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# Artificial Neural Network Model In Forecasting Post-Covid-19 Aviation Business Development Using Multi Layer Perceptron (MLP)

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## Abstract

*Aviation business forecasting is one way to find out the next steps that must be taken by aviation business actors as well as steps that the government must take to improve the country's economy, especially from the air transportation sector. before the covid-19 pandemic, the global aviation industry experienced a positive trend, where the volume of global passenger flow in december 2019 increased by 4.9% based on the calculation of revenue passenger kilometers, but since covid-19 began to emerge in early 2020, the movement the global rpk experienced a drastic decline until march 2020, then from april 2020 it experienced an increasing trend again, but lower than in 2019. To be able to provide recommendations for industry players aviation for study material and policy implementation to continue to improve flight performance, especially in Indonesia. MLP is also able to show better performance than the classic arima model. In this study, the mlp model will be used to forecast post-covid-19 flight conditions which will provide research results about the description of the condition of the aviation industry for the future, especially in responding to the challenges of the post-covid-19 aviation industry. to be able to provide recommendations for industry players aviation for study material and policy implementation to continue to improve flight performance, especially in indonesia.*

Keywords
forecasting; multi-layer model; ANN; backpropagation

## I. Introduction

The spread of Covid-19 has occurred all over the world. Covid-19 has entered Indonesia since 02 March 2020. Until now, 04 January 2021 it has infected772,103 people throughout Indonesia. Covid-19 not only has an impact on public health, but it has also even resulted in the number of deaths that have reached 22,911 people as of January 4, 2021, in all parts of Indonesia.

The outbreak of this virus has an impact of a nation and Globally (Ningrum et al, 2020). The presence of Covid-19 as a pandemic certainly has an economic, social and psychological impact on society (Saleh and Mujahiddin, 2020). Covid 19 pandemic caused all efforts not to be as maximal as expected (Sihombing and Nasib, 2020).

Covid-19 has also paralyzed the world economy, including Indonesia. Information quoted on compas.com On November 8, 2020, the decline in Indonesia's economic growth in the second quarter of 2020 was minus 5.32 percent. It is no exception that the airline business is under tremendous pressure considering that the number of flights has decreased significantly in line with the restrictions imposed by the government in each country. The losses experienced by the aviation industry at the global level were the reduction of passenger seats by up to 35% by various airlines. And the reduction of more than 800 million passengers from international passenger traffic resulted in an estimated loss of

more than USD 150 billion. (Source ICAO 2020). For the national level, the growth of the aviation sector in the first quarter of 2020 experienced a contraction of up to 13.3%. Foreign tourists in the first quarter of 2020 decreased by 31% compared to the same period in 2019, as well as domestic tourists. (Source BPS 2020). The conditions are very concerning when compared to conditions before experiencing the Covid-19 Pandemic. The following table describes flight conditions before the pandemic and during the pandemic.

**Table 1.** Flight Conditions Before the Pandemic and During the Pandemic

| Conditions Before the Covid-19 Pandemic | Conditions During the Covid 19 Pandemic |
|---|---|
| Prior to the COVID-19 pandemic, the global aviation industry experienced a positive trend, where the volume of passenger flow globally in December 2019 increased by 4.9% based on the calculation of Revenue Passenger Kilometers (RPKs). (IATA, 2019) | Since COVID-19 began to emerge since early 2020, the global RPK movement experienced a drastic decline until March 2020, then since April 2020 it experienced an increasing trend again, but lower than in 2019 |
| Passenger Load Factor (PLFs) or the ratio between the number of passengers and the maximum capacity on flights globally in December 2019 was 82.6%. Figures that are appropriate and the largest in the history of the world of aviation. | PLF in June 2020 fell to 57.6%, the lowest in history |
| The trend of cargo flow contracted in December 2019, increasing by 3.3%. | The cargo industry has shown an upward trend since May 2020, although it is still below the figure in 2019; FTK in May 2020 decreased by 20.1% and 17.6% in June 2020. |

Source: https://balitbanghub.dephub.go.id

The table above serves as study material for researchers about flight conditions before and during the pandemic so that it attracts researchers' attention whether flight conditions will recover completely as they were before the pandemic or will experience a more significant increase compared to before the COVID-19 pandemic. In the development of statistical forecasting models, the Artificial Neural Network (ANN) model is a model that is considered good in forecasting. ANN is a model that can explain complex forecasting problems with non-linear relationships. The ANN model shows better performance than classical time series models such as ARIMA. One of the ANN models used in forecasting is the Multi-Layer Perceptron (MLP) model. Multi-Layer Perceptron (also known as multilayer feed-forward networks) is the most popular and widely used ANN model. MLP shows good performance compared to several other models, both multiple linear regression models, and other ANN models. In forecasting, MLP is also able to show better performance than the classic ARIMA model. In this research,

How to apply the MLP model in the Aviation Business Paramalan after the Covid-19 Pandemic, especially in Indonesia with a comparison of the ELM model which is also an ANN model.

## II. Review of Literature

### 2.1. Multi-Layer Perceptron

Artificial Neural Network (ANN) is a statistical model whose structure and function are similar to the human brain. Artificial neurons in ANN have functions similar to neurons in the human nervous system. Figure 1 shows an artificial neuron model. The ANN consists of artificial neurons consisting of layers which are combined in one model.

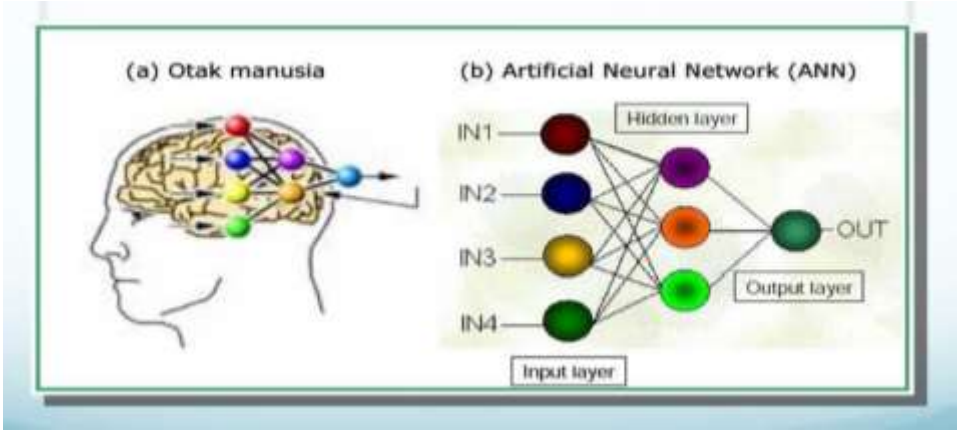


***Figure 1.*** *Artificial Neural Model*

The Multi-Layer Perceptron consists of an input layer and an external layer as well as a hidden layer. However, the number of hidden layers in MPL can vary. The number of input layers is equal to the number of independent variables in the model. While the number of neurons in the external variable is the same as the dependent variable in the model. Figure 2 shows the Multi-Layer Perceptron (MLP) model. In the time series model using MLP, a point in time t with h-step forward forecasting is calculated using n+1 lag from observations, which is n points backward from time by stating the number of inputs to the MLP neuron.

The functional form of the MLP with a single layer with a single node is as follows: With is a vector containing observations in the form of time series data with the known number of inputs on the MLP. The network parameters are written as weights and from the output and hidden layers of the MLP. and are the bias of each neuron. I and H represent the number of inputs and neurons in the hidden layer in the MLP network. The g function is a non-linear transfer function, which usually uses a sigmoid logistic or hyperbolic tangent function.

### 2.2. Neural Network

Artificial Neural Network (ANN) or neural network is a computational method that imitates a biological neural network system. This method uses basic non-linear computational elements called neurons which are organized as interconnected networks, so that they are similar to human neural networks. Artificial Neural Networks are formed to solve a particular problem such as pattern recognition or classification due to the learning process (Sahat, 2013). Like biological neurons, the Artificial Neural Network is also a system that is "fault tolerant" in 2 respects. First, it can recognize an input signal that is somewhat different from what it has received before. As an example, humans can often recognize someone whose face has been seen from a photo or can recognize someone whose face is slightly different because they haven't seen him for a long time. Second, still

able to work even though some of the neurons are not able to work properly. If a neuron is damaged, other neurons can be trained to replace the function of the damaged neuron (Sahat 2013). According to Wuryandari (2012) Artificial Neural Network (ANN) is an information processing system that has characteristics resembling a biological neural network (JSB). ANN was created as a generalization of a mathematical model of human cognition based on the following assumptions: other neurons can be trained to replace the function of the damaged neuron (Sahat 2013). According to Wuryandari (2012) Artificial Neural Network (ANN) is an information processing system that has characteristics resembling a biological neural network (JSB). ANN was created as a generalization of a mathematical model of human cognition based on the following assumptions: other neurons can be trained to replace the function of the damaged neuron (Sahat 2013). According to Wuryandari (2012) Artificial Neural Network (ANN) is an information processing system that has characteristics resembling a biological neural network (JSB). ANN was created as a generalization of a mathematical model of human cognition based on the following assumptions:

1. Information processing occurs in simple elements called neurons
2. Signals flow between nerve cells/neurons through a connecting junction.
3. Each connecting joint has an appropriate weight. This weight will be used to multiply / multiply the signal sent through it.
4. Each nerve cell will apply an activation function to the weighted summation signal that enters it to determine the output signal.

The model of the neural network neuron structure is described in Figure 2 below:

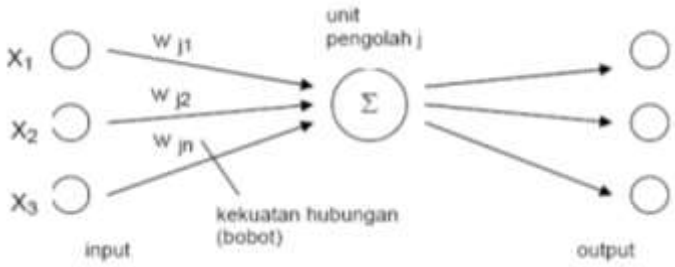


***Figure 2.*** *ANN Structure Model*

According to Wuryandari (2012), Neural Networks can learn from experience, generalize from the examples they get and abstract the essential characteristics of input even for irrelevant data. The algorithm for ANN operates directly with numbers so that non-numeric data must be converted to numeric data. ANN is not programmed to produce a specific output. All outputs or conclusions drawn by the network are based on their experiences during the learning process. In the learning process, input (and output) patterns are entered into the ANN and the network will be taught to provide acceptable answers. Basically the characteristics of ANN are determined by:

1. The pattern of connections between neurons (called network architecture)
2. Method of determining connection weights (called training or network learning process)
3. The activation function will determine whether the signal from the input neuron will be forwarded to other neurons or not.

### 2.3. Application of Neural Networks Artificial Neural Networks (ANN)

According to Siang (2009), the Artificial Neural Network consists of several applications, including:

1. Pattern Recognition
   Artificial Neural Networks that can be used to recognize patterns (eg letters, sound numbers or signatures) that have changed slightly. This is similar to the human brain which is still able to recognize people it has not seen for a while.
2. Signal Processing
   Artificial Neural Networks (ADALINE Model) can be used to suppress noise in telephone lines.
3. Forecasting
   Artificial Neural Networks can also be used to predict what will happen in the future based on the pattern of events that existed in the past.. This can be done given the Neural Network's ability to remember and make generalizations from what has been there before.

### 2.4. Neural Network Architecture

According to Wuryandari (2012), in the Neural Network, neurons will be collected in layers called neuron layers. The neurons in one layer will be connected to the layers before and after it. The information given to the neural network will be propagated layer to layer, starting from the input layer to the output layer through the hidden layer. General structure of Neural Networks because some Neural Networks exist which do not have hidden layers. The most important factor in determining the behavior of a neuron is the activation function and its weight pattern. Generally, neurons located in the same layer will have the same state so that in each of the same layers the neurons have the same activation function. If neurons in one layer (eg hidden layer) are connected to neurons in another layer (eg output layer) then every neuron in that layer (hidden layer) must also be connected to every neuron in another layer (output layer). There are 3 types of ANN architectures, namely:

1. Single layer net

This network has only 1 layer with linked weights. This network only accepts input and then directly processes it into output without having to go through a hidden layer. In the following figure, the neurons in the two layers are interconnected. How large the connection between 2 neurons is is determined by the corresponding weights. All input units will be connected to each output unit.

2. Network with a competitive layer (competitive layer net)

The relationship between neurons in this competitive layer is not shown in the architectural diagram. The above shows an example of a network architecture with a competitive layer that has a weight of - $n$

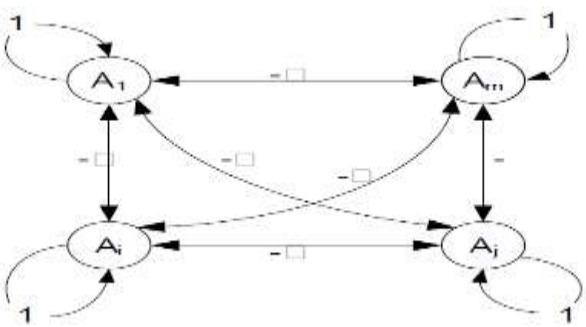


***Figure 3.*** *Competitive Neural Networks*

## 2.5 Algorithm Backpropagation

According to Sahat (2013), backpropagation or backpropagation is one of the most widely used supervised learning learning/training techniques. This method is a very good method in dealing with complex pattern recognition problems. In the back propagation network, every unit in the input layer is connected to every unit in the hidden layer. Each unit in the hidden layer is connected to every unit in the output layer. This network consists of many layers (multilayer network). When the network is given an input pattern as a training pattern, then the pattern goes to the hidden layer units to be further forwarded to the units in the output layer. Then the output layer units will respond as the output of the Artificial Neural Network. When the output is not as expected, the output will be propagated backwards in the hidden layer then from the hidden layer to the input layer. This training stage is a step to train an Artificial Neural Network, namely by changing the weights. While problem solving will be carried out if the training process has been completed, this phase is called the Testing phase.

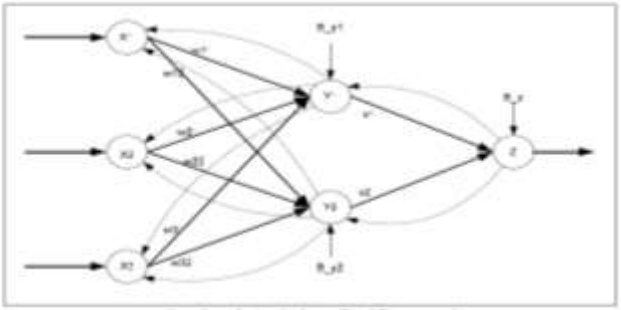

***Figure 4.*** *Backpropogation Algorithm*

*Backpropagation* is an artificial neural network model with multiple screens. Like other artificial neural network models, backpropagation trains the network to find a balance between the network's ability to recognize the patterns used during training and the network's ability to respond correctly to input patterns that are similar (but not the same) as the patterns used during training.

## 2.6. Extreme Learning Machine (EML)

*Extreme Learning Machine*is a single hidden layer feed forward neural networks with input weights and biases generated randomly while the output is calculated analytically. The mechanism of ELM will be explained in the following steps. For example, for an ELM with k hidden layers, you have an activation function to model the sample data. Mathematically the ELM model can be written as Parameter is the weight of the relationship between input and neurons in the hidden layer. While the parameter is the weight of the link between the hidden and outer layers. The parameter is the bias of the jth node in the hidden layer. Matrix H is the outer matrix of the hidden layer. The matrix is the MoorePenrose generalized inverse matrix of the H matrix.

# III. Results and Discussion

The data used in this study is the number of Departures on Domestic Flights at Kauala Namu Airport in 2018, 2019 and 2020. Later this data will be used for training in order to predict the number of departures in 2021.

**Table 2.** Number of Airplane Passengers at Main Airport (Persons) (Polonia region)

| Year | Jan | Feb | March | April | May | June | July | Aug | Sept | Oct | Nov | Des |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2019 | 280839 | 198871 | 202298 | 195395 | 155731 | 245820 | 236009 | 225363 | 214364 | 225484 | 229847 | 220846 |
| 2020 | 288819 | 227602 | 172348 | 29386 | 3593 | 28567 | 62904 | 89451 | 74638 | 85663 | 116956 | 133574 |
| 2021 | 157614 | 100191 | 122498 | 119306 | 104644 | 150762 | 51362 | 49711 | 80935 | 116465 | 0 | 0 |

In table 2 it is known that the number of months is 36 months, hereinafter referred to as the 1st, 2nd and so on. For the first stage of training and pattern preparation, it will be carried out using the 1st month to the 24th month. However, the data for In data processing several things are done:

1. Matrix transpose
2. Converts matrix data to vectors.
3. Finding the min max value of the original data.

**Table 3.** Pattern recognition sequence

| Pattern | Input data | Target |
|---|---|---|
| 1 | Data in the 1st month to the 12th month | Data on month 13 |
| 2 | Data in the 2nd month to the 13th month | Data on month 14 |
| 3 | Data in the 3rd month to the 14th month | Data on the 15th month |
| . | . | . |
| . | . | . |
| . | . | . |
| 12 | Data in the 12th month to the 23rd month | Data on the 24th month |

1. Data normalization.

$$normalisasis\ data\ ke\ i = \frac{data\ ke\ i - \min\_data}{\max\_data - \min\_data}$$

**Table 4.** Maximum and Minimum Data

| Month | Data |
|---|---|
| 1st month | 1 |
| 2nd month | 0.7776 |
| 3rd month | 0.8363 |
| . | . |
| . | . |
| . | . |
| 36th month | 0.35188 |

2. Prepare normalization training data.
3. Compiling training data for normalization.
4. Prepare training targets for normalization.
5. Set the ANN parameter with number_neuron1=100.
6. Build a backpropagation ANN architecture.
7. Conduct network training.
8. Testing and training

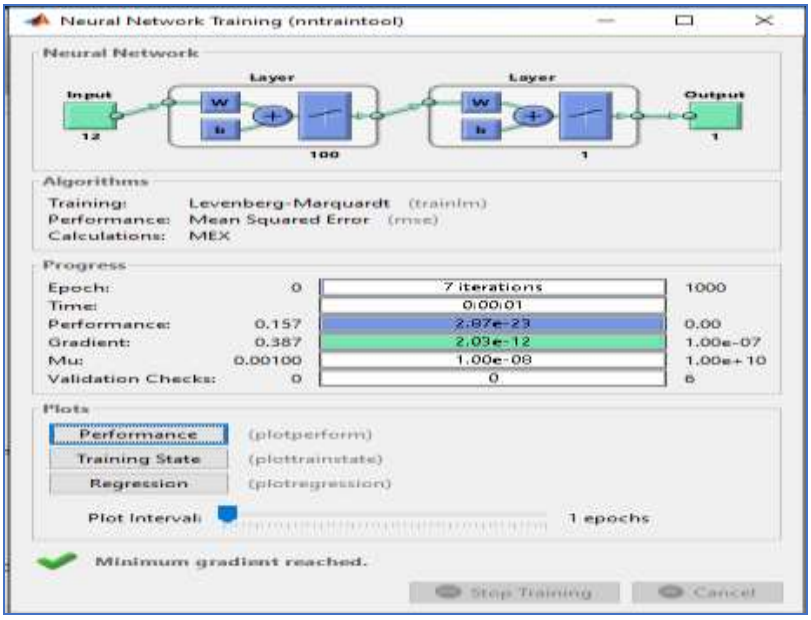


***Figure 5.*** *ANN with 100 neurons*

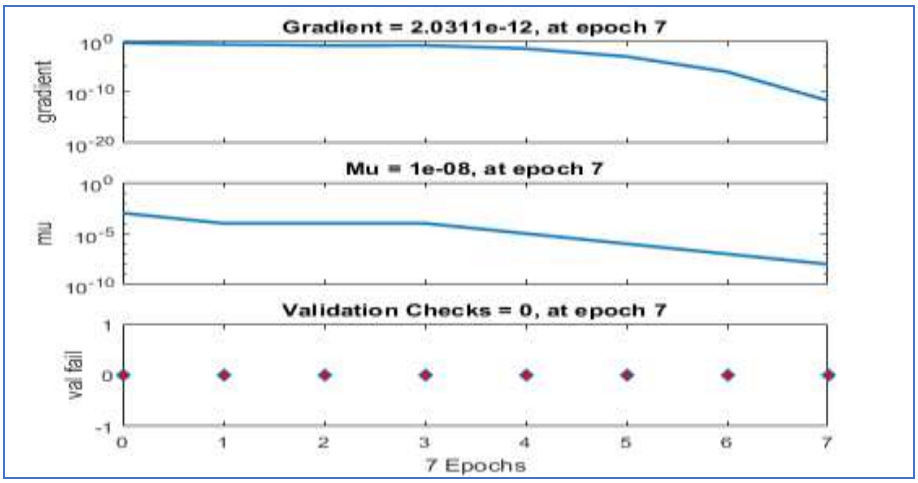


***Figure 6.*** *Training state training*

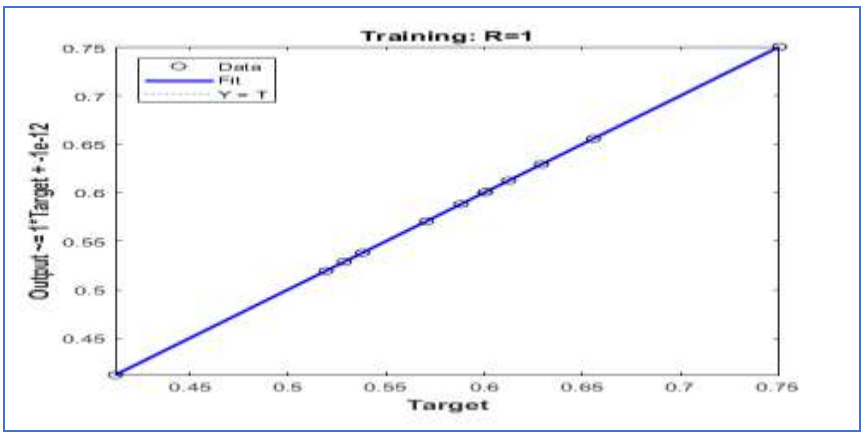


***Figure 7.*** *Training regression*

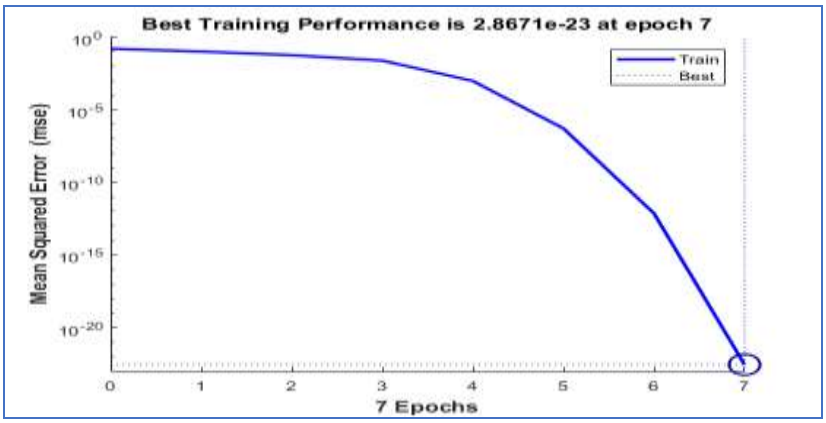


***Figure 8.*** *Training performance*


***Figure 9.*** *Results of ANN Training*

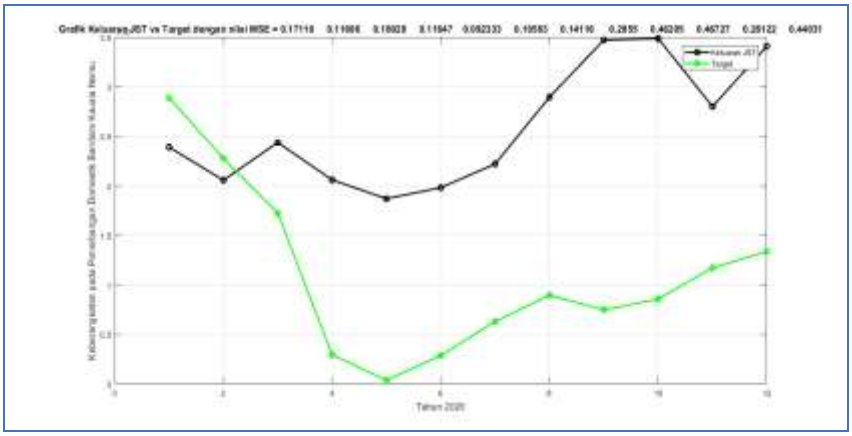

***Figure 10.*** *Results of ANN Training*

The result of testing and prediction of ANN from training is the value of MSE = 2.8761e-23 for testing and prediction of MSE is also very small. The neurons used are as many as 100 neurons in one layer.

## IV. Conclusion

After conducting several experiments to determine the appropriate number of neurons for training, it can be concluded that:

1. This study shows that ANN can predict a value with a very small MSE level with a value of 2.8761e-23 in training.. This results in predictive testing resulting in a small MSE with none above one. Likewise with MSE on predictions.
2. The number of passengers predicted by JST proves that people are quite enthusiastic about using airplanes as a means of transportation, even during the pandemic.

The suggestions for further research that can be done are:

1. Conduct training with data that emerged at the start of the pandemic with a smaller amount of training, so that it can determine predictions in a smaller number of months such as in less than 6 months or 4 months.
2. With higher computer capabilities, computing for ANN will be more flexible in determining the number of neurons and layers, considering that computation in ANN is quite heavy to do because it requires a lot of calculations and iterations.

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