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Forecasting Inflation Rate in Padang City Using Backpropagation Method

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Abstract- Desire to maximize economic growth in the Padang City, so it need to know the minimum estimate of inflation, that matter is done so that can anticipate the value of inflation outside the desired rate. This research was conducted to obtain forecasting inflation rates in the Padang City using the Backpropagation method. The data of this research is secondary data. Data obtained through the West Sumatra BPS website about inflation of Padang City in January 2013-December 2019. The results of research obtained a forecasting inflation rate in the Padang City with MSE value is 0.010689.

1. Introduction

Inflation can be interpreted as a general and continuous increase in prices [1]. Inflation is a major economic problem that is often faced by people and one of the indicators to measure the economic success of a country. The various impacts of inflation force each country to be able to keep the inflation rate always within the desired level. This is necessary to boost economic growth to the maximum and create a controlled national economy. The inflation rate in Padang city over the last seven years can be seen in Figure 1, where the inflation rate is very fluctuating but the longer data tends to decrease. The lowest inflation rate occurred in February 2015 with a value of -2.07 and the highest inflation rate of 3.44 occurred in November 2014. In February, the value of inflation is always decreasing from the previous month, while compared to the previous months in May, June, July, and November the inflation rate always increases. The pattern will be studied by the backpropagation method through data training.

The inflation rate in Padang city in the next few years needs to be predicted in order to keep the inflation rate at the required value. Forecasting is an activity to predict what will happen in the future. Inflation forecasts can be used to prepare government policies to keep inflation normal. In addition, the results of inflation forecasting can also be utilized by the public to anticipate the negative impact of socioeconomic conditions at the time of inflation. To achieve this goal, appropriate forecasting methods are needed to forecast using inflation data.

Inflation data is one of the time-series data by modeling past data and can be used to predict future data [2]. Besides that, inflation data is also data whose value is irregular (can suddenly rise and also fall), so according to the statement [3] that various types of data that have irregular patterns tend to be difficult to predict, but there is a type of forecasting method that is artificial neural network backpropagation method, where this method can predict data whose value is irregular as in previous research, namely forecasting the inflation rate in Samarinda City [4] and forecasting Indonesia inflation rate [5] through process training.

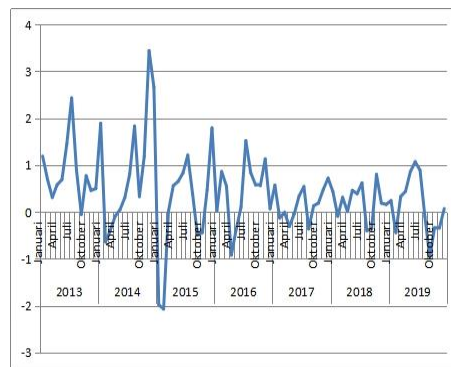


Figure. 1 Padang City Inflation Rate 2013-2019

Artificial neural networks can recognize a pattern in the data and predict future values [3] and do not require factors to be addressed, are not familiar with formulas and rules, and apply in general. Therefore, artificial neural networks can be directly applied in predicting the inflation of Padang City without having to look at the data pattern first because it's will study the patterns. Besides, the relationship between variables can be known using artificial neural networks so that it can be determined that the results issued are the best. Thus, the most suitable method applied to forecasting is the artificial neural network backpropagation method because this method has the advantage of minimizing errors in the output produced by the network [6].

2. Methods

This research is applied research. The data used in this study is secondary data taken from the official website of the Central Statistics Agency of West Sumatra. Data obtained in the form of monthly data, namely inflation data of Padang City from 2013-2019. To analyze the data in this study, artificial neural networks were used with one of the learning methods, namely the backpropagation method using Microsoft Excel and Matlab software with the procedure.

1. Collecting Padang City Inflation data to be used, namely monthly inflation data at Padang city in 2013-2019.
2. Determines the appropriate activation function for the data. This study used a bipolar sigmoid activation function that is

$$g(x) == \frac{1-e^{-x}}{1+e^{-x}} \tag{1}$$

With its first derivative

$$g'(x) == \frac{(1+g(x))(1-g(x))}{2} \tag{2}$$

3. Normalize data into the range 0.1-0.9 using equations

$$x' = \frac{0,8(x-a)}{b-a} + 0,1 \tag{3}$$

4. After the data transformation is determined the target pattern of the data through

Table 1. Input and Target Data Patterns

| Pattern | Input Data | Target |
|---------|---|-------------------------------------|
| 1 | Data for the 1 st month to the 12 th month | Data for the 13 th month |
| 2 | Data for the 2 nd month to the 13 th month | Data for the 14 th month |
| 3 | Data for the 3 rd month to the 13 th month | Data for the 15 th month |
| ... | Data for the ... month to the ... month | ... |
| 70 | Data for the 70 th month to the 81 th month | Data for the 82 th month |
| 71 | Data for the 71 th month to the 82 th month | Data for the 83 th month |
| 72 | Data for the 72 th month to the 83 th month | Data for the 84 th month |

- Data is divided into two. 1st to 36th data pattern (2013-2016 data) as training data and 37th to 72nd data (2016-2019 data) as testing data.
- Determining the architecture of the backpropagation method, in this study the architecture is twelve input units, ten units on a hidden screen, and one output unit. Then determined the maximum iteration of 1000 iterations, and learning rate (0.1), after which just completed the backpropagation algorithm in the forecasting process.
- Completed the calculation of 1000 iterations on the Artificial Neural Network Backpropagation Method. The backpropagation method is carried out through the following steps [7]

Step 0: Initialize weights and biases.

Weights and biases can be initialized with small random numbers.

Step 1: If the training process has not stopped then do steps 2-9;

Step 2: For each training process do step 3-8;

Phase I: Feedforward

Step 3: Each input unit ($X_i, i = 1, \dots, n$); receive the input X_i and run the signal to all units in the hidden layer.

Step 4: On each unit in the hidden layer ($Z_j, j = 1, \dots, p$); sum weights and biases with their respective input signals

$$Z_{in_j} = V_{0j} + \sum_{i=1}^n X_i V_{ij}$$

Then calculate the output signal value of the hidden layer by using the predetermined activation function

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

This output signal is sent to the entire unit at the next layer (output layer)

Step 5: On each unit on the output layer ($Y_k, k = 1, \dots, m$); sum its weight and bias with input signals

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

Then calculate the output signal from the output unit concerned by using the activation function that has been specified

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

This output signal is sent to all units on the network output.

Phase II: Backpropagation of Error

Step 6: Each unit on the output layer ($Y_k, k=1,2,\dots,m$); receive a network-generated output pattern. To calculate the error between the input target and the output generated by the network.

$$\delta_k = (T_k - Y_k)f'(Y_{in_k}) = (T_k - Y_k)Y_k(1 - Y_k)$$

The fault δ_k will be used to improve the W_{jk} in the hidden layer with a learning rate of α .

$$\Delta W_{jk} = \alpha \delta_k Z_j; (k = 1,2,\dots,m; j = 1,\dots,p)$$

Calculate also the bias correction factor that will be used to improve the weight of the W_{0k}

$$\Delta W_{0k} = \alpha \delta_k; (k = 1,2,\dots,m)$$

The δ_k is then sent to the layer located in step 7.

Step 7: For each unit on the hidden layer ($Z_j, j = 1,\dots,p$); delta input from step 6. Then calculate the factor δ for each hidden unit based on the error of each hidden unit.

$$\delta_{in_j} = \sum_{k=1}^m \delta_k W_{jk}; (j = 1,\dots,p)$$

Calculate the δ in hidden units using the derived activation function to calculate the error value (the error)

$$\delta_j = \delta_{in_j} f'(Z_{in_j}) = \delta_{in_j} Z_j(1 - Z_j)$$

Calculate the change in V_{ij} weight to be used to improve the weight V_{ij} ,

$$\Delta V_{ij} = \alpha \delta_j X_i; (j = 1,2,\dots,p; i = 1,\dots,n)$$

Then calculate the bias changes that will be used to correct the bias V_{0j} .

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

Phase III: Weight and Bias Update

Step 8: Calculate the change in weight and bias in the hidden unit to the output unit.

$$W_{jk}(new) = W_{jk}(old) + \Delta W_{jk}$$

Calculate also changes in weight and bias in the input unit to the hidden unit.

$$V_{ij}(new) = V_{ij}(old) + \Delta V_{ij}$$

Step 9: The training process will stop when the conditions have been met, but if it has not been met then do step 2-9.

8. Then in the target conformity test with the forecast results through error goal (MSE) comparison.

3. Result and Discussion

The first step that will be done when using this backpropagation method is to create a network initialization. Before the backpropagation algorithm training is done, first determine the desired parameter value in order to obtain optimal results. This study used 12 input neurons, 10 hidden screens, and 1 output neuron, bipolar sigmoid activation function, and a learning rate of 0.1.

(a) Analysis Result

In the process of running the Backpropagation Algorithm, monthly data is used for 7 consecutive years (January 2013-December 2019) as network input. The data is normalized using the equation (3) so that it returns the following value.

Table 2. Inflation Data Transformation Of Padang City

| YEARS | JAN | FEB | ... | NOV | DEC |
|-------|--------|--------|-----|--------|--------|
| 2013 | 0.5733 | 0.5022 | ... | 0.4673 | 0.4731 |
| 2014 | 0.6750 | 0.3076 | ... | 0.9000 | 0.7868 |
| 2015 | 0.1131 | 0.1000 | ... | 0.4688 | 0.6604 |
| 2016 | 0.4034 | 0.5254 | ... | 0.5646 | 0.4107 |
| 2017 | 0.4833 | 0.3817 | ... | 0.4702 | 0.5051 |
| 2018 | 0.4630 | 0.3875 | ... | 0.4281 | 0.4238 |
| 2019 | 0.4354 | 0.3367 | ... | 0.3512 | 0.4107 |

The data to be used must be divided into two parts, the first for the training data and the second for the test data. Then the training data and test data are processed using a backpropagation algorithm that can be seen in point seven of the research method, the training data is used phase one to phase three to get better weight and bias, then the weight and bias obtained from the training data processing is used to process the test data, test data is only used phase one backpropagation algorithm to get the desired forecast results. The final output of the test data output unit for a single epoch can be seen in Table 3.

Table 3. Output Unit Result

| Months | Y_k 2020 | Y_k 2021 | Y_k 2022 |
|-----------|---------------|---------------|---------------|
| January | 0.42 | 0.41 | 0.43 |
| February | 0.46 | 0.40 | 0.39 |
| March | 0.41 | 0.41 | 0.39 |
| April | 0.40 | 0.39 | 0.40 |
| May | 0.38 | 0.40 | 0.39 |
| June | 0.39 | 0.43 | 0.43 |
| July | 0.41 | 0.40 | 0.41 |
| August | 0.39 | 0.40 | 0.38 |
| September | 0.39 | 0.39 | 0.40 |
| October | 0.41 | 0.40 | 0.42 |
| November | 0.40 | 0.40 | 0.42 |
| December | 0.42 | 0.06 | 0.41 |

Furthermore, the output value of Y_k obtained from the algorithm is substituted back into the equation (3), where Y_k here instead of the variable x' , to calculate the value of x which becomes the actual data of the forecast. Obtained forecast results that can be seen in Table 4.

Table 4. Forecast Results in one iteration

| Months | 2020 | 2021 | 2022 |
|-----------|-------|-------|-------|
| January | 0.13 | 0.06 | 0.20 |
| February | 0.44 | -0.01 | -0.09 |
| March | 0.09 | 0.04 | -0.04 |
| April | -0.01 | -0.05 | 0.007 |
| May | -0.16 | 0.002 | -0.08 |
| June | -0.04 | 0.22 | 0.21 |
| July | 0.08 | 0.03 | 0.04 |
| August | -0.05 | -0.02 | -0.11 |
| September | -0.05 | -0.08 | 0.02 |
| October | 0.05 | -0.02 | 0.14 |
| November | -0.02 | -0.03 | 0.13 |
| December | 0.11 | 0.06 | 0.10 |

All the steps of the backpropagation algorithm above are only one epoch (iteration), then the steps are repeated up to 1000 times the epoch and obtained MSE or the smallest error value. From the resulting output will be obtained MSE value and forecast results along with its MSE value graph. After the Matlab program is run, the results are obtained in Figure 2. The 12-10-1 architectural model image can explain that the epoch (Iteration) occurred by 1000 with a length of 8 seconds.

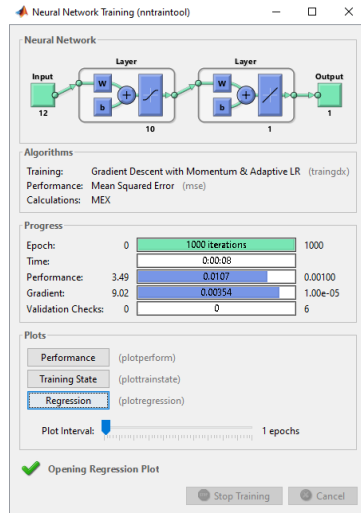


Figure 2. Backpropagation training results using Matlab

Then obtained MSE value chart for inflation forecast for the next three years with MSE value is performance value listed in Figure 3. Based on Figure 3 it is known that the MSE value is 0.010689 and the iteration is discontinued in the 1000th epoch with a tolerance limit of 10^{-2} greater than the specified tolerance limit (10^{-4}). The MSE value obtained is the performance value listed at the top of the chart. The calculation process is stopped by itself because it is considered to have reached the desired target. While the resulting R correlation coefficient is 0.75541 as shown in Figure 4.

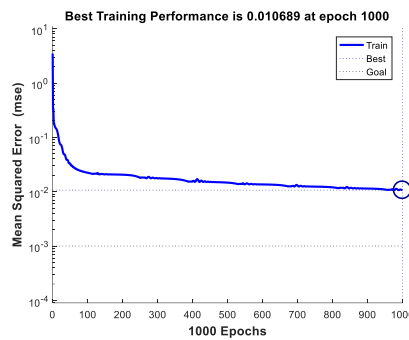


Figure 3. MSE rate chart of monthly inflation forecast 2020-2022

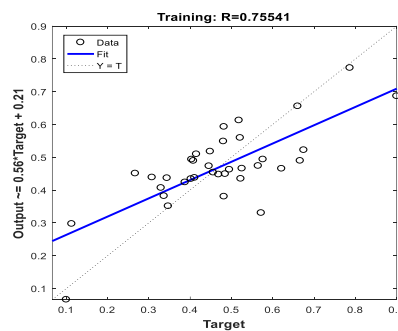


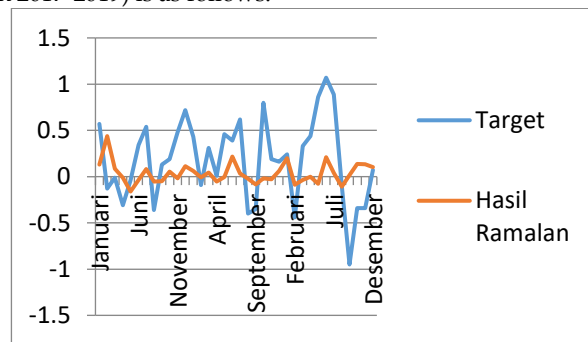
Figure 4. Graph of coefficients of collegiate R

Then, the final result is the output of the forecasted inflation rate in Padang city in Table 5.

Table 5. Padang City Inflation Forecast Result Using MATLAB

| Months | 2020 | 2021 | 2022 |
|-----------|-------|-------|-------|
| January | 0.72 | 0.67 | 0.89 |
| February | -0.76 | -0.49 | -0.47 |
| March | 0.27 | 0.58 | 1.00 |
| April | 0.72 | 0.25 | 1.12 |
| May | 1.49 | 0.89 | 0.69 |
| June | 0.46 | 0.43 | 0.34 |
| July | 1.90 | 0.51 | 0.48 |
| August | 0.63 | 0.01 | 0.11 |
| September | 1.62 | 1.06 | 0.39 |
| October | 0.47 | 0.57 | 0.50 |
| November | 1.53 | 1.15 | 0.38 |
| December | 0.62 | 0.90 | 1.03 |

The comparison graph of the forecast results obtained with the target (Padang City Inflation data three years earlier, namely in 2017-2019) is as follows.

**Figure 5.** Forecast versus target result

(b) Discussion

Based on the results of the analysis above, the results of the monthly Inflation forecast in Padang City for three years. The analysis begins by describing the data obtained from the results of the study. Next, it is specified the activation function to be applied. Then the data must first be transformed using equation 3. The data of this transformation will then be divided into two training data and testing data that will be used in the forecasting process with calculations using the Matlab program.

In Matlab programming the first step is to create a network initialization, first determined the desired parameter value to obtain optimal results. The architecture used in this study is 12 layer inputs, 10 hidden layers, and 1 output layer. The parameters used in general in Matlab application with backpropagation algorithm are as follows.

```
net.performFcn = 'mse';
net.trainParam.goal = 0.001;
net.trainParam.show = 20;
net.trainParam.epochs = 1000;
net.trainParam.mc = 0.95;
net.trainParam.lr = 0.1;
```

Both processes are used to $\alpha=0.1$ and the initial weight and initial bias are the same. Based on the process of running the program it is known that the calculation process is stopped automatically if it has reached the expected tolerance limit. The result appears that $MSE=0.010689$ occurred in the 1000th iteration (epoch). The resulting MSE is different from the MSE included in the programming synth, this is because

the 1000th iteration of MSE is already very small, although the continued iteration will still produce the same MSE value. So that by itself the program will stop at the iteration of 1000 and the tolerance 10^{-2} . The results of the forecast can be seen in Figure 6, the data of the results of the three-year forecast tends to increase even though there are some who have decreased. However, compared to the inflation rate in previous years, the predicted result is a more stable and standardized inflation rate.

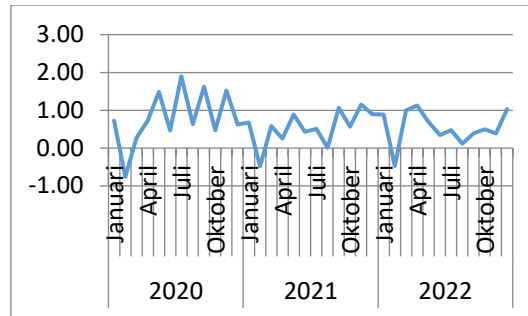


Figure 6. Forecast inflation rate in padang city in 2020-2022

In general, at the beginning of the year inflation was high, then decreased in February and increased until July. Then the inflation rate began to decline again until September and has increased over the last three months. The fluctuating data is caused by many external factors that affect the inflation rate in Padang city itself. However, judging from the results of forecasting in this study it can be known that the Backpropagation Method can maintain intrinsic properties (actual value) in conducting forecasting. The smaller the MSE value, the better the forecasting results, in this study obtained an MSE value of 0.010689 which is less than the MSE target inputted in Matlab programming. This is in line with previous research by [5] which also applied artificial neural networks backpropagation method to predict the monthly inflation rate in Indonesia. The results showed that the backpropagation algorithm performance with a fairly good predicted accuracy based on an MSE value of 0.0171. then it can be said that the results of this prophecy are good. Then for the R chart is obtained a value of 0.75541, where according to [8] if the correlation value is in the range of 0.75 to 0.99 then the correlation relationship is very strong.

4. Conclusion

Analysis of inflation rate forecasting in Padang city using the Backpropagation method has been implemented. Based on the results of research and discussion, it is concluded that the forecast results show that the inflation rate in Padang City in the period 2020 to 2022 will fluctuate every month, where the lowest inflation rate is predicted to occur in February 2020 at -0.76 while the highest occurred in July 2020. But although the data fluctuates, it can be seen that the forecast results in February, June, and August tend to decrease and the forecast results in March, July, September tend to rise, it can not be separated from the process of learning patterns by backpropagation algorithms in analyzing input data patterns that are inflation rate data in previous years.

The use of the Backpropagation method in this study with parameters such as bipolar sigmoid activation function and learning rate 0.1 was able to produce a fairly good forecasting error rate with an MSE value of 0.010689. This indicates that this Backpropagation method can be an alternative method in predicting the inflation rate in Padang City and data obtained from the forecasting process using the Artificial Neural Network Backpropagation Method as the minimum data of reference inflation rate in Padang city for 2020-2022.

References

1. Bank Indonesia. 2020. *Pengenalan Inflasi*. Accessed 20 January 2020, <http://www.bi.go.id>.
2. Suparti. 2013. *Analisis Data Inflasi di Indonesia Menggunakan Model Regresi Spline*. Media Statistika, Vol.6, No. 1, 1-9.
3. Sawitri, M. N., Sumarjaya, I. W., & Tastrawati, N. K. 2018. *Peramalan Menggunakan Metode Backpropagation Neural Network*. E-Jurnal Matematika Vol. 7(3), 264-270.
4. Wong, K. 2019. *Prediksi Tingkat Inflasi Dengan Menggunakan Metode Backpropagation Neural Network*.

- Sains, Aplikasi, Komputasi dan Teknologi Informasi* Vol 1, No.2, Agustus 2019, pp. 8-13.
5. Amrin. 2014. *Peramalan Tingkat Inflasi Indonesia Menggunakan Neural Network Backpropagation Berbasis Metode Time Series*. *Jurnal Techno Nusa Mandiri*.
 6. Siang, J. J. 2009. *Jaringan Syaraf Tiruan dan Pemogramannya Menggunakan MATLAB*. Yogyakarta: Andi Offset.
 7. Fausett, L. 1994. *Fundamental of Neural Networks: Architectures, Algorithms, and Applications*. New Jersey: Prentice Hall.
 8. Jonathan, S. 2006. *Metode Penelitian Kuantitatif dan Kualitatif*. Yogyakarta: Graha Ilmu.