



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 method artificial neural network quite reliable in solve problem. In research 5 models are used architecture: 4-15-1, 4-30-1, 4-45-1, 4-60-1, 4-75-1, from five models Thus, the architectural model 4 -75-1 provides the best accuracy with 452 iteration epochs and MSE is 0.00001536.

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Corresponding Author:

Solikhun

AMIK & STIKOM Tunas Bangsa, Pematangsiantar

Jl. Sudirman, No.1, 2 & 3, Pematang Siantar City, North Sumatra, 21142, Indonesia

Email: solikhun@amiktunasbangsa.ac.id

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	Expenditures Per Capita Adjusted (Thousand Rupiah/Person/Year)									
	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Nias	5710	5914	5980	6234	6409	6629	6941	7042	6898	6995
Christmas										9771
Mandailing	8871	8960	9040	9096	9237	9385	9653	9900	9684	
South Tapanuli							1120	1141	1123	11304
	10357	105	10593	10623	10821	10955	9	0	6	
Middle Tapanuli							1006	1017	1007	10138
	9324	9382	9489	9555	9694	9852	7	5	1	
North Tapanuli							1160	1179	1164	11710
	10786	10850	10964	11079	11242	11407	7	1	8	
Toba Samosir							1209	1237	1215	12224
	11043	11178	11250	11535	11687	11846	5	5	4	
Labuhan Batu							1105	1119	1115	11212
	10058	10210	10325	10356	10559	10760	3	3	0	
Sharpen							1073	1098	1089	11030
	9773	9895	9988	10067	10288	10477	5	3	0	
Simalungun							1131	1142	1130	11376
	10358	10494	10597	10728	10855	11055	1	2	8	
Dairi							1049	1060	1035	10504
	9520	9580	9642	9708	10190	10395	2	2	0	
Karo							1236	1247	1234	12412
	11359	11453	11548	11800	11925	12059	7	4	9	
Deli Serdang							1213	1231	1222	12291
	10785	10924	11065	11359	11683	11891	2	7	5	
Langkat							1108	1120	1107	11142
	9910	9970	10062	10364	10567	10784	8	8	1	
South Nias	6213	6266	6329	6454	6647	6792	6941	7105	6974	7041
Humbang										8016
Hasundutan	6562	6670	6736	6889	7135	7412	7630	7902	7850	
Mr. West	7205	7269	7364	7496	7641	7913	8099	8402	8170	8254
Samosir	7533	7600	7667	7698	7813	8163	8348	8654	8422	8504
Serdang Bedagai							1073	1106	1095	11017
	9817	9882	10042	10110	10246	10551	7	1	0	
Coal							1038	1057	1041	10539
	9069	9218	9370	9692	9886	10084	5	5	0	
North Lawas								1019		10055
	8887	9076	9171	9363	9600	9737	9912	4	9987	
Old Field	7740	7825	7910	7955	8094	8445	8772	9100	8807	8921
South Batu							1128	1155	1149	11562
Labuhan	9866	10040	10111	10319	10712	10892	0	3	5	
North Batu							1173	1195	1177	11840
Labuhan	10979	11063	11147	11201	11278	11510	0	7	9	
North Nias	5442	5523	5580	5627	5770	5835	6041	6245	6064	6155
West Nias	5038	5061	5156	5207	5391	5594	5817	6009	5830	5924
Sibolga							1140	1165	1147	11540
	10352	10525	10623	10765	11034	11221	5	6	3	
Tanjung Balai							1110	1138	1113	11225
City	9872	10001	10133	10326	10577	10778	2	3	2	
Pematang Siantar							1229	1257	1237	12436
City	11039	11139	11204	11388	11878	12106	0	1	2	
Cliff City							1243	1289	1287	12939
	10666	10829	10918	11393	11747	12055	4	5	6	
Medan City							1484	1503	1489	14999
	13750	13902	13984	14191	14393	14613	5	3	0	
Binjai City							1075	1126	1099	11063
	9829	9943	10058	10098	10342	10487	0	0	7	

County / City	Expenditures Per Capita Adjusted (Thousand Rupiah/Person/Year)									
	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Padangsidempuan							1079	1118	1085	
City	9421	9518	9623	9668	10198	10464	5	1	6	10965
Gunungsitoli City	6492	6524	6685	6742	6963	7300	7639	8058	7980	8134

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) ([Govoruschenko, 2007](#)) which often manages 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 Percapita

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

No	Variable	Criteria
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

No	Variable	Criteria
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:

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

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 on 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	0.5782	0.5839
4	0.6162	0.6194	0.6254	0.6291	0.6369	0.4609	0.4791	0.4883	0.4794	0.4851

Data	X1	X2	X3	X4	X5	X6	X7	X8	X9	Target
5	0.6980	0.7016	0.7080	0.7144	0.7236	0.5927	0.6096	0.6252	0.6131	0.6184
6	0.7124	0.7200	0.7240	0.7400	0.7485	0.6299	0.6510	0.6747	0.6560	0.6619
7	0.6573	0.6658	0.6722	0.6740	0.6853	0.5378	0.5627	0.5745	0.5709	0.5762
8	0.6413	0.6482	0.6534	0.6578	0.6702	0.5139	0.5357	0.5567	0.5489	0.5607
9	0.6741	0.6817	0.6875	0.6948	0.7019	0.5628	0.5845	0.5940	0.5843	0.5901
10	0.6272	0.6305	0.6340	0.6377	0.6647	0.5069	0.5151	0.5245	0.5031	0.5161
11	0.7301	0.7354	0.7407	0.7548	0.7618	0.6479	0.6740	0.6831	0.6725	0.6779
12	0.6980	0.7058	0.7137	0.7301	0.7483	0.6337	0.6541	0.6698	0.6620	0.6676
13	0.6490	0.6524	0.6575	0.6744	0.6858	0.5399	0.5656	0.5758	0.5642	0.5702
						0.1201				
14	0.4420	0.4450	0.4485	0.4555	0.4663	5	0.2142	0.2281	0.2170	0.2226
15	0.4615	0.4676	0.4713	0.4798	0.4936	0.2541	0.2726	0.2956	0.2912	0.3053
16	0.4975	0.5011	0.5064	0.5138	0.5219	0.2965	0.3123	0.3380	0.3183	0.3254
17	0.5159	0.5197	0.5234	0.5251	0.5316	0.3177	0.3334	0.3593	0.3397	0.3466
18	0.6438	0.6474	0.6564	0.6602	0.6678	0.5201	0.5359	0.5634	0.5539	0.5596
19	0.6019	0.6102	0.6188	0.6368	0.6476	0.4805	0.5061	0.5222	0.5082	0.5191
20	0.5917	0.6023	0.6076	0.6184	0.6316	0.4511	0.4660	0.4899	0.4723	0.4781
21	0.5275	0.5322	0.5370	0.5395	0.5473	0.3416	0.3694	0.3972	0.3723	0.3820
22	0.6465	0.6563	0.6602	0.6719	0.6939	0.5490	0.5819	0.6051	0.6001	0.6058
23	0.7088	0.7135	0.7183	0.7213	0.7256	0.6014	0.6201	0.6393	0.6242	0.6294
24	0.3988	0.4034	0.4065	0.4092	0.4172	0.1204	0.1379	0.1552	0.1398	0.1475
25	0.3762	0.3775	0.3828	0.3857	0.3960	0.1000	0.1189	0.1352	0.1200	0.1280
26	0.6737	0.6834	0.6889	0.6969	0.7119	0.5769	0.5925	0.6138	0.5983	0.6040
27	0.6469	0.6541	0.6615	0.6723	0.6863	0.5394	0.5668	0.5906	0.5694	0.5773
28	0.7122	0.7178	0.7214	0.7317	0.7592	0.6519	0.6675	0.6913	0.6745	0.6799
29	0.6913	0.7004	0.7054	0.7320	0.7518	0.6476	0.6797	0.7188	0.7172	0.7225
30	0.8640	0.8725	0.8771	0.8887	0.9000	0.8644	0.8841	0.9000	0.8879	0.8971
31	0.6445	0.6508	0.6573	0.6595	0.6732	0.5147	0.5370	0.5802	0.5579	0.5635
32	0.6216	0.6270	0.6329	0.6354	0.6651	0.5128	0.5408	0.5735	0.5460	0.5552
33	0.4576	0.4594	0.4684	0.4716	0.4840	0.2446	0.2733	0.3088	0.3022	0.3153

3.3 Design Architecture and Result

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	0.00002461
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.

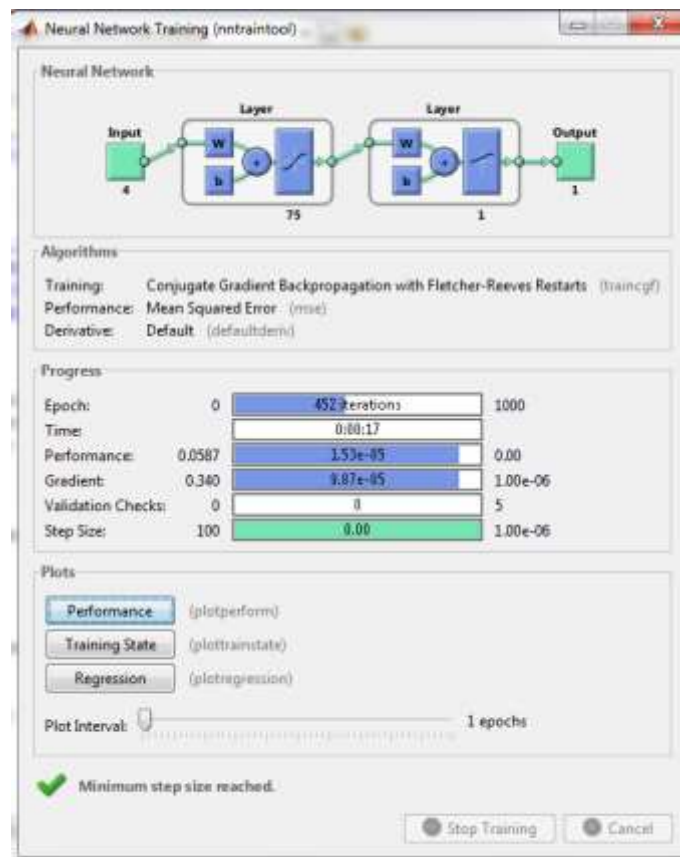


Figure 1. Architectural Model 4-75-1

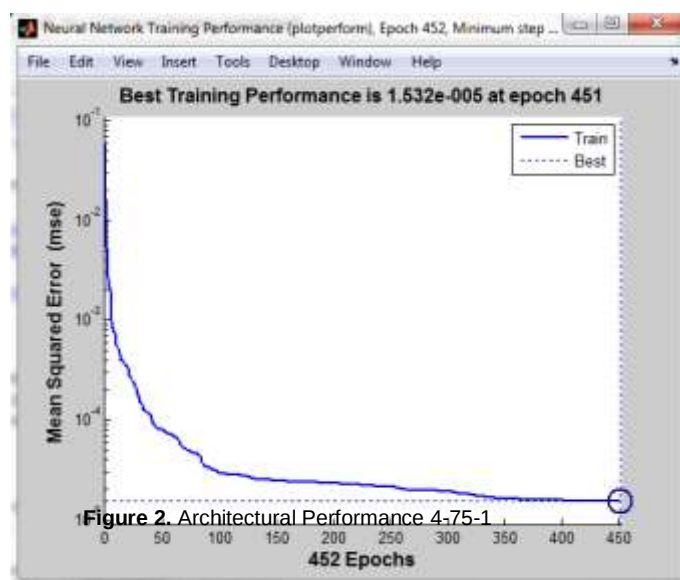


Figure 2. Architectural Model 4-75-1

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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