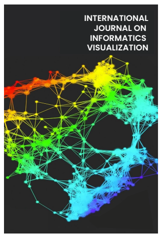
JOIV : Int. J. Inform. Visualization, 7(3) - September 2023 673-680

INTERNATIONAL JOURNAL
ON INFORMATICS VISUALIZATION

journal homepage : www.joiv.org/index.php/joiv



Prediction of Civil Servant Performance Allowances Using the Neural Network Backpropagation Method

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***Abstract*— Performance allowance is a form of appreciation given by an agency to its human resources. The Office of the Ministry of Religion of Batu City provides performance allowances to civil servants who work in the agency. Several things that affect the provision of performance allowances, such as grade, deduction, taxable income, income tax, and total tax, are used in this study to produce the total gross performance allowances and total performance allowances received. Based on the data obtained, there are some missing data from the parameters of taxable income, income tax, and total tax. This study aims to predict performance allowance when there is missing data. The method used is Neural Network Backpropagation. This study uses 480 data with split data ratios of 50:50, 60:40, 70:30, and 80:20, with epochs 40,000 and a learning rate 0,9. Four types of models used in this study are distinguished based on the number of hidden layers and epochs used. Model A uses two hidden layers to produce the highest accuracy with a 50:50 data split ratio of 65,16%. Model B uses four hidden layers to produce the highest accuracy with a 50:50 data split ratio of 69,34%. Model C uses six hidden layers to produce the highest accuracy with a 50:50 data split ratio of 68,18%. Model D uses eight hidden layers to produce the highest accuracy with a 50:50 data split ratio of 70,90%.**

***Keywords*— Performance allowance; neural network; backpropagation; prediction.**

Manuscript received 8 Mar. 2023; revised 11 Jun. 2023; accepted 9 Jul. 2023. Date of publication 10 Sep. 2023.

I. Introduction

Human Resources (HR) is an important factor supporting organizational success [1]. Organizations are working towards improving the quality of their services and bringing added value to them by employing resources. The most valuable resource within the organization is human resources [2]. Human resources are an important element of any organization because better human resource performance results in a greater overall organization's success. Therefore, an organization needs to have good staff [3], [4]. Human resources are people within work organizations who set overall goals and priorities, plan employment processes, manufacture goods and services, control their efficiency, and allocate financial resources to sell products and services [5].

Human resources in the government organizations of the Republic of Indonesia are known as civil servants. The civil servant is a profession for government employees bound by work agreements to serve in government agencies. Civil servant employees function as public policy executors, public services, and glue and unifier of the nation [6]. Civil servants are needed in government organizations to assist in achieving goals. However, it is necessary for civil servants who have good performance in their fields to achieve this goal.

Performance is individuals' achievement level at a particular time when carrying out their duties and functions compared to the expected work results and the targets to be achieved, originally planned and agreed upon together [7]. Improving human resources performance can make it easier to achieve organizational goals. One way that can be done to improve the performance of human resources is to provide performance allowances. Performance allowances are expected to improve performance measured by key agency performance indicators [8]. Regulation of the Minister of Religion Number 11 of 2019 concerning Giving Employee Performance Allowances at the Ministry of Religion has determined that performance allowances are given to Civil Servants who work in the Ministry of Religion. Performance allowance is an award for performance carried out and given in the form of wages to increase employee morale. Performance allowances need to be given to employees to be more committed to carrying out work so that employees are expected to perform well [9]. One of the objectives of providing performance allowances is an effort by the government to provide performance motivation to employees in the context of implementing bureaucratic reforms. Providing performance allowances is expected to increase welfare for civil servants and can increase self-actualization through performance for civil servants to support the implementation of bureaucratic reforms can be achieved [10].

Previous research on predictions of European Union Allowances (EUAs) benefits has been carried out by Jaramillo-Morán et al. [11], which is a right to emit CO2 that can be sold or purchased by companies to reduce greenhouse gas emissions. This study uses the Neural Network method with the Multilayer Perceptron (MLP) and Long Short-Term Memories (LSTM) algorithms, which have the best results Mean Absolute Percentage Error (MAPE) of 2.91% for the prediction of the first datum and 5.65% for the second datum twenty, with an average value of 4.44%.

Research on employee benefits was carried out by Rukhiyati [12] at PT POS Yogyakarta using the SAW method. The validation results from 20 employee data reached 85% with several data criteria such as length of service, position, attendance, education, and dependents. Another study related to determining the provision of allowances for educators and education staff has been carried out by Asrori and Falani [13] using the Tahani Fuzzy Database Model. The result is a decision support information system for determining the provision of allowances to a list of educators and educational staff entitled to receive them according to predetermined criteria.

The Ministry of Religion of Batu City, as a Work Unit within the Ministry of Religion, has implemented performance allowances for civil servants working in the agency. Several things affect the provision of performance allowances, including the position class (grade), work discipline (deductions), taxable income, income tax, and the total tax each employee earns. There are some missing data in the parameters of taxable income and income tax, so it becomes difficult to determine the civil servant performance allowance for the following month.

Based on these problems, a study is needed to predict the amount of civil servant performance allowances received in the following month, even though no work discipline parameter data exists in the previous month. Based on these problems, a study is needed to predict the amount of state civil servant performance allowances received in the following month, even though no work discipline parameter data exists in the previous month. Research to predict civil servant performance allowances where there is some missing data on the parameters of taxable income, income tax, and total tax, and the resulting output is in the form of multiple outputs has never been reported before in the literature. Most of the research that has been done has resulted in a decision support system for granting performance allowances. Therefore, this research was conducted to become a new reference in predicting the number of performance allowances using the Neural Network Backpropagation method.

II. Materials And Method

The research method for predicting civil servant performance allowances can be seen in Figure 1.

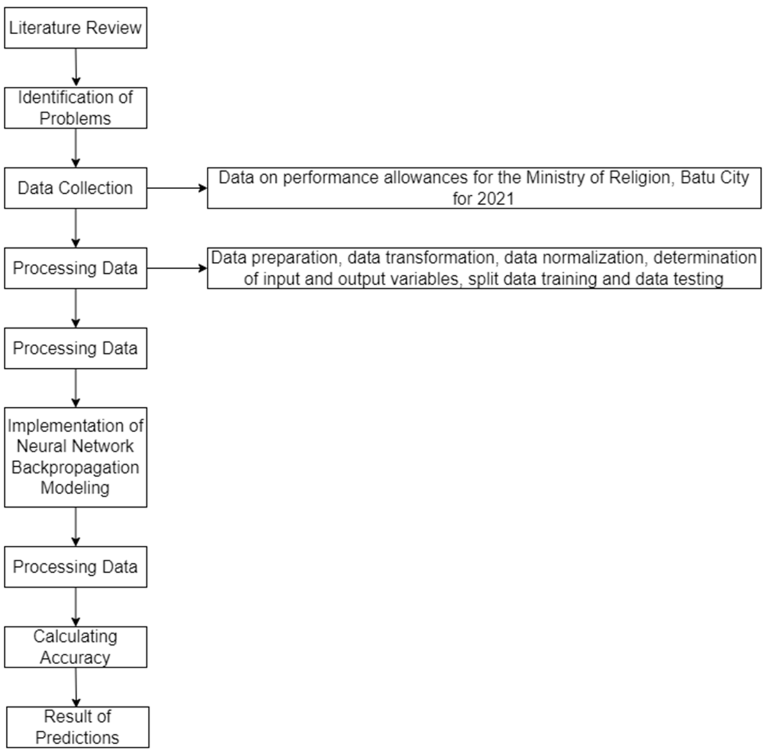

Fig. 1 Methodology

In Figure 1, there are several stages of the research process as follows:

1. Literature study to find references related to research.
2. Identification of problems in the provision of performance allowances for civil servants.

3. Collect performance allowance data for the Ministry of Religion of Batu City in 2021.
4. Processing data includes preparation of data or preparing the necessary data, data transformation to change object attributes to numeric, and data normalization to change the range of values in data on a certain scale. The processing data also include determining input and output variables, and dividing training data and test data by ratios of 50:50, 60:40, 70:30, and 80:20, respectively.
5. Implementation of modeling using Neural Network Backpropagation.
6. Calculate the resulting accuracy.
7. Obtain results from predicting civil service performance allowances.

A. Data Preparation

The data preparation is considered a mandatory step that includes techniques such as integration, normalization, cleaning, and transformation [14]. The data used was obtained from the Office of the Ministry of Religion of Batu City. The data is performance allowance data for every month in 2021, as shown in Table I.

TABLE I
DATASETS

	month	name	grade	deduction	taxable_income	income_tax	total_tax	total_gross	total_received
0	May	Nawawi	13	128430	146427161	16964074	1279067	9712637	8433570
1	April	Nawawi	13	128430	131450631	14717595	1164097	9597667	8433570
2	January	Nawawi	13	0	125036081	13755412	1091905	9653905	8562000
3	February	Nawawi	13	0	125036081	13755412	1091905	9653905	8562000
4	March	Nawawi	13	0	125036081	13755412	1091905	9653905	8562000
...	...	...	...	...	...	...	...	...	...
475	Agustus	Ratih Harlianingtyas	6	129696	0	0	0	2031904	2031904
476	September	Moh Asaddin Nur	7	35136	0	0	0	2307264	2307264
477	September	Ratih Harlianingtyas	6	162120	0	0	0	1999480	1999480
478	Oktober	Moh Asaddin Nur	7	35136	0	0	0	2307264	2307264
479	Oktober	Ratih Harlianingtyas	6	32424	0	0	0	2129176	2129176

Missing data in this study can be seen in rows 475 – 479 in the Taxable Income, Income Tax, and Total Tax columns. The data consists of several features as follows.

TABLE II
DATA FEATURES

No.	Name	Code
1.	month	X1
2.	name	X2
3.	grade	X3
4.	deduction	X4
5.	taxable_income	X5
6.	income_tax	X6
7.	total_tax	X7
8.	total_gross	Y1
9.	total_received	Y2

There are nine features used in research data. The first feature is the moon. The month in the research data indicates the time the performance allowance is received. The second feature is the name, which indicates the recipient of the performance allowance. The third feature is grade, namely the level of a person's position in an agency. The fourth feature is deductions obtained based on employee discipline at work. The fifth feature is taxable income, the taxpayer's income on which the income tax is calculated. The sixth feature is income tax, a tax imposed on individuals or entities on income received in a tax year. The seventh feature is the total tax, that is, the total tax to be paid. The eighth feature is the gross total, namely the employee's gross income, before deducting taxes. The last feature is the total received, namely the total performance allowance employees receive.

B. Data Transformation

Depending on model needs, this step converts the raw data into a specified format [14], [15]. This study transforms data by encoding labels from the Scikit-learn library and using the panda's library to change data with categorical attributes into numeric ones.

C. Data Normalization

Data normalization is the process of changing the form of raw data to scale down the transformation in such a way as to make it all possible requires careful intervention attributes values to be adequate and acceptable [16][17]. In this study, data normalization was carried out to obtain the same range of values, namely between 0.1 – 0.99. General Min-Max Normalization is a procedure that normalizes data according to the values between 0 and 1, which are presented for each element in an entire dataset x [18]. The Min-Max normalization equation used in this study is as follows [19], [20].

$$x_i = \frac{(x - min)}{max - min} \quad (1)$$

where:
x_i : the result of data normalization,
x : the value to be normalized,
max : the maximum values of the entire data,
min : the minimum values of the entire data.

TABLE III
DATA NORMALIZATION RESULTS

	month	name	grade	deduction	taxable_income	income_tax	total_tax	total_gross	total_received
0	0.727273	0.386364	1.0	0.283060	1.000000	0.312147	0.358689	1.000000	0.219728
1	0.090909	0.386364	1.0	0.283060	0.897720	0.270811	0.326448	0.985094	0.219728
2	0.363636	0.386364	1.0	0.000000	0.853913	0.253106	0.306203	0.992385	0.224114
3	0.272727	0.386364	1.0	0.000000	0.853913	0.253106	0.306203	0.992385	0.224114
4	0.636364	0.386364	1.0	0.000000	0.853913	0.253106	0.306203	0.992385	0.224114
...	...	...	...	...	...	...	...	...	...
475	0.000000	0.636364	0.3	0.285850	0.000000	0.000000	0.000000	0.004204	0.001107
476	1.000000	0.545455	0.4	0.077440	0.000000	0.000000	0.000000	0.039904	0.010511
477	1.000000	0.636364	0.3	0.357313	0.000000	0.000000	0.000000	0.000000	0.000000
478	0.909091	0.545455	0.4	0.077440	0.000000	0.000000	0.000000	0.039904	0.010511
479	0.909091	0.636364	0.3	0.071463	0.000000	0.000000	0.000000	0.016815	0.004429

D. Determination of Input and Output Variables

The input variables used in this study are those with code X in Table I. Meanwhile, the output variables are those with code Y.

E. Split Data Training and Data Testing

Split data is the division of training data and testing data. Training data is data that has attributes/classes to recognize the characteristics of the data so that it can produce a model or pattern of data in machine learning. Data testing is data with a label/class to test the model's or pattern's accuracy [21]. This study uses various data-sharing ratios, namely 50:50, 60:40, 70:30, and 80:20. research using different data split ratios has been carried out by Iriananda et al. [22] to classify car logos using the Backpropagation and Decision Tree Artificial Neural Network (ANN) methods. The inputs used are 12 different car logos in Indonesia and tested using a split ratio that varies from 10:90 to 90:10 for training data and data testing. The results obtained from this research are that the ANN-Backpropagation method is better than the Decision Tree method, which achieves an accuracy of up to 92.50% with a split ratio 50:50.

Another study using different data split ratios was conducted by Nurdiansyah and Marisa [23] to classify laying hens using the Artificial Neural Network and Decision Tree methods. This study used data input in the form of 8 different types of chickens in Indonesia to be tested using different split ratios ranging from 10:90 to 90:10. The Artificial Neural Network method is proven to be better than the Decision Tree because it obtains an accuracy of 92.50% at a split ratio of 50:50 between training data and testing data.

F. Neural Network Backpropagation

A neural Network or Artificial Neural Network (ANN) is a computational method that imitates the workings of biological neural networks [24]–[27]. Backpropagation is a supervised learning method for artificial neural networks. After processing a set of data, each neuron's error contribution has been estimated. The goal of backpropagation is to train a neural network by modifying the weights and accurately mapping all inputs to outputs [28], [29].

A backpropagation neural network consists of input, output, and hidden layers between the input and output layers. The hidden layer may have many layers, affecting the neural network's training process [30]. Research on the Neural Network Backpropagation method was carried out by [31] to predict the results of the Self-Assessment Questionnaire (SAQ) in 2021 on the Regional Government of East Java Province website. This study used 4 test models and obtained the results that model D was the best model with an MSE value of 0.0036, a MAPE value of 18.71%, and an accuracy of 81.28% using nine hidden layers and 2000 iterations.

Another study using the Artificial Neural Network (ANN) method was carried out by Shodiq et al. [32] to predict earthquakes based on automatic grouping in Indonesia. The experimental results obtained an ANN model with a learning rate of 0.1 and 2 hidden layers with 32 neurons each and 10,000 epochs.

G. Mean Squared Error

The Mean Squared Error (MSE) is a method for evaluating forecasting methods. There is a square for each error or remainder. Then added up and added to the number of observations. This approach regulates a large forecasting error. The method is likely to produce minor errors, which might be better in the case of small errors [33]. The equation for calculating MSE is as follows [34].

$$MSE = \frac{\sum_{k=1}^{n}(t_k - y_k)^2}{n} \quad (2)$$

where:
n : amount of data
t_k: actual value
y_k: predicted value

H. Mean Absolute Percentage Error

Mean Absolute Percentage Error (MAPE) is the average value of the absolute difference that exists from the prediction and the realization value, referred to as the percentage of the actual value. The use of MAPE from the prediction results can see the level of accuracy of the prediction numbers and realization numbers [35], [36]. The average absolute percentage error is shown in this index; the lower the MAPE, the higher the accuracy [37]. The equation for calculating MAPE is as follows [38], [39].

$$MAPE = \frac{\sum_{t=1}^{n}\left|\frac{x_t - y_t}{x_t}\right|}{n} \times 100\% \quad (3)$$

where:
n : the amount of data
x_t : actual value
y_t : predicted value

I. Accuracy

Accuracy is the accuracy level of prediction success calculated after obtaining the percentage of MAPE values. The smaller the percentage error, the more accurate the forecast will be. The equation for calculating the level of accuracy is as follows [40].

$$Accuracy = 100\% - MAPE \quad (4)$$

where:
$MAPE$: Mean Absolute Percentage Error

III. Result and Discussion

This study applies the Backpropagation Neural Network method using the Python programming language. There are four models used in this study, namely models A, B, C, and D. All models use a learning rate of 0.9 and an epoch of 40000. The model is differentiated based on the number of hidden layers and the ratio of data sharing.

A. Model A

Model A consists of several types, namely model A1, model A2, model A3, and model A4. The parameters used in model A can be seen in Table IV.

TABLE IV
A Model Parameters

Parameter	Model A			
	A1	A2	A3	A4
Learning Rate	0,9			
Epoch	40000			
Hidden Layer	40→38			
Data Training	384	336	288	240
Data Testing	96	144	192	240

Model A uses two hidden layers with 40 and 38 neurons, respectively. Models A1 to A4 use a data sharing ratio of 80:20 to 50:50 for each training data and data testing. The results of model A testing can be seen in Table V.

TABLE V
Model Test Results A

Model	MSE		MAPE	Accuracy
	Total Gross	Total Received		
A1	0.000110	0.000028	53.072174	46.927825
A2	0.000073	0.000025	42.159726	57.840273
A3	0.000056	0.001177	43.873177	56.126822
A4	0.000051	0.000952	34.834738	65.165261

It can be seen from Table V that the A4 model of 65.16% obtained the highest accuracy value with a data sharing ratio of 50:50. The graph of A4 modeling results can be seen in Figure 2 below.

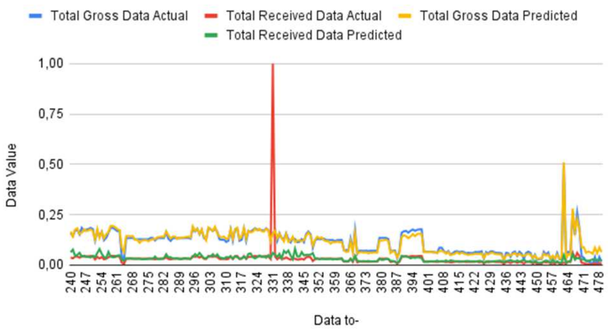

Fig. 2 Graph of modeling results A4

The results of the A4 modeling, which displays the actual total gross (TG) data with the predicted total gross (TG) data and the actual total received (TR) data with the predicted total received (TR) data, can be seen in Table IV below.

TABLE VI
Modeling Results A4

Data to-	TG Data Actual	TG Data Predicted	TR Data Actual	TR Data Predicted
475	0.004204	0.001107	0.0562	0.028848
476	0.039904	0.010511	0.086449	0.024915
477	0	0	0.059113	0.026394
478	0.039904	0.010511	0.087481	0.025375
479	0.016815	0.004429	0.063986	0.020626

B. Model B

Model B consists of several types: model B1, model B2, model B3, and model B4. The parameters used in model B can be seen in Table VII.

TABLE VII
B Model Parameters

Parameter	Model B			
	B1	B2	B3	B4
Learning Rate	0,9			
Epoch	40000			
Hidden Layer	40→38→36→34			
Data Training	384	336	288	240
Data Testing	96	144	192	240

Model B uses 4 hidden layers with 40, 38, 36, and 34 neurons respectively. Models B1 to B4 use a data sharing ratio of 80:20 to 50:50 for each training data and data testing. The results of model B testing can be seen in Table VIII.

TABLE VIII
Model Test Results B

Model	MSE		MAPE	Accuracy
	Total Gross	Total Received		
B1	0.000168	0.000046	61.120198	38.879801
B2	0.000121	0.000030	55.281649	44.718350
B3	0.000067	0.001133	38.468402	61.531597
B4	0.000054	0.000928	30.652440	69.347559

It can be seen from Table VIII that the highest accuracy value was obtained by model B4 of 69.34% with a data sharing ratio of 50:50. The graph of the results of the B4 modeling can be seen in the following Figure 3.

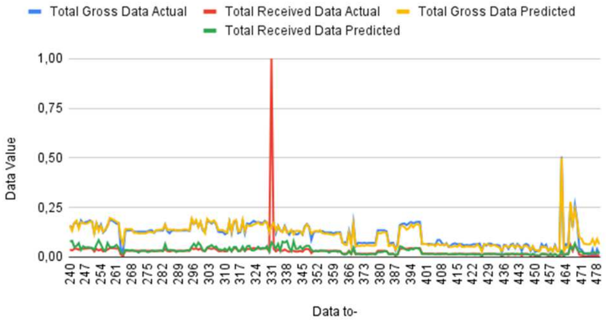

Fig. 3 Graph of modeling results B4

The results of the B4 modeling, which displays the actual total gross (TG) data with the predicted total gross (TG) data and the actual total received (TR) data with the predicted total received (TR) data, can be seen in Table VII below.

TABLE IX
MODELING RESULTS B4

Data to-	TG Data Actual	TG Data Predicted	TR Data Actual	TR Data Predicted
475	0.004203	0.001107	0.065932	0.019135
476	0.039903	0.010510	0.090113	0.023534
477	0	0	0.061832	0.020506
478	0.039903	0.010510	0.091086	0.024838
479	0.016814	0.004429	0.064369	0.017926

C. Model C

Model C consists of several types, namely model C1, model C2, model C3, and model C4. The parameters used in model C can be seen in Table X.

TABLE X
C MODEL PARAMETERS

Parameter	Model C			
	C1	C2	C3	C4
Learning Rate	0,9			
Epoch	40000			
Hidden Layer	40→40→38→38→36→36			
Data Training	384	336	288	240
Data Testing	96	144	192	240

Model C uses six hidden layers with 40, 40, 38, 38, 36, and 36 neurons, respectively. Models C1 to C4 use a data sharing ratio of 80:20 to 50:50 for each training data and data testing. The results of testing the C model can be seen in Table XI.

TABLE XI
MODEL TEST RESULTS C

Model	MSE		MAPE	Accuracy
	Total Gross	Total Received		
C1	0.000098	0.000034	53.112501	46.887498
C2	0.000081	0.00003	51.135008	48.864991
C3	0.000052	0.001166	44.606102	55.393897
C4	0.000041	0.000936	31.819032	68.180967

It can be seen from Table XI that the highest accuracy value was obtained by model B4 of 68,18% with a data sharing ratio of 50:50. The graph of the results of the B4 modeling can be seen in the following Figure 4.

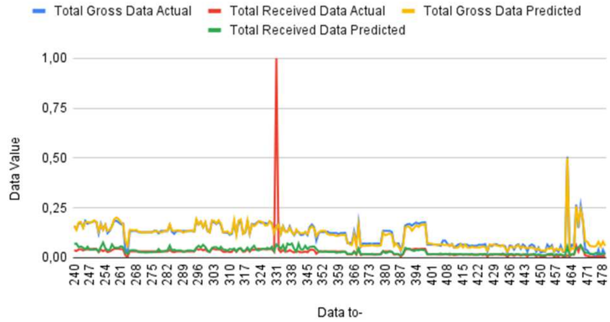

Fig. 4 Graph of modeling results C4

The results of the C4 modeling, which displays the actual total gross (TG) data with the predicted total gross (TG) data and the actual total received (TR) data with the predicted total received (TR) data, can be seen in Table X below.

TABLE XII
MODELING RESULTS C4

Data to-	TG Data Actual	TG Data Predicted	TR Data Actual	TR Data Predicted
475	0.004204	0.001107	0.05881	0.023881
476	0.039904	0.010511	0.080017	0.019897
477	0	0	0.05665	0.018136
478	0.039904	0.010511	0.080845	0.020988
479	0.016815	0.004429	0.059411	0.016453

D. Model D

Model D consists of several types, namely model D1, model D2, model D3, and model D4. The parameters used in model D can be seen in Table XIII.

TABLE XIII
D MODEL PARAMETERS

Parameter	Model D			
	D1	D2	D3	D4
Learning Rate	0,9			
Epoch	40000			
Hidden Layer	40→40→38→38→36→36→34→34			
Data Training	384	336	288	240
Data Testing	96	144	192	240

Model D uses eight hidden layers with 40, 40, 38, 38, 36, 36, 34, and 34 neurons, respectively. Models D1 to D4 use a data sharing ratio of 80:20 to 50:50 for each training data and data testing. The results of testing the D model can be seen in Table XIV.

TABLE XIV
MODEL TEST RESULTS D

Model	MSE		MAPE	Accuracy
	Total Gross	Total Received		
D1	0.000098	0.000035	56.351142	43.648857
D2	0.000068	0.000021	46.683536	53.316463
D3	0.000054	0.001175	36.387155	63.612844
D4	0.000046	0.000945	29.097051	70.902948

It can be seen from Table XIV that the D4 model of 70,90% obtained the highest accuracy value with a data sharing ratio of 50:50. The graph of the D4 modeling results can be seen in Figure 5 below.

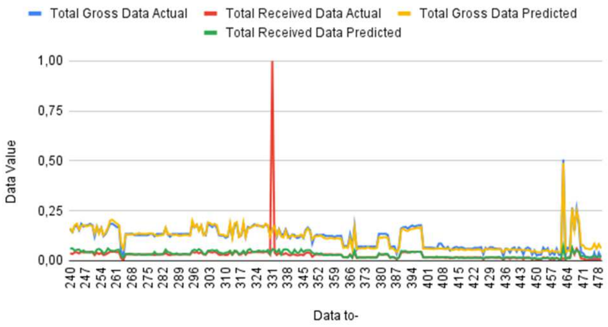

Fig. 5 Graph of modeling results D4

The results of the D4 model, which displays the actual total gross (TG) data with the predicted total gross (TG) data, and the actual total received (TR) data with the predicted total received (TR) data, can be seen in Table XIII below.

TABLE XV
MODELING RESULTS D4

Data to-	TG Data Actual	TG Data Predicted	TR Data Actual	TR Data Predicted
475	0.004204	0.001107	0.062103	0.020467
476	0.039904	0.010511	0.084802	0.023763
477	0	0	0.059871	0.018988
478	0.039904	0.010511	0.083417	0.023642
479	0.016815	0.004429	0.062182	0.017021

The following is a comparison of MAPE and Accuracy of all models that have been tested.

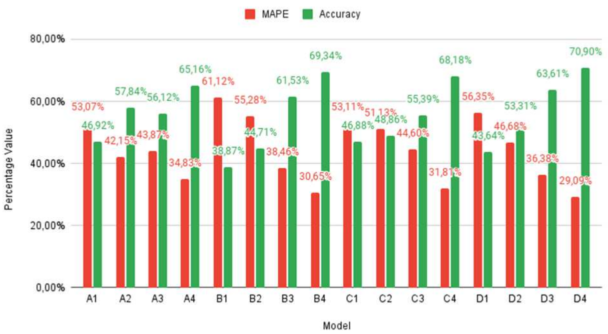

Fig. 6 Comparison Chart of MAPE and Accuracy

Based on the 24 models that have been tested, the best accuracy is obtained by the D4 model, which uses a 50:50 split ratio resulting in an accuracy of 70,90%.

TABLE XVI
MAPE AND ACCURACY VALUES

Model	MAPE	Accuracy
A1	53.07%	46.92%
A2	42.15%	57.84%
A3	43.87%	56.12%
A4	34.83%	65.16%
B1	61.12%	38.87%
B2	55.28%	44.71%
B3	38.46%	61.53%
B4	30.65%	69.34%
C1	53.11%	46.88%
C2	51.13%	48.86%
C3	44.60%	55.39%
C4	31.81%	68.18%
D1	56.35%	43.64%
D2	46.68%	53.31%
D3	36.38%	63.61%
D4	29.09%	70.90%

IV. CONCLUSION

Based on the results of the research conducted, it can be concluded that the application of the Neural Network Backpropagation method to predict civil servant performance allowances with some missing data on the parameters of taxable income, income tax, and total tax can be carried out, but with a sufficient number of learning rates, epochs, and hidden layers large. The results obtained are that the D4 model is the best model with an accuracy of 70,90%. Future research is expected to be able to add to the dataset and use different methods to find out the resulting accuracy comparison and which method is the best to use.

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