Determining the Best Performance Using the Backpropagation Algorithm for Expenditure per Capita in North Sumatra

Yogi Pratama¹, Solikhun²

¹STIKOM Tunas Bangsa, Indonesia
²AMIK & STIKOM Tunas Bangsa, Indonesia

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ABSTRACT

In an effort to maintain per capita income in Indonesia, the Government must take action through strengthening national protection. Per capita is the average income of all residents in a country. Per capita income is obtained from the distribution of the national income of a country by the total population of that country. There is a decrease in the population per capita of North Sumatra at the Central Statistics Agency (BPS) in 2020. The author will use the backpropagation algorithm to make a performance. Backpropagation is one of the methods in solving an artificial neural network problem. In research 5 models are used: 4 - 15 - 1, 4 - 30 - 1, 4 - 45 - 1, 4 - 60 - 1, 4 - 75 - 1. Thus, the architectural model 4 - 75 - 1 provides the best accuracy with 452 iteration epochs and MSE is 0.00001536.

Keywords:
Artificial Neural Network
Backpropagation
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Performance

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1. INTRODUCTION

Per capita income is the average income of all individuals in a country. Income per capita earned of income on a certain day divided by the added value of the population a country on that day. If the community holding income or high tip fairy tales mostly poisons live their lives and deposit ahead of their future costs. If most incomes decline a difficult fairy tale for most it anchors his life plan (Wahyu Azizah & Kusuma, 2018)

The pandemic has created negative economic growth in almost all countries, including Indonesia, especially in North Sumatra in 2020 (Susilawati et al., 2020). Thus, the decline in Indonesia’s per capita income is an unavoidable consequence (Hook & Replogle, 1996). However, through an adaptive and credible fiscal policy response, the Government was able to withstand a deeper economic contraction (Erinç Yeldan & Ünüvar, 2016).

In Table 1 it can be seen that there is a significant difference, Income per capita in 2020 decreased but did not last long (Miller et al., 2020). This was due to the Pandemic that hit almost all over the world. If this is allowed, it will have an impact on the Indonesian economy in the future (Woo & Hong, 2010).
### Table 1. Adjusted per capita expenditure data
(Source: BPS 2021)

| County / City            | 2012 | 2013 | 2014  | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 |
|--------------------------|------|------|-------|------|------|------|------|------|------|------|
| Nias                     | 5710 | 5914 | 5980  | 6234 | 6409 | 6629 | 6941 | 7042 | 6898 | 6995 |
| Christmas                |      |      |       |      |      |      |      |      |      |      |
| Mandailing               | 8871 | 8960 | 9040  | 9096 | 9237 | 9385 | 9653 | 9900 | 9684 |      |
| South Tapanuli           | 10357| 105 | 10593 | 10623| 10821| 10955| 1120 | 1141 | 1123 |      |
| Middle Tapanuli          | 9324 | 9382 | 9489  | 9555 | 9694 | 9852 | 7    | 5    | 1    |      |
| North Tapanuli           | 10786| 10850| 10964 | 11079| 11242| 11407| 1160 | 1179 | 1164 |      |
| Toba Samosir             | 11043| 11178| 11250 | 11535| 11687| 11846| 1209 | 1237 | 1215 |      |
| Labuhan Batu             | 10058| 10210| 10325 | 10356| 10559| 10760| 3    | 3    | 0    |      |
| Sharpen                  | 9773 | 9895 | 9988  | 10067| 10288| 10477| 5    | 3    | 0    |      |
| Simalungun               | 10358| 10494| 10597 | 10728| 10855| 11055| 1113| 1142 | 1130 |      |
| Dairi                    | 9520 | 9580 | 9642  | 9708 | 10190| 10395| 1049 | 1060 | 1035 | 10504|
| Karo                     | 11359| 11453| 11548 | 11800| 11925| 12059| 1236 | 1247 | 1234 |      |
| Deli Serdang             | 10785| 10924| 11065 | 11359| 11683| 11891| 1213 | 1231 | 1222 |      |
| Langkat                  | 9910 | 9970 | 10062 | 10364| 10567| 10784| 1108 | 1120 | 1107 |      |
| South Nias               | 6213 | 6266 | 6329  | 6454 | 6647 | 6941 | 7015 | 6974 |      |      |
| Humbang                  | 6562 | 6670 | 6736  | 6889 | 7135 | 7412 | 7630 | 7902 | 7850 |      |
| Hasundutan               | 7205 | 7269 | 7364  | 7496 | 7641 | 7913 | 8099 | 8402 | 8170 |      |
| Mr. West                 | 7533 | 7600 | 7667  | 7698 | 7813 | 8163 | 8348 | 8654 | 8422 |      |
| Samosir                  | 9817 | 9882 | 10042 | 10110| 10246| 10551| 1038 | 1057 | 1041 |      |
| Deli Serdang Bedagai     | 9069 | 9218 | 9370  | 9692 | 9886 | 10084| 1019 | 1019 | 10055|
| North Lawas              | 8887 | 9076 | 9171  | 9363 | 9600 | 9737 | 9912 | 9987 |      |      |
| Old Field                | 7740 | 7825 | 7910  | 7955 | 8094 | 8445 | 8772 | 9100 | 8807 |      |
| South Batu               | 9866 | 10040| 10111 | 10319| 10712| 10892| 1128 | 1155 | 1149 |      |
| Labuhan                 | 10979| 11063| 11147 | 11201| 11278| 11510| 1173 | 1195 | 1177 |      |
| North Batu               | 5442 | 5523 | 5580  | 5627 | 5770 | 5835 | 6041 | 6245 | 6064 |      |
| North Nias               | 5038 | 5061 | 5156  | 5207 | 5391 | 5594 | 5817 | 6009 | 5930 |      |
| West Nias                | 10352| 10525| 10623 | 10765| 11034| 11221| 1110 | 1138 | 1113 |      |
| Sibolga                  | 9872 | 10001| 10133 | 10326| 10577| 10778| 1229 | 1257 | 1237 |      |
| Tanjung Balai City       | 11039| 11139| 11204 | 11388| 11878| 12106| 1243 | 1289 | 1287 |      |
| Pematang Siantar City    | 10666| 10829| 10918 | 11393| 11747| 12055| 1484 | 1503 | 1489 |      |
| Cliff City               | 13750| 13902| 13984 | 14191| 14393| 14613| 1075 | 1126 | 1099 |      |
| Medan City               | 9829 | 9943 | 10058 | 10098| 10342| 10487| 7    | 5    | 3    |      |

| Toba Samosir             | 9771 |      |      |      |      |      |      |      |      |      |
| Labuhan Batu             | 10138|      |      |      |      |      |      |      |      |      |
| Deli Serdang Bedagai     | 12224|      |      |      |      |      |      |      |      |      |
| North Lawas              | 12291|      |      |      |      |      |      |      |      |      |
| Old Field                | 11840|      |      |      |      |      |      |      |      |      |
| South Batu               | 6155 | 5924 |      |      |      |      |      |      |      |      |
| Labuhan                 | 11540| 11543|      |      |      |      |      |      |      |      |
| North Batu               | 12436| 12437|      |      |      |      |      |      |      |      |
| North Nias               | 12939| 12940|      |      |      |      |      |      |      |      |
| West Nias                | 14999| 14999|      |      |      |      |      |      |      |      |
| Sibolga                  | 11063|      |      |      |      |      |      |      |      |      |
The author will use the backpropagation algorithm to predict how much North Sumatra’s per capita expenditure will be in the future (Anggraeni et al., 2019). Backpropagation is one of the methods used in Artificial Neural Networks (ANN) (Govoroschenko, 2007) which often manage to solve the problem. Backpropagation is a well-known and successful method to be applied to various fields apps, like introduction pattern, site selection, and performance evaluation. Algorithm backpropagation goes through two stages, the process training and testing process (Purba & Wanto, 2018).

On research Previously, a study was conducted to determine the average per capita expenditure of food and non-food products by province with an accuracy of 97% using architectural model 9-8-1 with MSE 0.0720399, research this shows that Artificial neural networks have adaptive properties, namely: network trying to achieve stability again to achieve expected results through the learning process by adjusting the weight of the connection (Wardani, 2019). It is encouraging the author to use the backpropagation algorithm to determine per capita expenditure in North Sumatra. In addition, he did research using backpropagation neural network to predict the income per capita of urban communities at the poverty line per province. This study found that the best architectural model is 6-3-2-1. We conducted a study to predict the amount of beef production in each province (Woli et al., 2004). Study This results in a 100% accuracy rate with best architectural model 6-3-2-1. We conducted a study to predict the amount of beef production per province. Study it generates 100% accuracy rate, with model best architecture is 11-28-1. model (Revi, 2018).

2. RESEARCH METHOD

2.1 Collection Data

This study uses data per capita expenditure adjusted to look at North Sumatra from 2012 to 2021. The Central Bureau of Statistics of North Sumatra provides economic data.

2.2 Algorithm Backpropagation

Backpropagation algorithm is a supervised educational algorithm and generally used by perceptron with multiple layout screens to change the weights contained in the hidden arrangement (Purba & Wanto, 2018). A distinctive characteristic of backpropagation relates 3 arrays: array input, where information is introduced to the network; hidden layer, where information is processed; as well as the output array, where the result of the input given by the input array (Fardhani, 2018).

2.3 Per Capita

Income per capita or gross domestic product per capita is used as an indicator of population progress or the level of welfare in the region (Bidone & Lacerda, 2004). Product Gross domestic product per capita is obtained by dividing the value of the gross domestic product of an area by the total population (Guha, 1974). Population growth increases productivity society and also serves as a source of new demand. In other words, depending on the income of the population and the residents themselves, it is possible to increase the product produced in the market and economic areas (Fields, 2004). Area the market will be wider. First, if the ratio of population/labor to other factors of production is relatively high, that is, if population is relatively small, if there are other factors of production, population growth will increase wealth society and vice versa (Wahyu Azizah & Kusuma, 2018).
2.4 Data Used

The information used is Total Expenditure Per capita in North Sumatra 2012-2021. The training data uses information for 2012-2015 and 2016 as targets (Guide, n.d.). On the other hand, testing information uses information for 2017-2020 and 2021 as targets or targets. Next try session with test results information processing by testing through the application Matlab R2011b. Until the final assessment session is tried, it aims to identify whether the results match the expectations.

3. RESULT AND DISCUSSIONS

3.1 Input and Target Data

Information variable used is a criterion that be a reference in getter decision. Variable is set by viewing method dependence of information on research that tried. Variables are determined by looking at the dependence of the data on the research conducted. The criteria used are based on data from the Central Bureau of National Statistics. There is also input information as well as targets or targets that can be seen in tables 2 and 3 following.

| Table 2. Input Data and Training Targets |
| Variable | Criteria          |
| No   |                |
| 1    | X1              | 2012 data     |
| 2    | X2              | 2013 data     |
| 3    | X3              | 2014 data     |
| 4    | X4              | 2015 data     |
| 5    | Target          | 2016 data     |

| Table 3. Input Data and Test Target |
| Variable | Criteria          |
| No   |                |
| 1    | X1              | 2017 data     |
| 2    | X2              | 2018 data     |
| 3    | X3              | 2019 data     |
| 4    | X4              | 2020 data     |
| 5    | Target          | 2021 data     |

3.2 Data Processing

The sample data used is per capita expenditure in North Sumatra from 2012 to 2021. This information will later be transformed into information between 0 and 1 before trying out the training (Alliger & Janak, 1989) and testing using an Artificial Neural Network using the backpropagation method with the formula:

\[ x' = \frac{0.5 \times (x - a)}{b - a} + 0.1 \]

Information:
- \( x' \) = Normalization data
- \( x \) = Data to be normalized
- \( a \) = Data lowest
- \( b \) = Data highest

The results of the information transformation that have been tried can be seen in the table 4 following.

| Table 4. Data Transformation |
| Data | X1   | X2   | X3   | X4   | X5   | X6   | X7   | X8   | X9   | Target |
|------|------|------|------|------|------|------|------|------|------|--------|
| 1    | 0.4138 | 0.4253 | 0.4289 | 0.4432 | 0.4530 | 0.1877 | 0.2142 | 0.2227 | 0.2105 | 0.2187 |
| 2    | 0.5908 | 0.5958 | 0.6003 | 0.6034 | 0.6113 | 0.4213 | 0.4440 | 0.4650 | 0.4466 | 0.4540 |
| 3    | 0.6740 | 0.1000 | 0.6872 | 0.6889 | 0.7000 | 0.5544 | 0.5759 | 0.5929 | 0.5762 | 0.5839 |
| 4    | 0.6162 | 0.6194 | 0.6254 | 0.6291 | 0.6369 | 0.4609 | 0.4791 | 0.4883 | 0.4794 | 0.4851 |
The architecture used and the results obtained in this study can be seen in tables 5 and 6 below.

### Table 5. Network Architecture

| Characteristics         | Specification |
|-------------------------|---------------|
| Input Data              | 4             |
| Hidden Layers           | 15,30,45,60,75 |
| Goal                    | 0.01          |
| Maximum epoch           | 1000          |
| Learning Rate           | 0.1           |

### Table 6. Results Training and Testing

| model  | epoch | MSE    |
|--------|-------|--------|
| 4-15-1 | 394   | 0.000002461 |
| 4-30-1 | 560   | 0.00002005 |
| 4-45-1 | 481   | 0.00001754 |
| 4-60-1 | 701   | 0.00001609 |
| 4-75-1 | 452   | 0.00001536 |

Based on the results of training and testing, the best architecture is 4-75-1 with the lowest MSE 0.00001536 from several other architectures at the same level of accuracy.
4. CONCLUSION

Based on the research that has been done, several conclusions were obtained, namely: (1) In determining the best architectural model, it can be seen from the accuracy of the truth, the number
of epochs and the MSE of each architectural model. (2) After doing the training experiment and testing the architectural models 4-15-1, 4-30-1, 4-45-1, 4-60-1, and 4-75-1, the architectural model is obtained best is model 4-75-1 with MSE 0.00001536.

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