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DETERMINATION OF THE BEST FORECASTING METHOD FROM MOVING AVERAGE, EXPONENTIAL SMOOTHING, LINEAR REGRESSION, CYCLIC, QUADRATIC, DECOMPOSITION AND ARTIFICIAL NEURAL NETWORK AT PACKAGING COMPANY

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ABSTRACT

PT. Peace Industrial Packaging is a company that produces Styrofoam and plastic bottles that are used as containers or places or commonly referred to as packaging used by other companies to place their finished products. After getting data on the number of demand and production results obtained every month then the data will be processed using several forecasting methods such as Single Moving Average; Double Moving Average; Weight Moving Average; Single Exponential Smoothing; Double Exponential Smoothing; Linear Regression; Quadratic Method, Method Cyclic; Decomposition Method; and Artificial Neural Network (ANN) Method. After conducting the research calculation, the following conclusions can be drawn. The best forecasting method used for the HBL 100 mL product is the ANN (Artificial Neural Network) method because it has the smallest error value, namely the Mean Absolute Deviation error method of 760.583554, the Mean Square Error method of 863,032.834043, the Sum Deviation Errorr method of 970.304264, the Mean Absolute Percentage Error method is 0.112530, and the MPE error method is 0.112530.

***Keyword**: Forecasting, Artificial Neural Network, Evaluating Forecats Accuracy*

ABSTRAK

PT Peace Industrial Packaging merupakan perusahaan yang memproduksi Stereoform dan Botol plastic yang biasanya digunakan untuk plastic container yang diperuntukkan sebagai tempat produk akhir dari produksi pabrik. Setelah mendapatkan data dari jumlah permintaan dan hasil produksi per bulan maka selanjutnya data diproduksi menggunakan beberapa metoda peramalan seperti Rata-rata Bergerak Tunggal, Rata-rata Bergerak Ganda, Pembobotan Rata-rata Bergerak, Eksponensial Pemulusan Tunggal, Eksponensial Pemulusan Berganda, Regresi Linier, Metoda Kuadratik,Mmetoda Siklis, Metoda Dekomposisi, dan Jaringan Syaraf Tiruan. Setelah menyelesaikan seluruh perhitungan, hasil yang diperoleh adalah sebagai berikut: hasil peramalan terbaik menggunakan metoda peramalan jaringan syaraf tiruan untuk produk HBL 100 mL dengan hasil kesalahan terkecil dalam evaluasi akurasi menggunakan metoda rata-rata deviasi absolut dengan hasil 760,583554, metoda kesalahan rata-rata kuadrat sebesar 863.032,834043, dengan jumlah kesalahan devisasi sebesar 970,304264, the persentase kesalahan rata-rata absolut sebesar 0,112530, and the metoda persentase kesalahan rata-rata sebesar 0,112530 dibandingkan dengan metoda-metoda peramalan yang lain.

***Keyword**: Peramalan, Jaringan Syaraf Tiruan, Evaluasi Akurasi Peramalan.*

INTRODUCTION

PT. Peace Industrial Packaging is a company that produces Styrofoam and plastic bottles that are used as containers or places or commonly referred to as packaging used by other companies to place their finished products. Forecasting is an attempt to see situations and conditions in the future by estimating the influence of future situations and conditions on future developments [1]. According to Heizer and Render [2], forecasting is the art and science of predicting future events by taking historical data and projecting it into the future with a systematic approach model. Therefore, forecasting is one of the references to predict the number of requests received by the company within a certain period of time and to predict the needs of machines and resources based on the number of requests.

Fluctuating consumer demand requires companies to forecast and plan production. The results of the forecasting method can be used as an illustration of the estimated number of products that customers will request in the following year. The number of customer demands between the forecasting results that have been made and the Sales Order issued by the Marketing division when the customer buys a product with a certain quantity. Several previous studies also use forecasting and production planning as an illustration and prediction of the number of products that customers will demand in the following year, namely research conducted by Samuel [3], Karina [4] and Juliantara & Mandala [5],[6]. The research objectives were made to answer the formulation of the problem above is to determine the right forecasting method for the production process activities at PT. Peace Industrial Packaging

LITERATURE REVIEW

Forecasting

Forecasting is the basic input in the operations management decision-making process in providing information about future demand to determine the amount of capacity or inventory needed to meet demand. In its use, forecasting plays an important role, including a. Scheduling of existing resources. b. Forecasting the demand for products, materials, labour, finance is an important input for scheduling. c. Forecasting is needed to determine future resource requirements. d. Determine the desired resource. All organisations or companies must determine what resources they want to have in the long run.

Forecasting Method

There are many methods used for forecasting according to the data and variables used [7]. The following is an explanation of the forecasting method.

1. SMA (Simple Moving Average) Method

Single Moving Average is a forecasting method carried out by taking a group of observed values and then looking for the average of these values as a forecast for the future period. The single moving average formula can be seen in Table 1.

Table 1. Single Moving Average

Time	Moving Average		Forecasting
T	$X = \frac{X_1+X_2+X_3+X_4+\cdots+X_{T+1}}{T}$	(1)	$F_{T+1} = \bar{X} = \sum_{i=1}^{T} \frac{X_t}{T}$
T+1	$X = \frac{X_2+X_3+X_4+\cdots+X_{T+1}}{T}$	(2)	$F_{T+2} = \bar{X} = \sum_{i=2}^{T+1} \frac{X_t}{T}$

2. Metode DMA (Double Moving Average) method

The DMA method or multiple moving average is a method that can reduce systematic errors if the SMA method is used on data that has a certain tendency. Double moving formula averages are as follows:

$$S't = \frac{X_t+X_{t-1}+X_{t-2}+\cdots+X_{t-N+1}}{N} \quad (3)$$

$$S''t = \frac{S'_t+S'_{t-1}+S'_{t-2}+\cdots+S'_{t-N+1}}{N} \quad (4)$$

$$a_t = S't + (S'_t - S''_{t-1}) = 2S'_t - S''_t \quad (5)$$

$$bt = \frac{2(S'_t - S''_t)}{(N-1)} \quad (6)$$

$$F_{t+m} = a_t + b_t m \quad (7)$$

3. WMA (Weight Moving Average) method

Data in a certain period is given a weight, where the weight is determined based on experience. The formula for weight moving average is as follows:

$$Ft = \frac{W1At-1+W2At-2+WnAt-n}{W1+W2+Wn} \quad (8)$$

4. SES (Single Exponential Smoothing) method

The SES method is calculated employing the forecast value in period t+1, which is the actual value in period t plus adjustments originating from forecast value errors in period t. The single exponential smoothing formula is as follows:

$$F_{t+1} = a\, X_t + (1-a)F_t \quad (9)$$

5. DES (Double Exponential Smoothing) method

The DES method is generally used for data that has a trend data pattern. The double exponential smoothing formula is as follows:

$$S'_t = \propto X_t + (1-\propto)S'_{t-1} \quad (10)$$

$$S''_t = \propto X_t + (1-\propto)S''_{t-1} \quad (11)$$

$$a_t = 2S'_t - S''_t \quad (12)$$

$$bt = \frac{\propto(S'_t - S''_t)}{(1-\propto)} \quad (13)$$

$$F_{t+m} = a_t + b_t m \quad (14)$$

6. Linear Regression

Linear Regression is a quantitative forecasting method included in the time series model. This method uses time as the basis for forecasting and is based on the assumption that the growth pattern of historical data is linear. It is assumed that there is a relationship between the variables to be predicted and the independent variables. The linear regression formula is as follows:

$$b = \frac{N\sum_{t=1}^{N} t.Y(t) - \sum_{t=1}^{N} Y9t).\sum_{t=1}^{N} t}{N\sum_{t=1}^{N} t^2 - \left(\sum_{t=1}^{N} t\right)^2} \quad (15)$$

$$a = \frac{\sum_{t=1}^{N} Y(t) - b\sum_{t=1}^{N} t}{N} \quad (16)$$

$$Y(t) = a + b(t) \quad (17)$$

7. Quadratic Method

The quadratic method is a forecasting method based on the assumption that the growth pattern of historical data is quadratic. The quadratic formula is as follows:

$$Y(t) = a + b(t) + c(t)^2 \quad (18)$$

$$\gamma = \left(\sum_{t=1}^{N} t^2\right)^2 - N\sum_{t=1}^{N} t^4 \quad (19)$$

$$\delta = \sum_{t=1}^{N} t \sum_{t=1}^{N} Y(t) - N\sum_{t=1}^{N} t.Y(t) \quad (20)$$

$$\theta = \sum_{t=1}^{N} t^2 \sum_{t=1}^{N} Y(t) - N\sum_{t=1}^{N} t^2 Y(t) \quad (21)$$

$$\alpha = \sum_{t=1}^{N} t \sum_{t=1}^{N} t^2 - N\sum_{t=1}^{N} t^3 \quad (22)$$

$$b = \frac{\gamma\delta - \theta\alpha}{\gamma\beta - \alpha^2} \quad (23)$$

$$c = \frac{\theta - b\alpha}{\gamma} \quad (24)$$

$$a = \frac{\sum_{t=1}^{N} Y(t) - b\sum_{t=1}^{N} t - c\sum_{t=1}^{N} t^2}{N} \quad (25)$$

8. Cyclic Method

This method is used for data that has a cyclic data pattern. The cyclic formula is as follows

$$Y'(t) = a + b\sin\frac{(2¶t)}{N} + c\frac{(2¶t)}{N} \quad (26)$$

$$a = \frac{\sum Y(t)}{N} \quad (27)$$

$$b = \frac{\sum Y(t)\sin\frac{(2¶t)}{N}}{N} \quad (28)$$

$$c = \frac{\sum Y(t)\cos\frac{(2¶t)}{N}}{N} \quad (29)$$

9. Decomposition Method

Decomposition is a method that uses the data with four types of data patterns: trend, cyclic, seasonal, and irregular. All data showing the four patterns are separated and forecasted to get more accurate results.

10. Artificial Neural Network (ANN) Method

An artificial Neural Network or artificial neural network is a branch of science that imitates the human brain's performance, namely neurons (nerve cells). This ANN can solve complex problems if solved by conventional computing. ANN is formed as a generalisation of the mathematical model with the assumption that; a. Information processing occurs in many simple elements (neurons). b. Signals are sent between many neurons via a link. c. Connectors between neurons have weights that will amplify or weaken the signal. d. Determining the output of each neuron uses an activation function that is imposed on the number of inputs received. The magnitude of this output is then compared with a threshold.

Validasi dan Verifikasi Peramalan

After the forecast has been calculated, the next step is to test all forecasting methods' errors. The smaller the error obtained, the method will have a high probability of being selected. There are three methods used to test errors:

1. Mean Absolute Deviation (MAD)

This method is used to evaluate forecasting methods using the sum of absolute errors. Mean Absolute Deviation (MAD) measures the accuracy of the forecast by calculating the mean of the estimated error (the absolute value of each error).

$$\text{MAD} = \frac{|Xi - Fi|}{n} \quad (30)$$

2. *Mean Squared Error (MSE)*

This method is used to produce moderate errors, which are probably better for small and sometimes large errors

$$\text{MSE} = \frac{(Xi - Fi)^2}{n} \quad (31)$$

3. *Mean Absolute Percentage Error* (MAPE)

The problem with MAD and MSE is that their value depends on the size of the item being estimated. If the forecasted items are in the thousands, then the MAD and MSE can be very large. To avoid such problems, we can use MAPE, which is the average of the absolute differences between the observed and forecasted values for that period.

$$\text{MAPE} = \frac{100\,\frac{|Xi - Fi|}{Xi}}{n} \quad (32)$$

RESULT AND DISCUSSION

The plot of Demand Data and Production Plan

Before determining the right forecasting method, the first thing is to make a data plot in the form of a comparison graph between the number of requests and the obtained results. The comparison graph between the number of requests and production results from January 2018 to December 2020 can be seen in Figure 1.

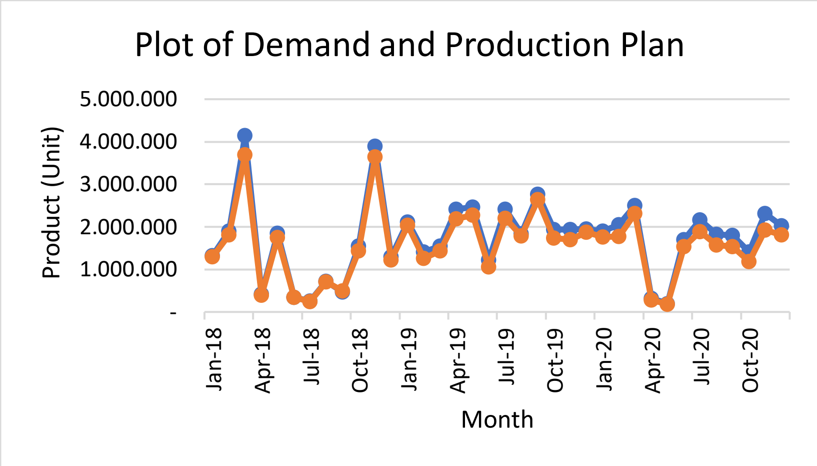

Figure 1. Plot of Demand and Production Plan

Based on the data plot graph above, it can be seen that the production results obtained every month other than September 2018 cannot reach the number of requests given.

Forecasting result

After getting data on the number of requests and production results obtained every month then the data will be processed using several forecasting methods such as Single Moving Average; Double Moving Average; Weight Moving Average; Single Exponential Smoothing; Double Exponential Smoothing; Linear Regression; Quadratic Method, Method Cyclic; Decomposition Method; and Artificial Neural Network (ANN) Method. These methods are used to get the estimated number of requests for HBL 100 ML products in 2021. The method that will be chosen is the method with the smallest error value [8].

Artificial Neural Network (ANN)

This forecasting method is slightly different from all the methods used in this study. The ANN method uses the results of the normalisation of request data for further processing using the MATLAB application [9]. The table of results of normalisation of HBL 100 ML product data can be seen in Table 2.

Table 2. Normalisation Result of Demand Data

Month	Normalisation	Month	Normalisation
1	0,286099	19	0,563322
2	0,430427	20	0,416317
3	1,000000	21	0,652035
4	0,055297	22	0,442297
5	0,417576	23	0,440747
6	0,036256	24	0,444694
7	0,015650	25	0,431652
8	0,133460	26	0,470543
9	0,067243	27	0,585571

Continue Table 2. Normalisation Result of Demand Data

Month	Normalisation	Month	Normalisation
10	0,340979	28	0,029474
11	0,937435	29	0,000000
12	0,278509	30	0,379667
13	0,484780	31	0,499548
14	0,307978	32	0,413421
15	0,343274	33	0,405726
16	0,561070	34	0,308044
17	0,574755	35	0,535752
18	0,257981	36	0,464088

The following is an example of calculating demand data normalisation on an HBL 100 ML product.

$$Xn = \frac{X - Xmin}{Xmax - Xmin}$$

$$Xn = \frac{1.326.720 - 198.514}{4.141.920 - 198.514}$$

$$Xn = 0{,}286099325$$

After the data normalisation results have been obtained, the next step is to process the MATLAB application's request normalisation data [10]. The software calculation uses the first symbol, namely the symbol 'p' to form the data pattern for the first year to the second year to be 'p1' and the data pattern for the second year to the third year to be 'p2'. The second symbol, the 't' symbol, is used for the target of the next year's results. The results of normalising data input into the MATLAB application can be seen in Figure 2.

```
%program jaringan syaraf tiruan produk HBL 100 ML oleh Sharin Chandra
%input dan output
p=[0.286099325  0.430427071 1   0.055296654 0.417576085 0.036255825 0.015649997 0.133459693 0.067242818 0.340978646 0.937434792 0.278509077
0.430427071 1   0.055296654 0.417576085 0.036255825 0.015649997 0.133459693 0.067242818 0.340978646 0.937434792 0.278509077 0.484779704
1   0.055296654 0.417576085 0.036255825 0.015649997 0.133459693 0.067242818 0.340978646 0.937434792 0.278509077 0.484779704 0.307978048
0.055296654 0.417576085 0.036255825 0.015649997 0.133459693 0.067242818 0.340978646 0.937434792 0.278509077 0.484779704 0.307978048 0.343273979
0.417576085 0.036255825 0.015649997 0.133459693 0.067242818 0.340978646 0.937434792 0.278509077 0.484779704 0.307978048 0.343273979 0.561069764
0.036255825 0.015649997 0.133459693 0.067242818 0.340978646 0.937434792 0.278509077 0.484779704 0.307978048 0.343273979 0.561069764 0.574754817
0.015649997 0.133459693 0.067242818 0.340978646 0.937434792 0.278509077 0.484779704 0.307978048 0.343273979 0.561069764 0.574754817 0.257981498
0.133459693 0.067242818 0.340978646 0.937434792 0.278509077 0.484779704 0.307978048 0.343273979 0.561069764 0.574754817 0.257981498 0.563321625
0.067242818 0.340978646 0.937434792 0.278509077 0.484779704 0.307978048 0.343273979 0.561069764 0.574754817 0.257981498 0.563321625 0.41631744
0.340978646 0.937434792 0.278509077 0.484779704 0.307978048 0.343273979 0.561069764 0.574754817 0.257981498 0.563321625 0.41631744  0.652035369
0.937434792 0.278509077 0.484779704 0.307978048 0.343273979 0.561069764 0.574754817 0.257981498 0.563321625 0.41631744  0.652035369 0.442296566
0.278509077 0.484779704 0.307978048 0.343273979 0.561069764 0.574754817 0.257981498 0.563321625 0.41631744  0.652035369 0.442296566 0.440747374
]
p1=transpose(p(1:8,:));
p2=transpose(p(9:12,:)); %data testing
```

Figure 2. Source Code Input Artificial Neural Network Part One

Based on the input data above, the symbol 'p' is normalised data [11] in months 1 to 12. Then there are the first 8 data patterns used as training data given the symbol 'p1', and the next 4 data patterns are used as testing data given the symbol 'p2' . The second part of the Source Code Input Artificial Neural Network results can be seen in Figure 3.

```
t1=t(:,1:8); %target pertama
t2=t(:,9:12); %target untuk menghitung error

p3=[0.484779704 0.307978048 0.343273979 0.561069764 0.574754817 0.257981498 0.563321625 0.41631744  0.652035369 0.442296566 0.440747374 0.444694116
0.307978048 0.343273979 0.561069764 0.574754817 0.257981498 0.563321625 0.41631744  0.652035369 0.442296566 0.440747374 0.444694116 0.431651903
0.343273979 0.561069764 0.574754817 0.257981498 0.563321625 0.41631744  0.652035369 0.442296566 0.440747374 0.444694116 0.431651903 0.470543229
0.561069764 0.574754817 0.257981498 0.563321625 0.41631744  0.652035369 0.442296566 0.440747374 0.444694116 0.431651903 0.470543229 0.585570703
0.574754817 0.257981498 0.563321625 0.41631744  0.652035369 0.442296566 0.440747374 0.444694116 0.431651903 0.470543229 0.585570703 0.02947416
0.257981498 0.563321625 0.41631744  0.652035369 0.442296566 0.440747374 0.444694116 0.431651903 0.470543229 0.585570703 0.02947416  0
0.563321625 0.41631744  0.652035369 0.442296566 0.440747374 0.444694116 0.431651903 0.470543229 0.585570703 0.02947416  0   0.379667467
0.41631744  0.652035369 0.442296566 0.440747374 0.444694116 0.431651903 0.470543229 0.585570703 0.02947416  0   0.379667467 0.499547889
0.652035369 0.442296566 0.440747374 0.444694116 0.431651903 0.470543229 0.585570703 0.02947416  0   0.379667467 0.499547889 0.413420741
0.442296566 0.440747374 0.444694116 0.431651903 0.470543229 0.585570703 0.02947416  0   0.379667467 0.499547889 0.413420741 0.40572616
0.440747374 0.444694116 0.431651903 0.470543229 0.585570703 0.02947416  0   0.379667467 0.499547889 0.413420741 0.40572616  0.308044098
0.444694116 0.431651903 0.470543229 0.585570703 0.02947416  0   0.379667467 0.499547889 0.413420741 0.40572616  0.308044098 0.535751548
]

p4=transpose(p3) %data tahun 2 dan 3

t3=[0.431651903 0.470543229 0.585570703 0.02947416  0   0.379667467 0.499547889 0.413420741 0.40572616  0.308044098 0.535751548 0.464087605
]
```

Figure 3. Source Code Input Artificial Neural Network Part Two

The input data that is also used to form the network is a trial using tansig and logsig calculations. Based on the results of the trial calculations, it is known that the activation function that is able to produce the best value is the tansig activation function as the hidden layer and logsig as the output layer. The next step is to perform parameter training using the trainlm function, a network training function that can update the weight values based on Levenberg-Marquardt optimisation. The input results for the formation of an artificial neural network can be seen in Figure 4.

```
%membentuk jaringan
net=newff(minmax(p),[4,1],{'tansig','logsig'})

%menghitung bobot-bobot
bobotAkhir_bias_lapisan=net.b{2,1};
bobotAkhir_lapisan=net.LW{2,1};
bobotAkhir_input=net.IW{1,1};
bobotAkhir_bias_input=net.b{1,1};

%training parameter
net.trainParam.show=100;
net.trainParam.lr=1;
net.trainParam.epochs=5000;
net.trainParam.goal=1e-7;
```

Figure 4. Input for Artificial Neural Networks

After the network formation input data has been entered, the next step is testing to compare the existing error values and find out the best error values. The results of Source Code Testing and Error Neural Networks can be seen in Figure 5.

```
%simulasi
y=sim(net1,p1)

%testing
hasil=sim(net1,p2)

error=norm(t2-hasil) %error dengan jarak euclid
error2=[t2-hasil] %error dengan selisih

%atau perbandingkan sendiri
error3=[t2;hasil] %akurat sekali
```

Figure 5. Source Code Testing and Error Neural Networks

Next is to enter the code to get the forecasting results using the symbol 't=' starting from the symbol 't5' to 't15' using normalised data from January 2018 to December 2020. The results of the Forecasting Data Input can be seen in Figure 6 on the next page.

```
%forecasting
t4=transpose(t3)
d=sim(net1,t4)
t5=[0.470543229;0.585570703;0.02947416;0;0.379667467;0.499547889;0.413420741;0.40572616;0.308044098;0.535751548;0.464087605
;d]
e=sim(net1,t5)
t6=[0.585570703;0.02947416;0;0.379667467;0.499547889;0.413420741;0.40572616;0.308044098;0.535751548;0.464087605
;d;e]
f=sim(net1,t6)
t7=[0.02947416;0;0.379667467;0.499547889;0.413420741;0.40572616;0.308044098;0.535751548;0.464087605
;d;e;f]
g=sim(net1,t7)
t8=[0;0.379667467;0.499547889;0.413420741;0.40572616;0.308044098;0.535751548;0.464087605
;d;e;f;g]
h=sim(net1,t8)
t9=[0.379667467;0.499547889;0.413420741;0.40572616;0.308044098;0.535751548;0.464087605
;d;e;f;g;h]
i=sim(net1,t9)
t10=[0.499547889;0.413420741;0.40572616;0.308044098;0.535751548;0.464087605
;d;e;f;g;h;i]
j=sim(net1,t10)
t11=[0.413420741;0.40572616;0.308044098;0.535751548;0.464087605;d;e;f;g;h;i;j]
k=sim(net1,t11)
t12=[0.40572616;0.308044098;0.535751548;0.464087605;d;e;f;g;h;i;j;k]
```

Figure 6. Forecasting Data Input

After all of the input process has been entered into the MATLAB application. The next step is to run it by pressing the run button. The image of the artificial neural network training process can be seen in Figure 7.

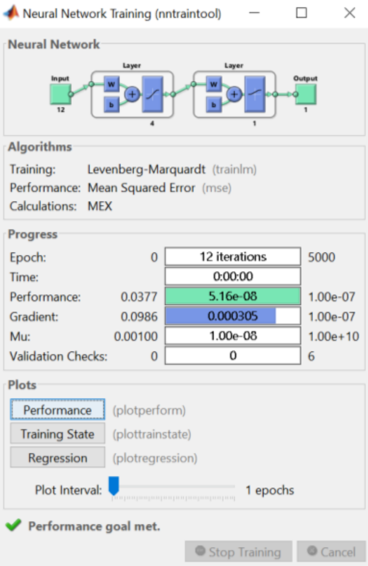

Figure 7. Artificial Neural Network Training Process

The result from the training process of artificial neural networks is the results of testing, errors, and normalisation of forecasting data. The training results from the artificial neural network training process can be seen in Figure 8.

```
c =

  Columns 1 through 11

    0.4318    0.4706    0.5856    0.0296    0.0004    0.3798    0.4998    0.4137    0.4060    0.3085    0.5359

  Column 12

    0.4641
```

Figure 8 Artificial Neural Network Training Results

The results of the error calculation from the artificial neural network training process can be seen in Figure 9.

```
error =

    0.2201


error2 =

    0.2021    0.0371    0.0162    0.0772


error3 =

    0.6520    0.4423    0.4407    0.4447
    0.4500    0.4052    0.4245    0.3675
```

Figure 9. Artificial Neural Network Error Results

The results of the normalised value of forecasting data from the artificial neural network training process can be seen in Figure 10.

```
t4 =

    0.4317
    0.4705
    0.5856
    0.0295
         0
    0.3797
    0.4995
    0.4134
    0.4057
    0.3080
    0.5358
    0.4641


d =

    0.3978
```

Figure 10. Result of Normalisation Value of Forecasting Data

After getting the normalised value of forecasting data for one year, the data will be denormalised to get the forecast value in the form of units. The results of 1-year normalisation for HBL 100 ML products can be seen in Table 3.

Table 3. Overall Normalization Score Results

Month	**Normalization**
1	0.3978
2	0.0010
3	0.0001163
4	0.4460
5	0.5758
6	0.5122
7	0.6191
8	0.7077
9	0.7164
10	0.4283
11	0.0091
12	0.000054701

The results of the artificial neural network denormalisation values can be seen in Table 4.

Table 4. Result of Denormalisation Value

Month	**Denormalisation**
1	1.767.201
2	202.458
3	198.973
4	1.957.273
5	2.469.127
6	2.218.327
7	2.639.877
8	2.989.263
9	3.023.570
10	1.887.475
11	234.399
12	198.730

The following calculation is an example of a denormalisation calculation for an HBL 100 ML product.

$$Y = \left(a \text{ x } (Xmax - Xmin)\right) + Xmin$$
$$Y = \left(0{,}3978x(4.141.920 - 198.514)\right) + 198.514$$

$Y = 1.767.201$

After the denormalisation calculation has been obtained, the next step is to calculate the error in all types of forecasting methods to determine the appropriate forecasting method used for the HBL 100 ML product by looking at the smallest error value. The table comparing the error values result for all types of forecasting methods for HBL 100 ML products can be seen in Table 5.

Table 5. Error Result Comparison

Error Method	MAD	MSE	SDE	MAPE	MPE
SMA 2	784.628,70	1.113.595.783.666,53	1.102.194,07	95,77	65,49
SMA 3	713.523,54	962.986.985.982,29	996.534,16	101,40	73,89
SMA 4	547.468,34	557.988.962.439,12	758.939,13	78,21	57,36
SMA 5	658.794,88	858.900.898.847,06	942.088,60	100,69	73,81
SMA 6	606.507,75	761.046.015.287,88	887.293,06	90,18	62,95
SMA 7	591.040,20	776.942.430.430,81	897.045,36	76,51	49,19
SMA 8	560.571,18	689.865.456.830,46	845.822,69	76,31	48,48
SMA 9	558.856,24	688.144.905.712,46	845.347,28	72,49	44,00
SMA 10	545.294,50	681.567.257.492,95	841.920,39	73,28	46,26
SMA 11	457.479,15	435.805.264.420,22	673.768,37	72,22	50,00
SMA 12	467.260,51	476.393.928.218,12	705.057,95	75,27	52,61
SMA 13	470.624,05	488.600.948.683,27	714.709,79	78,02	56,36
SMA 14	477.772,70	480.986.986.293,18	709.852,89	79,51	56,87
SMA 15	505.735,37	520.197.154.399,97	739.058,19	83,05	59,03
SMA 16	481.808,73	484.259.954.856,40	713.965,91	84,93	62,82
DMA 2	921.268,78	2.006.156.826.008,91	1.438.349,48	140,48	123,85
DMA 3	971.423,01	1.555.837.188.045,53	1.267.950,48	131,55	112,64
DMA 4	913.096,08	1.483.324.852.305,21	1.239.475,99	102,88	84,24
DMA 5	808.996,25	1.182.901.995.504,35	1.108.331,28	90,61	74,61
DMA 6	604.582,19	664.824.002.492,37	832.180,87	84,36	73,62
DMA 7	692.690,52	891.545.663.671,02	965.437,97	98,07	87,64
DMA 8	790.003,90	1.174.203.658.073,03	1.110.366,53	112,39	94,95
WMA 3	704.087,63	971.828.772.869,15	1.001.098,61	98,40	70,42
WMA 4	656.896,35	809.157.401.447,73	913.925,19	89,12	60,64
WMA 5	664.402,21	819.840.238.500,65	920.417,43	94,11	66,25
WMA 6	623.356,71	747.236.394.841,80	879.205,99	84,15	56,04
WMA 7	599.631,30	724.022.453.268,98	865.956,35	72,53	43,94
WMA 8	591.200,49	720.430.410.392,49	864.357,00	73,42	44,52
WMA 9	580.554,44	717.576.121.164,30	863.235,31	71,35	41,94
WMA 10	568.335,28	716.775.150.892,52	863.392,24	72,38	45,27
SES 0,1	663.487,36	890.426.781.528,03	957.400,55	93,97	64,48
SES 0,2	681.209,66	928.933.832.300,93	977.883,13	97,58	69,61
SES 0,3	708.739,46	970.963.081.803,47	999.760,38	98,18	69,32
SES 0,4	724.909,35	1.015.034.492.317,43	1.022.197,85	97,09	67,55
SES 0,5	739.356,49	1.063.947.591.849,58	1.046.537,23	95,97	65,35
SES 0,6	756.550,05	1.120.907.921.632,37	1.074.186,11	95,36	63,13
SES 0,7	781.076,00	1.189.364.896.901,14	1.106.501,79	95,17	61,06
SES 0,8	808.612,82	1.273.227.593.808,17	1.144.847,35	95,24	59,22
SES 0,9	839.894,48	1.377.237.161.969,41	1.190.690,61	95,65	57,62
DES 0,1	693.416,53	970.691.365.578,89	1.000.053,13	103,88	78,93
DES 0,2	758.522,99	1.099.506.954.183,95	1.064.342,68	103,95	75,15
DES 0,3	795.639,04	1.241.651.175.414,19	1.131.051,27	101,32	68,17
DES 0,4	848.832,66	1.412.797.421.683,92	1.206.486,41	101,14	61,87
DES 0,5	895.806,55	1.629.109.952.671,89	1.295.560,47	99,54	56,59
DES 0,6	978.956,88	1.912.021.575.144,51	1.403.553,21	108,91	52,49
DES 0,7	1.093.349,73	2.291.971.871.733,09	1.536.693,06	128,05	49,58
DES 0,8	1.232.589,96	2.813.521.397.448,56	1.702.580,28	149,71	47,70
DES 0,9	1.409.929,53	3.544.592.406.007,56	1.911.021,79	175,70	46,50
SIKLIK	641.784,48	766.217.892.681,35	887.755,50	95,65	72,24
LINIER	637.149,04	783.006.988.137,05	897.428.89	96,02	73,18
KUADRATIK	795.639,04	1.241.651.175.414,19	1.131.051,27	101,32	68,17
DEKOMPOSISI	350.997,04	296.490.145.369,98	487.023,73	31,54	15,71
ANN	760,583554	863.032,834043	970,304264	0,112530	0,112530
Result	760,583554	863.032,834043	970,304264	0,112530	0,112530

Based on the results of the error values for all forecasting methods in Table 5, it can be concluded that the chosen forecasting method with the smallest error value. The Artificial Neural Network (ANN) forecasting method with the MAD error value of 760.583554, the MSE error value of 863,032.834043, the value SDE error is 970.304264, MAPE error value is 0.112530, and MPE error value is 0.112530 is the chosen one.

After the forecasting method with the smallest error value has been selected, the method will be verified. The calculation table for the verification method for HBL 100 ML products can be seen in Table 6.

Table 6. Calculation of Forecasting Method Verification

No	Forecasting	Demand	ERROR	RSFE	Abs Error	Cum Error	MAD	TS
1	1.901.276,873	1.900.693	-584,0084	-584,0084	584,0084	584,0084	584,0084	-1
2	2.054.281,015	2.054.057	-223,8720	-807,8803606	223,872	807,8804	403,9402	-0,5
3	2.507.772,672	2.507.657	-115,5291	-923,4095034	115,5291	923,4095	307,8032	-0,333333
4	315.239,0949	314.743	-496,2377	-1.419,647218	496,2377	1.419,647	354,9118	-0,25
5	200.091,648	198.514	-1.577,3623	-2.997,009503	1.577,362	2.997,01	599,4019	-0,2
6	1.696.219,776	1.695.697	-522,6331	-3.519,642646	522,6331	3.519,643	586,6071	-0,166667
7	2.169.428,462	2.168.434	-994,1760	-4.513,818646	994,176	4.513,819	644,8312	-0,142857
8	1.829.901,23	1.828.800	-1.101,2297	-5.615,048361	1.101,23	5.615,048	701,881	-0,125
9	1.799.537,006	1.798.457	-1.079,8629	-6.694,9112	1.079,863	6.694,911	743,879	-0,111111
10	1.415.054,949	1.413.257	-1.797,8057	-8.492,716932	1.797,806	8.492,717	849,2717	-0,1
11	2.311.785,408	2.311.200	-585,4080	-9.078,124932	585,408	9.078,125	825,2841	-0,090909
12	2.028.648,878	2.028.600	-48,8777	-9.127,002646	48,87771	9.127,003	760,5836	-0,083333

The graph of the tracking signal calculation results for the HBL 100 ML product can be seen in Figure11 on the next page.

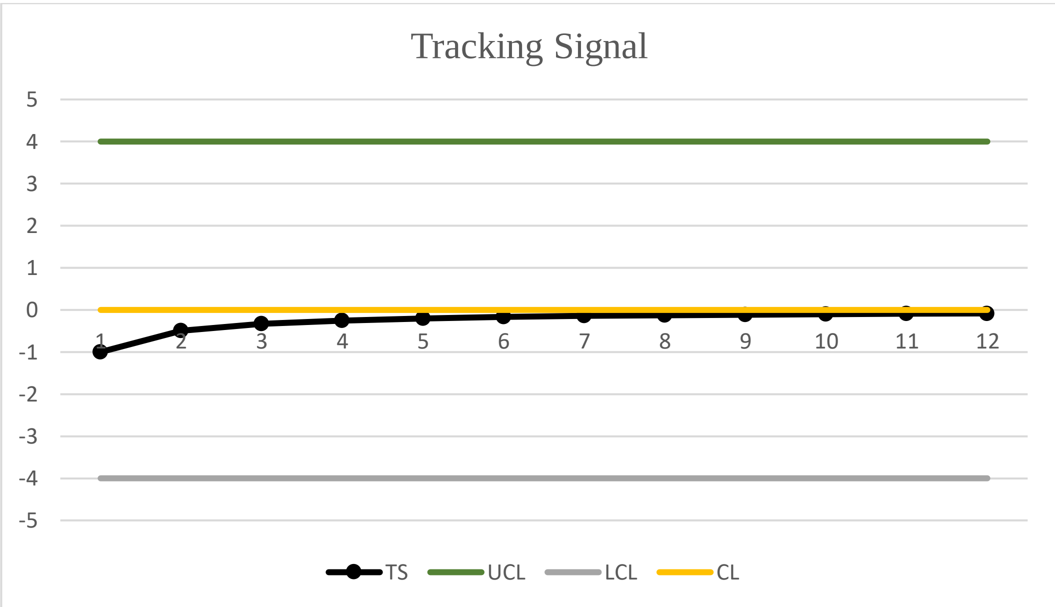

Figure 11. Tracking Signal Chart

Based on the graph above, it can be concluded that the tracking signal value for the HBL 100 ML product does not exceed the Upper Control Limit (UCL) of 4 and the Lower Control Limit (LCL) of -4.

CONCLUSION

After conducting the research calculation, the following conclusions can be drawn. The right forecasting method used for the HBL 100 ML product is the ANN (Artificial Neural Network) method because it has the smallest error value, namely the MAD error method of 760.583554, the MSE error method of 863,032.834043, the SDE error method of 970.304264, the MAPE error method is 0.112530, and the MPE error method is 0.112530.

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