449223	0.490674
10	October	0.511399	0.601554	0.550777	0.363212	0.542487	0.52487
11	November	0.580829	0.450259	0.545596	0.434715	0.583938	0.409845
12	December	0.687565	0.560104	0.550777	0.531088	0.620207	0.424274

Based on the data that has been transformed through normalization process, the data above will then be used as input and is data that has gone through the preprocessing stage. At this stage the data is formed in the form of time series data. This data is then made a pattern or data sharing scheme as in the following Table 3:

Table 3. Time Series Data

No	x_1	x_2	x_3	Target
1	January 2008	February 2008	March 2008	April 2008
	….	…	…	…
3	September 2019	October 2019	November 2019	December 2019

3.2. Stages of Data Processing Amount of Inflation

The allocation of training and testing data in this study is divided into 70% training data and 30% testing data. So from the total data in the previous table, obtained as many as 98 training data and 43 test data. In the backpropagation method, the architecture of a network will greatly determine the success of the target to be achieved because not all problems can be solved with the same architecture. The network architecture applied is a multilayer network that uses input, hidden and output layers. The number of hidden layers is determined by the user of the system by means of the best convergence experiment (trial and error), until the best training convergence results are obtained (the smallest number of epochs). The input system parameters for the formed pattern are:

Net Size: Input layer   : 3 Neuron

            Hidden Layer   : 3 Neuron, 11 Neuron dan 1 Neuron Output

            Layer   : 1 Neuron

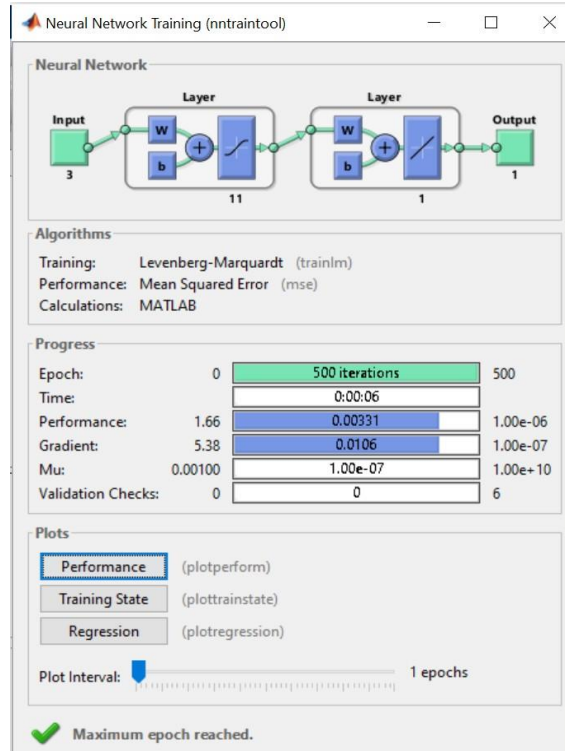Maximum epoch/ iteration   : 500

Goal/Target (MSE)   : 0,000001

Figure 7. Progress of Neural Network Training The

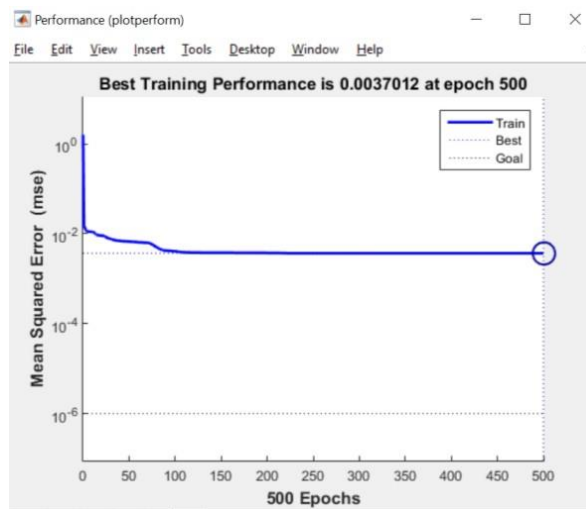The Following analysis is based on the Figure 7:

Figure 8. Performance Plot

Based on Figure 7 it can be seen that the results of the backpropagation ANN process are displayed in the form of images. Figure 8 shows the learning process at each epoch. In this process, the iteration is stopped at the 5th epoch, because the desired epoch limit has been reached MSE = 0.0037012, where this MSE is the MSE that appears when the training is completed according to the specified iteration.
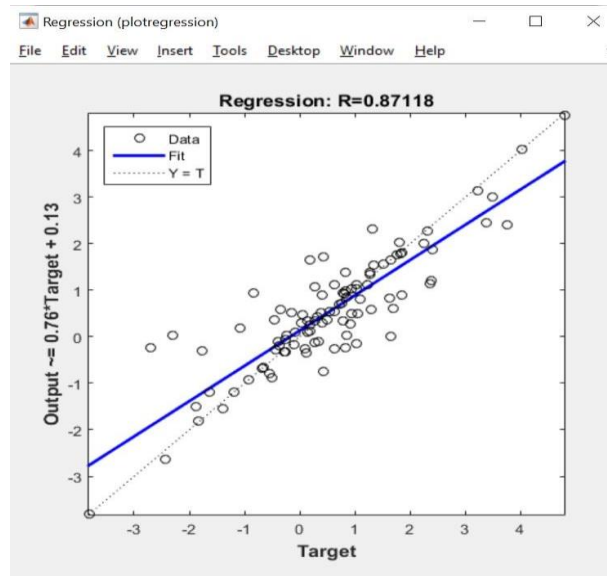

Figure 9. Plot regression

Figure 9 shows the relationship between the target and the network output on the training data. From testing on the training data for the match between the output and the target, the correlation coefficient is 0.87118 where the best result is 1, with a correlation coefficient of that size indicating that the network is able to predict well according to the existing data.

3.3. Training Phase

In training, the initial weight and bias values are determined with small random numbers in order to get the minimum error for variable prediction results because if there are no limits on the weight and bias values, the network output will change after forming the network if the training is repeated even though with the same hidden network. The results of the training and testing are as follows:

Table 4. Result of The Training

NO	Real Training Target	Output Target JST	NO	Real Training Target	Output Target JST
1	1.82	1.95	50	0.06	0.64

NO	Real Training Target	Output Target JST	NO	Real Training Target	Output Target JST
2	3.38	3.6	51	2.39	0.05
3	1.76	1.66	52	1.7	1.95
4	1.85	1.83	53	0.19	0.44
5	2.31	2.47	54	-1.87	-0.4
6	0.82	0.71	55	-2.44	-2.2
7	-1.63	-0.2	56	0.63	0.51
8	-1.4	-1.4	57	0.94	0.58
9	-1.84	-2.1	58	1.81	1.98
10	1.22	1.22	59	-2.29	-1.1
11	0.71	1.16	60	0.79	0.53
12	0.32	0.54	61	0.27	0.07
13	0.4	0.28	62	2.25	2.22
14	-0.11	0.21	63	-0.15	-0.2
15	-2.7	-0.3	64	4.03	3.58
16	1.1	1.11	65	4.79	4.85
17	1.27	0.72	66	-0.92	-0.9
18	-0.55	-1.1	67	-3.82	-3.7
19	0.76	0.34	68	0.53	0.53
20	0.5	0.29	69	1.51	1.6
21	3.49	2.6	70	0.81	1.23
22	3.23	3.22	71	0.85	1.17
23	-0.65	-0.8	72	0.64	0.49
24	0.27	0.27	73	0.92	0.4
25	-0.51	-0.1	74	0.4	0.17
26	-0.07	-0.5	75	0.18	0.32
27	0.85	0.63	76	0.14	0.18
28	1.28	1.84	77	0.12	-0.1
29	2.4	2.34	78	-0.26	-0.2
30	0.95	0.71	79	0.15	-0.3
31	-0.29	0.04	80	0.82	0.23
32	-0.24	-0.8	81	1.85	1.31
33	1.3	0.52	82	2.37	1.04
34	-0.83	-0.1	83	1.03	1.21
35	0.04	0.52	84	0.44	-0.7
36	-0.46	1.71	85	0.33	-0.3
37	0.09	-0.1	86	1.06	0.31
38	1.66	0.46	87	-0.25	-0.5
39	3.76	2.63	88	1.03	0.42
40	-1.2	-1.1	89	-1.77	-1.1
41	0.83	0.8	90	0.38	0.37
42	-0.4	-0.8	91	1.02	0.56
43	-0.67	-0.4	92	-0.44	-0.7
44	-0.34	0.44	93	0.62	0.55
45	0.43	0.84	94	0.28	0.54
46	1.62	2.03	95	0.18	0.83
47	1.31	2.67	96	-0.36	0.06
48	1.33	0.74	97	-1.07	-0.2
49	0.79	0.27	98	1.64	1.34

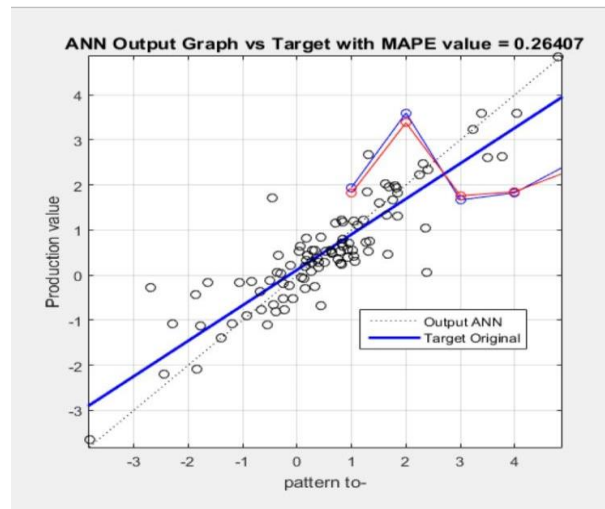With MAPE Value = 0.26407, the accuracy value is 73.6%.

Figure 10. Graph of Training Results The

Figure 10 shows the results of the comparison between the target line and the ANN output line in training with an alpha of 0.1. for the best results will occur if (o) occupy the position of the ANN target line and output line, but there are also those who do not occupy the target position and ANN output, this is due to a significant error during training.

3.3. Testing Phase of Test

At this stage the normalized test data will be processed using software to obtain test result data which will also be used to obtain MAPE in the testing process.

Table 5. Result of Testing Data

NO	Real Testing Target	Output Target JST	NO	Real Testing Target	Output Target JST
1	0.23	1.035862	23	-0.53	-0.03757
2	0.5	2.898894	24	1.19	0.220391
3	0.43	0.610657	25	0.94	-1.5379
4	-0.11	0.034911	26	-1.45	4.922222
5	0.53	-0.16276	27	0.15	1.650956
6	0.48	0.121407	28	-0.45	2.001972
7	0.53	0.548865	29	0.45	1.90969
8	0.28	0.133981	30	0.85	0.084719
9	-0.74	-0.02723	31	1.2	3.24246
10	1.13	0.45359	32	0.48	0.256334
11	-0.76	-2.94706	33	0.15	0.661957
12	0.2	-0.82654	34	0.86	0.187445
13	2.91	1.606182	35	-0.16	-0.31612
14	0.86	1.222331	36	1.46	0.00032
15	-2.08	-3.26409	37	0.42	-3.68897
16	-0.23	-2.48921	38	-0.03	1.692999
17	-1.28	3.428207	39	-0.18	0.009878
18	-0.59	-3.61129	40	-0.05	-0.0034
19	0.34	2.209172	41	0.28	-0.03709
20	0.63	4.362891	42	-0.83	0.340428
21	0.67	3.243943	43	-0.33	0.619199
22	-0.14	0.284794			

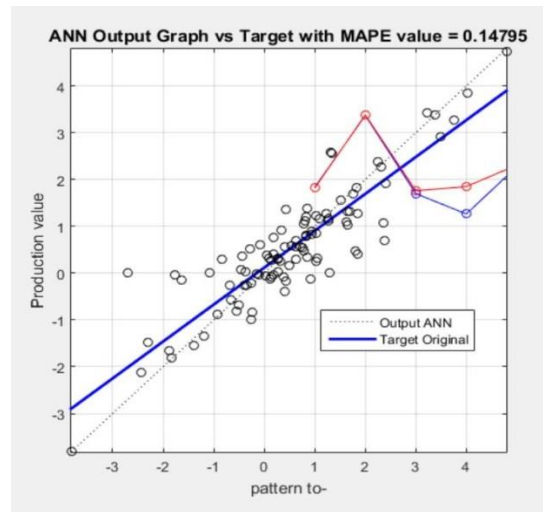With MAPE value = 0.14795, the accuracy value is 85.21%.

Figure 11. Graph of Test Results

3.4. Stages of Data Forecasting Analysis of Total Inflation

Forecasting Phase

From the results at the testing stage using a trained network, it can be predicted the amount of Inflation production in Ambon city for the next 5 months, namely January and April 2020, with the following:

Table 6. Forecasting Data

January 2020	February 2020	March 2020	April 2020
1.2665	2.8396	-1.7052	1.3765

Results from these results it can be seen that the inflation rate in Ambon City will increase significantly in January and February but then decrease in March and increase again in April 2020.

4. CONCLUSIONS

Based on the results of this study, it can be concluded that the Neural Network Method *Backpropagation* can be used to predict the Ambon Inflation Rate with an accurate level of accuracy. The Level is best prediction accuracy obtained by using the values of *Learning Rate* = 0.9, Momentum = 0.5, Maximum *Epoch* = 1000, Network Architecture 11-1 and data sharing *Training* and *Testing* by 30% and 70%. The accuracy rate for the prediction of the Ambon Inflation Rate is 99.753%. Average percentage error *absolute value* (MAPE) is 85.21%.

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