Analysis of the Backpropagation Algorithm in Viewing Import Value Development Levels Based on Main Country of Origin

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Abstract. In this study, we will discuss the development of import values in general based on the main country of origin in units of net weight (tons). The import value to be discussed is focused on the value of imports in North Sumatra Province, whose data is obtained from the Central Bureau of Statistics in 2009-2014. The algorithm that will be used to see and measure the level of development of import values is the backpropagation algorithm. This algorithm is one part of the Artificial Neural Network algorithm that is quite reliable in solving problems related to times series data. With the backpropagation algorithm, 5 architectural models will be formed that will be used to measure the level of development of import values, namely 4-12-1 architectural models, 4-15-1 models, 4-18-1 models, 4-19-1 models and model 4 -20-1. From the 5 models, one of the best that will be used as a reference to measure the development of import values will be chosen. After analyzing the best models were obtained 14-19-1 with the level of truth produced more than 90%. With this architectural model, calculations will be made on the level of development of import values based on the main country of origin for 2015 to 2020.

1. Introducing
Imports are the process of transporting goods or commodities from one country to another legally, generally, in the trade process, imports can be interpreted as purchasing goods and services from abroad into the country with cooperation agreements between 2 or more countries. Many developing countries also depend on imports to meet their domestic demand [1]. Why does a country need to do the import process? Because in practice, this must indeed be done because a country may have problems providing consumption. Imports of consumer goods are influenced by one's consumption expenditure, this is because the higher a person's income, the greater the ratio of expenditures to be spent and vice versa if the government cannot fulfill domestic consumption, the thing to do is to import consumer goods from abroad in order to meet internal needs. the country but if most of the
domestic consumption needs are met by abroad, it will result in a deficit in the domestic trade balance and imports usually reflecting the weakness of the government in meeting its needs [2].

As in Indonesia, especially in the province of North Sumatra, according to data from the Central Bureau of Statistics counted from 2009-2014 from 10 main origin countries, the condition of the level of development of imports carried out tends always to strengthen. Therefore, in this study, the author will measure the level of development of import values in North Sumatra for the next five years using the backpropagation algorithm. Backpropagation is one method of Artificial Neural Network, which is quite reliable in solving times series problems. Moreover, this algorithm has been numerous and has been successfully applied in various applications, such as forecasting or prediction [3]. In making the backpropagation algorithm goes through 2 processes, namely the training process and the testing process [4][5].

Previous research has been conducted to see the development of coal exports in Indonesia using the backpropagation algorithm; this study resulted in an accuracy rate of 93% [6]. Subsequent research predicts the level of development of coffee exports in Indonesia by using Polak-Ribiere Updates Analysis which produces an accuracy of 86% [7]. This is what underlies the author to use the backpropagation algorithm in measuring the level of development of import values in North Sumatra based on the leading country of origin. It is expected that the results of this study can provide references and input for the government in determining import policies in the future.

2. Methodology

2.1. Collection Data

North Sumatra import data from 2009 to 2014. Data sources came from the North Sumatra Statistics Agency.

Table 1. Amount of Import Value of North Sumatra

| Country of origin       | Net Weight (tons) |
|-------------------------|------------------|
|                         | 2009             | 2010             | 2011             | 2012             | 2013             | 2014             |
| Singapore               | 1,025.961        | 1,051.030        | 1,053.645        | 1,003.712        | 977.772          | 1,196.164        |
| China                   | 677.026          | 808.941          | 992.383          | 1,132.788        | 1,198.182        | 1,316.688        |
| Malaysia                | 1,123.554        | 1,342.221        | 747.533          | 940.246          | 967.387          | 761.477          |
| Australia               | 611.098          | 595.605          | 521.232          | 704.596          | 707.982          | 731.655          |
| United States of America| 245.561          | 275.937          | 26.869           | 333.875          | 289.600          | 288.121          |
| Argentina               | 170.828          | 265.041          | 290.621          | 340.519          | 402.466          | 508.006          |
| India                   | 33.934           | 396.582          | 783.593          | 594.489          | 66.163           | 596.348          |
| Thailand                | 162.022          | 13.453           | 345.154          | 111.509          | 167.898          | 311.673          |
| South Korea             | 83.226           | 112.968          | 97.974           | 64.262           | 118.287          | 86.304           |
| Taiwan                  | 81.391           | 84.182           | 93.952           | 150.986          | 132.189          | 113.581          |

Source: North Sumatra Statistic Center

2.2. Stages of Research

The stages of this study are as follows:

![Figure 1. Stages of Research](image-url)
Based on Figure 2, it can be explained that the training/testing data is the first data that must be present and stored on the computer. Then training/testing data must first be normalized using the formula found in equation (1). Normalized data will then be processed using the backpropagation algorithm using the sigmoid bipolar activation function. The next stage of the network will be training/testing data based on predetermined parameters. After all steps are taken, it will get the best test results that will be used to measure the level of development of import values.

2.3. Normalization
The formula used for the normalization of the initial data is as follows [8]–[10]:

$$x' = \frac{0.8(x - a)}{b - a} + 0.1$$  \hspace{1cm} (1)

where $x'$ is normalized data, $x$ is normalized data, $a$ is the data with the smallest value, and $b$ is the maximum data with the largest value.

This data is then divided into 2 (training and testing), Year 2009-2012 is used as input training data, while 2013 data is used as target training data. Year 2010-2013 is used as input testing, while 2014 data is used as target testing. Based on data table 1 will get the normalization results as follows:

### Table 2. Early Training Data for 2009-2012 / Targets for 2013

| Country of origin | 2009     | 2010     | 2011     | 2012     | Target |
|-------------------|----------|----------|----------|----------|--------|
| Singapore         | 1025961  | 1051030  | 1053645  | 1003712  | 977772 |
| China             | 677026   | 808941   | 992383   | 1132788  | 1198182|
| Malaysia          | 1123554  | 1342221  | 747533   | 940246   | 967387 |
| Australia         | 611098   | 595605   | 521232   | 704596   | 707982 |
| United States of America | 245561 | 275937   | 26869    | 340519   | 402466 |
| Argentina         | 170828   | 265041   | 290621   | 340519   | 402466 |
| India             | 33934    | 396582   | 783593   | 594489   | 66163  |
| Thailand          | 162022   | 13453    | 345154   | 111509   | 167898 |
| South Korea       | 83226    | 112968   | 93952    | 150986   | 118287 |
| Taiwan            | 81391    | 84182    | 93952    | 150986   | 132189 |

### Table 3. Normalization of Training Data for 2009-2012 / Targets for 2013

| Country of origin | 2009     | 2010     | 2011     | 2012     | Target |
|-------------------|----------|----------|----------|----------|--------|
| Singapore         | 0.71109  | 0.72607  | 0.72763  | 0.69780  | 0.68231|
| China             | 0.50267  | 0.58146  | 0.69104  | 0.77490  | 0.81396|
| Malaysia          | 0.76939  | 0.90000  | 0.54478  | 0.65989  | 0.67611|
| Australia         | 0.46329  | 0.45403  | 0.40961  | 0.51914  | 0.52116|
| United States of America | 0.24495 | 0.26309  | 0.11432  | 0.29770  | 0.10000|
| Argentina         | 0.20031  | 0.25658  | 0.27186  | 0.30167  | 0.33867|
| India             | 0.11854  | 0.33515  | 0.56632  | 0.45337  | 0.13779|
| Thailand          | 0.19505  | 0.10631  | 0.30444  | 0.16488  | 0.19856|
| South Korea       | 0.14798  | 0.16575  | 0.15679  | 0.13665  | 0.16892|
| Taiwan            | 0.14689  | 0.14855  | 0.15439  | 0.18846  | 0.17723|

### Table 4. Data Testing for 2010-2013 / Target 2014

| Country of origin | 2010     | 2011     | 2012     | 2013     | Target |
|-------------------|----------|----------|----------|----------|--------|
| Singapore         | 1.051030 | 1.053645 | 1.003712 | 977772   | 1.196164|
| China             | 808.941  | 992.383  | 1.132788 | 1.198182 | 1.316688|
| Malaysia          | 1.342.221| 747.533  | 940.246  | 967.387  | 761.477 |
| Australia         | 595.605  | 521.232  | 704.596  | 707.982  | 731.655 |
| United States of America | 275.937 | 26.869   | 333.875  | 2.896    | 288.121 |
3. Results and Discussion

3.1. Analysis
To get the results as expected, you have to go through a training and testing process where the parameters have been determined. The parameters that are considered in-network initialization on the network are:

- Maximum error
- Error tolerance
- Specifies the activation function
- Determine iteration (epoch)
- Determine the hidden layer and output layer
- Determine network training functions
- Determine the learning rate

3.2. Results
In this study, there are 5 architectural models used, including: Architecture 4-12-1, 4-15-1, 4-18-1, 4-19-1, 4-20-1. And between these five architectures the best architectural model is obtained with 90% accuracy, namely 4-19-1.

![Image of Neural Network Training](image1.png)

![Image of Best Training Performance](image2.png)

Figure 2. Training with Architecture 4-19-1
From Figure 2, it can be explained that the architectural model 4-19-1 is the best architecture with epoch, which is 2807 iterations with a fairly fast time of 17 seconds with Best training Performance of 0.000999982.

Table 6. Best Architectural Models with 4-19-1

| No  | Target | Output  | Error   | SSE   | Target | Output  | Error   | SSE   | Results |
|-----|--------|---------|---------|-------|--------|---------|---------|-------|---------|
| 1   | 0.68231| 0.68110 | 0.00121 | 0.00000146 | 0.81276 | 0.77240 | 0.04036 | 0.00162876 | 0 |
| 2   | 0.81396| 0.81010 | 0.00386 | 0.00001490 | 0.88475 | 0.86970 | 0.01505 | 0.00022646 | 1 |
| 3   | 0.67611| 0.67910 | -0.00299 | 0.00000894 | 0.55311 | 0.57110 | -0.01799 | 0.00032355 | 1 |
| 4   | 0.52116| 0.52550 | -0.00434 | 0.00001884 | 0.35350 | 0.70420 | -0.16890 | 0.02852746 | 1 |
| 5   | 0.10000| 0.08730 | 0.01270 | 0.00016129 | 0.27037 | 0.43510 | -0.16473 | 0.02713617 | 1 |
| 6   | 0.33867| 0.32640 | 0.01227 | 0.00015055 | 0.40171 | 0.49810 | -0.09639 | 0.00929100 | 1 |
| 7   | 0.13779| 0.14590 | -0.00811 | 0.00006577 | 0.45448 | 1.21250 | -0.75802 | 0.57459695 | 1 |
| 8   | 0.19856| 0.19540 | 0.00316 | 0.00000999 | 0.28444 | 0.30780 | -0.02336 | 0.00554381 | 1 |
| 9   | 0.16892| 0.24710 | -0.07818 | 0.00611211 | 0.14982 | 0.14630 | 0.00352 | 0.00001240 | 1 |
| 10  | 0.17723| 0.11850 | 0.05873 | 0.00344927 | 0.16611 | 0.16810 | -0.00199 | 0.00000394 | 1 |

Total: 0.009999307

MSE: 0.00099931

Explanation:

1 = True
0 = False

Error = Target-Output

SSE = Error²

Accuracy = correct results on ((Data / 10) * 100), yields 90%

MSE = Total SSE / (number of datatas)

Table 7. Results of Accuracy of Backpropagation Algorithms

| No  | Arsitektur | Training | Testing |
|-----|-------------|----------|----------|
|     |             | Epoch    | Time     | MSE       | MSE       | Accuracy |
| 1   | 4 - 12 - 1  | 8.284    | 0:04:49  | 0.00099872 | 0.044690  | 50%       |
| 2   | 4 - 15 - 1  | 4.357    | 0:02:28  | 0.00099980 | 0.026488  | 60%       |
| 3   | 4 - 18 - 1  | 3.749    | 0:02:22  | 0.00099960 | 0.046472  | 60%       |
| 4   | 4 - 19 - 1  | 2.807    | 0:01:17  | 0.00099930 | 0.064229  | 90%       |
| 5   | 4 - 20 - 1  | 1.778    | 0:00:11  | 0.00100050 | 0.532078  | 40%       |

Table 8. Prediction Results 6 Years in the Future with Backpropagation (Year 2015-2020)

| Country of origin | 2015   | 2016   | 2017   | 2018   | 2019   | 2020   |
|-------------------|--------|--------|--------|--------|--------|--------|
| Singapore         | 1.114136 | 1.115650 | 1.135815 | 1.197870 | 1.240428 | 1.309277 |
| China             | 1.358829 | 1.360117 | 1.359065 | 1.355209 | 1.357331 | 1.356463 |
| Malaysia          | 795.005  | 830.599  | 901.748  | 1.020477 | 1.159806 | 1.295822 |
| Australia         | 722.720  | 735.260  | 799.889  | 913.399  | 1.052718 | 1.196800 |
| United States of America | 364.525 | 363.566  | 420.694  | 656.951  | 891.312  | 1.154637 |
| Argentina         | 607.525  | 698.541  | 763.081  | 921.883  | 1.084382 | 1.244916 |
| India             | 632.594  | 683.725  | 781.560  | 908.129  | 1.061680 | 1.263889 |
| Thailand          | 404.358  | 340.536  | 557.258  | 792.566  | 921.970  | 1.208643 |
| South Korea       | 70.463   | 158.233  | 330.703  | 635.355  | 861.291  | 1.144220 |
| Taiwan            | 199.038  | 339.248  | 370.365  | 506.553  | 863.731  | 1.193576 |

4. Conclusion

Of the five architectural models used, the best architecture was obtained with an accuracy rate of 90%, epoch 2807 iterations, time 00:17, and MSE 0.00099982 namely architecture 4-19-1. From this discussion, it can also be concluded that the selection of architectural models is very influential to
obtain optimal accuracy. From the comparison of the initial import data (2009-2014) with the results of predictions obtained for 6 years (Year 2015-2020), there was a significant increase in the development of import values. If this is allowed by the government, it will be enough to disrupt the economy in North Sumatra.

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