Comparison of Trend Line Analysis Methods and Backpropagation Neural Network with Lowest Error Rate in Solopos Newspaper Industry

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Abstract

In today's digital era, many industries are affected by digitization. One of them is the newspaper industry which causes demand uncertainty and is difficult to predict. This causes a very high rate of return or newspaper returns which will result in losses for the company. Therefore, it is necessary to use a newspaper demand forecasting method that has a low error rate. The method used is trend line analysis method and backpropagation neural network. The data used is actual demand data, sales results, sales prices and stock from January 2020 to January 2021. The calculation process uses Microsoft Excel and Matlab. In addition, the selection of the best method is obtained by comparing the smallest MSE value. Based on the MSE comparison, it was found that the forecasting method with the smallest error rate was the backpropagation artificial neural network method with an MSE value of 0.0104 Therefore, the best forecasting method for forecasting the demand for the number of newspapers PT. Solopos script is a backpropagation method for artificial neural networks

Keywords
Backpropagation, Artificial Neural Network, Newspaper, MSE, Forecasting, Trend Line Analysis

1. Introduction

At this time, the majority of human activities are carried out completely digitally, so that quite a lot of industries are affected by this digitalization era, one example is print media such as newspapers or newspapers. In fact, in the past, print media was considered a medium with reliable accuracy. In 2014, Roy Morgan International Research found that the Jawa Pos newspaper was the most popular print media in Indonesia. The number of daily newspaper requests can change due to various factors, both internal and external. This is a challenge for the company in determining the amount of newspaper production. Calculation of the amount of newspaper production is very important for the company because it can minimize the possibility of company losses due to a lack of production, and too many unsold

newspapers and newspapers sold but at below market prices. In addition, the company must also be able to anticipate the existence of newspapers that are returned or returned.

Solopos script companies experience an average return from agents to companies of 5% (A'yun, et al. 2021). For example, in the 2017 total sales report, PT Aksara Solopos was able to sell up to IDR 18,400,000,000. This means that the company bears the loss for the return of the newspaper up to Rp. 920,000,000. One of the reasons why there are quite a lot of newspaper returns that occur is because of the daily production and the lack of stock regarding the latest news reports.Newspaper company supply chain has 5 entities involved, including suppliers who are suppliers of ink, plate and paper, PT Solo Grafika Utama, PT Aksara Solopos, newsagents and newspaper customers. The following are the activities carried out by each entity:

The supplier entity has activities to supply raw materials in the form of paper, plate and ink to printing companies. PT Solo Grafika Utama carries out the newspaper printing process, which consists of pre-printing, in-machine printing, and post press. Then PT. Aksara Solopos orders paper raw materials, sends content and news to printing companies and also sends newspapers that have been produced to newsagents. After that, newsagents distribute newspapers to regular customers such as newspaper hawkers and to dropout customers. Then the customer receives the newspaper. Customers consist of regular customers such as shoppers and dropout customers.

The issues raised relate to the company's tactical issues, where tactical planning supports strategic planning, which includes the tactics that the company plans to achieve strategic plans. Often, they are less than a year in scope and break the strategic plan into actionable chunks. The problem owner on the issues raised is manufacturing at PT. Solopos script as a business person. The parties involved and affected in this matter are as follows:

- Manufacturing at PT. Solopos
- Suppliers PT. Solopos
- Distributor agent PT. Solopos
- Solopos newspaper customer

The parties who resolve this issue are as follows:

- Manufacturing PT. Solopos script is because the manufacturer can determine the number of newspapers that must be produced from the results of forecasting the number of newspaper requests.
- The researcher who gave the best suggestion of the method used to solve the problem at PT. Solopos script.

There are 4 cycles in newspaper production activities that will influence decision making:

1. Customer Order Cycle
   Many unsold newspapers returned, relations with company agents, customer satisfaction
2. Replenishment Order Cycle
   Transportation mode capacity, route, facility location, distribution point determination, distribution time is limited.
3. Manufacturing Cycle.
   Occurs in intermediary distributors/producers and all processes related to distributor/retailer stock inventory. This cycle is initiated by ordering goods from distributors/retailers to producers or by sales, usually because of patterns of demand for goods. The process that occurs, that is, orders from warehouses, distributors, retailers, or ready-to-use customers. Production Planning; Manufacturing and Shipping; Receipt from Distributor, Retailer or Customer. Demand fluctuations cause losses, uncertain forecasts, Limited production capacity, limited time from prepress process to distribution, production planning, product development delays, machine performance, setup time, quality of raw materials (ink, paper, plate).
4. *Procurement Cycle*
   Occurs in intermediary producers / suppliers and all processes needed to ensure the availability of raw materials for the manufacture of a product that has been scheduled. Lead time, supplier-company relationship, warehouse capacity, high inventory cost, storage system, goods loading system, warehouse recording system, delivery quantity, delivery time, arrival delay, supplier-buyer contract. The parties involved in this problem are manufacturers, suppliers, distributor agents, and customers. The methods used in the approach to the problem are trend line analysis and backpropagation neural network methods. From the results of this comparison, it is expected to produce a forecast of the number of newspaper requests that have the smallest error rate so that it can reduce losses to the company.

1.1 Objectives

The purpose of this research is to find out the lowest error rate in forecasting the number of newspaper production in the PT Aksara Solopos newspaper industry. In predicting the amount of newspaper production, it will be done by comparing the two methods used. Based on previous research, which was conducted by A'yun et al, three methods were first used in forecasting the demand for the number of newspapers, including moving average, exponential smoothing, and trend line analysis. The smallest newspaper demand forecasting error value is obtained from the average absolute percentage (MAPE) by using the trend line analysis method. Thus, in order to obtain more accurate forecasting results for newspaper demand, a comparison of the MSE value and the error rate with the smallest value between the Trend Line Analysis method and the Backpropagation Neural Network method is carried out.

2. Literature Review

There are many methods for forecasting demand for example Backpropagation Neural Networks which have been proven in several cases forecasting can provide good forecasting results, such as in the case of forecasting water consumption, rainfall consumption, dollar exchange rates and forecasting electricity loads. In accordance with the tests carried out using data on the number of sales of Radar Madura newspaper in 2015 the best number of iterations was 200, and the best learning rate was 0.6, and testing of training data and test data resulted in the best training data values of 100 and test data of 10. And it produces the smallest error rate value, which is 0.0162 (Sakinah et al., 2018). Another study examines newspaper demand forecasting using several methods, namely trend line analysis, double exponential smoothing, and two months moving average. All methods were compared with the ARIMA method. The selection of the best forecasting method is done by comparing the error rate (MAPE) of each method and then selecting the best method. Trend line analysis is the chosen forecasting method with a MAPE value of 2.94% (Sutopo et al., 2021).

2.1 Trendline Analysis Method

The trend line analysis method begins with collecting data, making trendline charts, then calculating demand forecasts and finally calculating the MSE value. This forecasting method has the condition that the movement of the data has a pattern that continues to increase or continues to decrease with a relatively repeated pattern.

$$Ft = a + b\,t \quad (1)$$

$$a = \bar{A} - b\,\bar{t} \quad (2)$$

$$b = (\Sigma t\,A - n\,\bar{t}\,\bar{\bar{A}})/(\Sigma t2 - n\,\bar{t}2) \quad (3)$$

Description :
Ft = Forecasting value
a = Intercep
A = Average value of demand per period
A = Actual request data
b = slope
t = time index

Figure 1 is a flowchart of the trendline analysis method. In this method, it starts by making a trendline graph and then calculating the demand forecast using the formula mentioned above. This calculation uses Microsoft Excel which then calculates the MSE value and draws conclusions.

2.2 Backpropagation Neural Network Method

Backpropagation Neural Network is an algorithm that is included in supervised learning where the characteristic of this method is to minimize errors in the output generated by the network. The backpropagation algorithm for neural networks is generally applied to multilayer networks. This algorithm has at least an input section, an output section and several layers between input and output. The middle layer, which is also known as the hidden layer, can be one, two, three, and so on. The output of the last layer of the hidden layer is directly used as the output of the neural network. The forecasting of the Artificial Neural Network method begins with collecting newspaper request data, normalizing the data, forecasting the Backpropagation Neural Network Method, then calculating the MSE value. In forecasting demand with the Backpropagation Neural Network method, researchers use the help of MATLAB software.

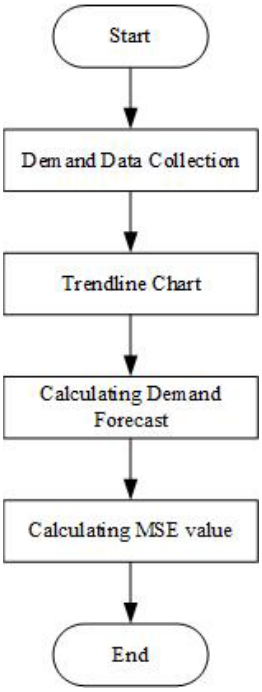

Figure 1. Trendline Analysis Method Flowchart

The following is a flowchart of the Backpropagation Neural Network method (Figure 2).

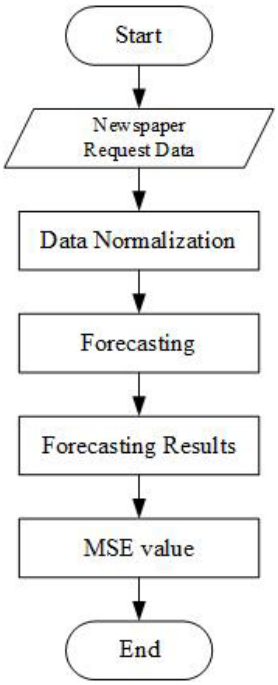

Figure 2. Backpropagation Neural Network Flowchart

Here are the steps for backpropagation:
Step 0

- Initialize all weights with small random numbers
- Set maximum epoh, target error and learning rate
- Initialization, epoh = 0
-As long as epoh <maximum_epoh and MSE < target_error, the following steps will be carried out

Step 1
If the stopping condition is still not met, do Steps 2-9

Step 2
For each training data, do steps 3-8 Phase I: Forward propagation (feedforward)

Step 3
Each input unit receives the input signal and propagates the signal to all units in the hidden layer

Step 4
Each hidden unit (Zj,j=1,2,3,...,p) will add up the weighted input signals including the bias using the following formula:

$z_{net_j} = v_{jo} + \sum_{i=1}^{n} x_i \, v_{ji}$ (1)

And using the specified sigmoid activation function to calculate the output signal of the hidden unit concerned,

$z_j = f(z_{net\ j}) = \frac{2}{1+e^{-znet\ j}} - 1$ (2)

Then send the output signal to all units on the output unit
Description :
z_net_j = input signal in the jth hidden layer
v_{jo} =bias to j hidden layer
v_{ji} =weights between the I-th input layer units and the j-th hidden layer
x_i =input layer unit to – i
z_j =jth input layer unit
i =order of input layer units
j = order of hidden layer units
p =maximum number of units in hidden layer

Step 5
Each output unit (yk ,k=1,2,3,…,m) will add up the weighted input signals including the bias

$y_{net\ k} = w_{ko} + \sum_{j=1}^{p} z_j w_{kj}$ (3)

And use the predefined activation function to calculate the output signal of the corresponding output unit:

$y_k = f(y_{net\ k}) = \frac{1}{1+e^{-y\_net_k}}$ (4)

Description :
y_netk = input signal output to – k
wko = bias to hidden layer le – k
wkj = output to – k and hidden layer to – j
zj = j hidden layer activation
Phase II : Backward propagation

Step 6
Each unit of output (y , k=1,2,3,…,m) receives a target (expected output) which will be compared with the resulting output.

$\delta_k = (t_k - y_k) f'(y_{net_k}) = (t_k - y_k) y_k (1 - y_k)$ (5)

The δk factor is used to calculate the error correction (Δwkj) used to update , where:

$\Delta w_{kj} = \alpha \delta_k z_j$ (6)

The δk factor sent to the front layer
Description :
δk = weight error correction factor of wjk
tk = k output target
yk = k activation output

Δwkj = value error correction factor of kj
zj = j activation hidden layer

Step 7
Each hidden unit (Zj,1,2,3,…,p) adds a weighted input delta (sent to the layer in Step 6).
$\delta_{net_j=\sum_1^m \delta_k w_{kj}}$ (7)
Then the result will be multiplied by the derivative of the activation function used by the network to produce the error correction δj factor , where:
$\delta_j = \delta_{net_j} f'\left(z_{net_j}\right) = d_{net_j} z_j(1 - z_j)$ (8)
The δj factor is used to calculate the error correction (Δvji) that will be used to update vik, where:
$\Delta_{v_{ji}} = \alpha\delta_k - x_i)$ (9)
Description :
δ_netj = sum of delta weights hidden layer j
δk = weight error correction factor wkj
wkj = weights between the k output and the j hidden layer
δj = weight correction factor vij
zj = j activation hidden layer
vji = vji weight error correction value
α = acceleration rate (learning rate)
δi = vji weight error correction factor
xi = i inputs unit
Phase III: Weight Change

Step 8
Each output unit (yk,k=1,2,3,…,m) will update its bias and weight with each hidden unit
$w_{kj}(new) = w_{kj}(old) + \Delta w_{kj}$ (10)
Likewise, each hidden unit will update its bias and weight with each input unit.
$v_{ji}(new) = v_{ji}(old) + \Delta v_{ji}$ (11)

Step 9
Checking the stop condition If the stop condition is met, the network training can be stopped

3.3 *Mean Square Error* (MSE)
In choosing the best alternative, there is the required performance measure, the researcher uses the MSE (Mean Square Error) measure. Mean Squared Error (MSE) is the average squared error between the actual value and the forecast value. The Mean Squared Error method is generally used to check the estimation of the error value in forecasting. A low Mean Squared Error value or a Mean Squared Error value close to zero indicates that the forecasting results are in accordance with the actual data and can be used for forecasting calculations in the future period. Here is the formula for MSE (Mean Square Error):

$$MSE = \frac{\sum_{t=1}^{n}(At - Ft)^2}{n}$$

3. Methods
The methods to be compared are trend line analysis and Backpropagation Neural Networks. The selection of the best method will be based on the Mean Square Error value which is the average squared error between the actual value and the forecast value. The following is a flowchart of the method in this research (Figure 3):

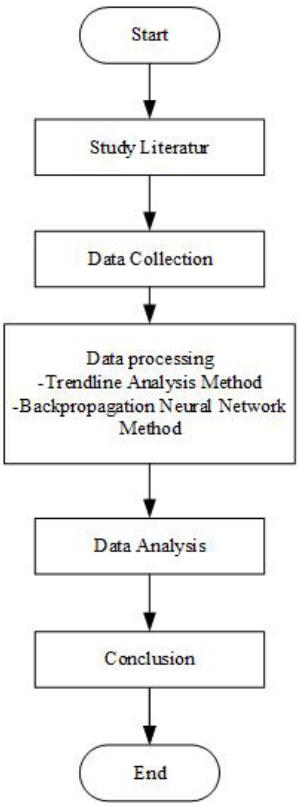

Figure 3. Research Methodology Flowchart

The step in this research begins with a literature study by reading papers on the problems in the Solopos newspaper industry and then identifying the problems. After that, collect demand data that will be used in both methods. After that, calculate the trendline analysis method and the Backpropagation ANN method to find the smallest MSE value. After that, it is analyzed and conclusions are drawn.

4. Data Collection

The data used in the case study for forecasting the number of requests is sales data for the period January 2020 to January 2021, which is the author's own assumption that it fell 2% from the previous demand. The following is a hypothetical actual demand data for PT. Solopos script for January 2020 - January 2021:

Table 1. Solopos Newspaper Actual Demand January 2020 - January 2021

No	Period	*Actual Demand*
1	Jan-20	668533
2	Feb-20	630291
3	Mar-20	638083
4	Apr-20	656248
5	Mei-20	588305
6	Jun-20	626366
7	Jul-20	582383
8	Agu-20	630395
9	Sep-20	606351
10	Okt-20	632480
11	Nov-20	621175
12	Des-20	600152
13	Jan-21	587839

Data collection was taken hypothetically by assuming the number of newspaper requests decreased by 2% due to the impact of this digitization. The hypothetical data used is the number of requests from January 2020 to January 2021 with a total of 13 months. The author did not survey directly to the company due to the unstable situation due to the COVID-19 pandemic. Although using hypothetical data, the results of this forecast can prove which method is the right one to use to predict the number of newspaper requests with the smallest error value.

5. Results and Discussion

The data that has been collected will be processed using trend line analysis and backpropagation neural networks to determine the Mean Square Error (MSE) value.

5.1 Trendline Analysis Method

The following are the results of the existing trend formulas using the trend line analysis method using trendline charts and also the trend line analysis formula calculations using Microsoft Excel.

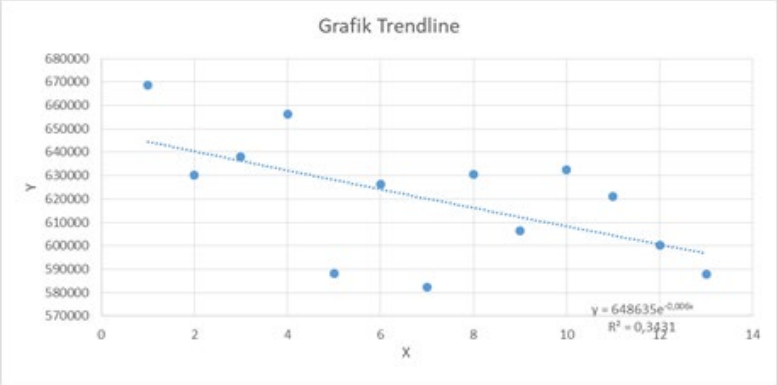

Figure 4. Trendline Analysis Chart

The trendline format is obtained to determine future trends in several periods (forecast forward) and also to find out the equations or formulas of the research problems produced, the equation on the chart in the graph above is y = 648635e0.006x with an R-squared value of 0.3431. Forecasting with trend line analysis is done by modeling existing historical data into a linear equation. The linear equation is determined by calculating the values of a and b. Then, forecasting in the next period can be calculated using the linear equation. The following is a calculation in obtaining the linear regression equation used in forecasting.

$$Ft = a + b\,t$$
$$a = \bar{A} - b\,\bar{t}$$
$$b = (\Sigma t\,A - n\,\bar{t}\,\bar{\bar{A}})/(\Sigma t2 - n\,\bar{t}\bar{2})$$

Description :
Ft = Forecasting value
a = intercept
A = Average value of demand per period
At = Actual request data
b = slope
t = time index

A' =	620662
∑tA =	55746533
n =	13
∑t2 =	819
t bar =	7

Calculation : $b = \frac{\sum tA - n(tbar)(A - bar)}{\sum t\text{^}2 - n(t - bar)\text{^}2}$

$$b = \frac{55746533 - 13x7x620662}{819 - 13x7\text{^}2}$$

$$b = \frac{-733709}{182} = b = -4031{,}368$$

$$a = A\text{bar} - \text{b tbar}$$
$$a = 620662 - (-4031{,}368)x7$$
$$a = 648881{,}576$$

then, ft : forecasting result for period t
Ft = 648881,576-4031,368 t

So, the results of the problem formulation using the trend line analysis method are the same as the two graph methods and manual calculations. With Ft =.648881,576-4031,368 t. The trend line analysis method is demand forecast, error, squared error, to the MSE (Mean Square Error) value. The demand forecast calculation uses the formula from the problem formula that has been obtained, namely Ft = 648881,576-4031,368 3 t. Where t is the period in the form of numbers. The next calculation is the error obtained from the difference between the actual demand and the forecast demand. From the error value, then calculate the squared error by squaring the value in the error table and the result is 54.79. So the MSE value or Mean Squared Error generated by the trend line analysis method is 4.21.

Table 2. Trendline Analysis Results

No	Period	*Actual Demand*	tA	t^2	*Demand Forecast*	Error	Error Kuadrat
1	Jan-20	668533	668533	1	644850,208	2,37	5,61
2	Feb-20	630291	1260582	4	640818,84	-1,05	1,11
3	Mar-20	638083	1914249	9	636787,472	0,13	0,02
4	Apr-20	656248	2624992	16	632756,104	2,35	5,52
5	Mei-20	588305	2941525	25	628724,736	-4,04	16,34
6	Jun-20	626366	3758196	36	624693,368	0,17	0,03
7	Jul-20	582383	4076681	49	620662	-3,83	14,65
8	Agu-20	630395	5043160	64	616630,632	1,38	1,89
9	Sep-20	606351	5457159	81	612599,264	-0,62	0,39
10	Okt-20	632480	6324800	100	608567,896	2,39	5,72
11	Nov-20	621175	6832925	121	604536,528	1,66	2,77
12	Des-20	600152	7201824	144	600505,16	-0,04	0,00
13	Jan-21	587839	7641907	169	596473,792	-0,86	0,75
						Total	54,79

5.2 Backpropagation Neural Network Method

This method requires data on actual demand, sales results, sales prices, and stock in one year with the period January 2020 to January 2021. Then, the data is created in an Excel file and normalized the data, then transposes the data. Data on sales results, sales prices, and stock data are included in the input data, while demand data is the target. Furthermore, data processing is carried out using Matlab software. In Matlab, enter input data, namely sales results data, sales prices, and stock data into the input workspace. Then, also enter the target data, namely the demand data into the target workspace.

Type "nntool" in the command window, then the Neural Network window appears. Then click Import, under Source select Import from Matlab workspace, and select input variables, then Import as Input data and click Import. Next, click Import, under Source select Import from Matlab workspace, and select target variable, then Import as Target data and click Import. Click New, then the Network or Data window appears and name it as desired. Then, in Network properties, on network type select Feed-forward backprop, on Input data select input variable, on Target data select target variable, on Training Function select TRAINGD, on Adaption learning function select LEARNGD on Performance function select MSE, on Number of layers type 2, on Number of neurons type 16, on transfer function select PURELIN. Then click view, a display like the image below will appear. And click Create. Double click on Network, then the Network window will appear, open the Train - Training Parameters tab, in epochs change to 3000, max_fail 1000, and lr to 0.1. Then click Train Network, and a window like the following image will appear. Click

Regression, then a Regression graph window will appear as shown in Figure 7. The closer the colored line is to the center line, the better.

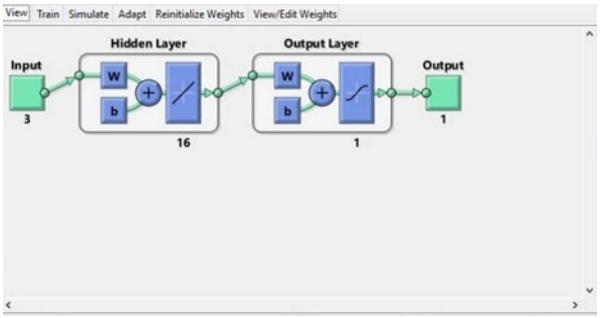

Figure 5. Custom Neural Network

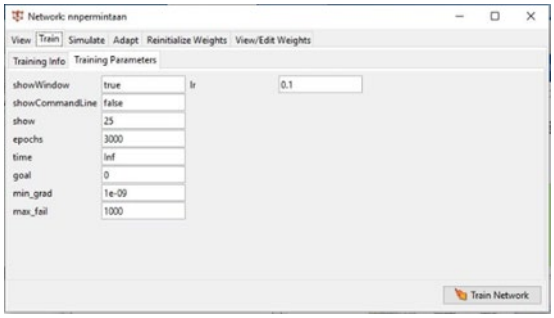

Figure 6. Train Parameters

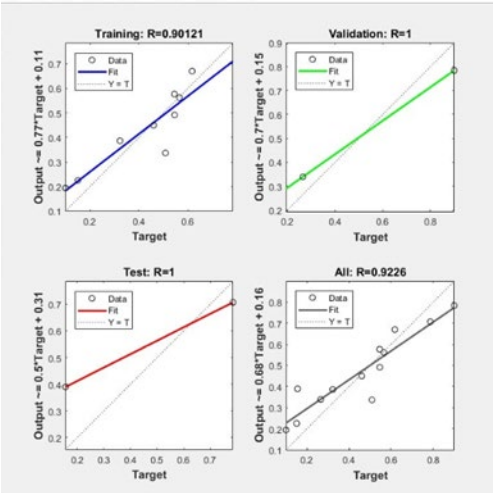

Figure 7. Regression Graph

Next, the Neural Network window will display Output data and Error data. Double-click on each one and a window will open containing each one, namely the output data and the error data. Copy and paste the data into excel and transpose. Then the results of the output data are denormalized so that the results of forecasting data demand for the next year period are obtained. The mean Squared Error (MSE) obtained in the Backpropagation Neural Network method is 0.0104. The following are the forecasting results obtained in this method.

Table 3. Results of Backpropagation Neural Network Method

Bulan Period (t)	Output	Jumlah JST	Jumlah JST (Pembulatan	Error
Januari 2020	0,78416	656058,480	656059	0,1158
Februari 2020	0,5766	633704,709	633705	-0,0317
Maret 2020	0,6702	643781,028	643782	-0,0530
April. 2020	0,7074	647796,695	647797	0,0785
Mei 2020	0,38952	613560,685	613561	-0,2345
Juni 2020	0,33675	607878,016	607879	0,1717
Juli 2020	0,1942	592527,163	592528	-0,0942
Agustus 2020	0,49145	624537,272	624538	0,0543
September. 2020	0,38633	613217,162	613218	-0,0637
Oktober 2020	0,56193	632127,087	632128	0,0033
November. 2020	0,44988	620060,703	620061	0,0103
Desember 2020	0,33899	608119,236	608120	-0,0740
Januari 2021	0,22494	595837,476	595838	-0,0743

6. Conclusion

Based on the results of research on predicting the number of newspaper requests using 2 methods, namely the trend line analysis method and the backpropagation neural network method, it can be concluded that the best method is the method that produces the smallest MSE (Mean Square Error) value. The MSE value of the trend line analysis method is 4.21 while the MSE value of the backpropagation artificial neural network method is 0.0104. So it can be seen that the most suitable method used to forecast the number of newspaper requests is the backpropagation neural network method. The advantage of this paper is that it is able to prove that the bacpropagation neural network method has the lowest MAPE value. While the drawback of this paper is to use hypothetical data. So that further research is expected to use real data and try to compare it with other methods such as Support Vector Regression (SVR). The results of this study can be used by companies to carry out production planning so that later the rate of return or newspaper returns can be lower, and the company can reduce losses that occur.

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