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ARTIFICIAL NEURAL NETWORK APPLICATION IN GROSS DOMESTIC PRODUCT FORECASTING AN INDONESIA CASE

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ABSTRACT

Gross Domestic Product (GDP) is a benchmark for economic production conditions of a country. Estimates of economic growth in the coming year in a country has important roles, among others as a benchmark in determining business plans for business entities, and the basis for devising government fiscal policy. Artificial Neural Network (ANN) has been increasingly recognized as a good forecasting tool in various fields. Its nature that can mimic the workings of the human brain makes it flexible for non-linear and non-parametric data. GDP growth forecasting techniques using ANN has been widely used in various countries, such as the United States, Canada, Germany, Austria, Iran, China, Japan and others. In Indonesia, forecasting of GDP is only done by government institutions, namely National Planning Board, using macroeconomic model. In this study, ANN is used as a tool for forecasting GDP growth in Indonesia, using some variables, such as GDP growth in the two previous periods, population growth rate, inflation, exchange rate and political stability and security conditions in Indonesia. Results from this study indicate that ANN forecasts GDP relatively better than the one issued by the government. Further study would be to use ANN to predict other economic indicators.

Keywords: *GDP growth, ANN, Forecasting*

1. INTRODUCTION

In aggregate term, the main measuring instrument used to measure a country's economic activity is Gross Domestic Product (GDP). GDP can also be used to obtain detailed data on all goods and services produced by a country during one period, and also to identify and examine the structure of the national economy. Short-term analysis of GDP will affect aggregate spending, interest rates, and labor market outcome, and influence decisions about economic issues that are going on and short-term policies issued by the government; while long-term analysis of the national income will influence government policy related to diversification, increased savings and investment, infrastructure and institutional development, economic planning and so forth, which aims to accelerate economic growth and increasing prosperity of the people. Every year, Badan Perencanaan Pembangunan Nasional (National Planning Agency) or better known as the Bappenas, issued a forecast of economic growth based on GDP of Indonesian economy for years to come. For business players, GDP is used as a benchmark for the number of products to be produced, to avoid losses due to lack or excess stock.

One of the forecasting techniques that can be used to forecast is the Artificial Neural Network (ANN). ANN is a technique used to simulate a condition such as human brain, with the aim to find the pattern that connects between the input and output. There are two techniques for ANN learning, namely supervised and unsupervised learning. In many studies, the ANN has proven to be an efficient tool for non-parametric model data in the form of non-linear function, such as business forecasting, credit scoring, bond rating, business failure prediction, medicine, pattern recognition and image processing. Therefore, in this study ANN is used as a forecasting technique to get the level of GDP in Indonesia.

2. PREVIOUS RESEARCH

Several studies used neural network models in forecasting GDP. The accuracy of the forecast is quite promising and showed that the ANN can be a

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good technique in forecasting the economic growth rate in a country.

Tkacz and Hu (1999) conducted a study on forecasting GDP in Canada. Tkacz and Hu use a static ANN model, and follow the recommendation of Kuan and White on the number of hidden layers used in the ANN architecture, i.e., one hidden layer. The result of the research by Tkacz shows that ANN model has the ability to capture the pattern of the relationship between GDP and the growth of financial indicators used.

Gonzalez (2000) also conducted research related to macroeconomic forecasting in Canada, and comparing the result with predictions by the linear regression model. In their study, Gonzalez augmented model using ANN with back propagation algorithm. The evaluation results show that the neural network has a smaller error than the linear regression, with the difference 13-25% on training data, and 20-40% in the experimental data.

According Tkacz and Hu (1999), ANN can be used in conditions when the linear model can not solve this problem, or difficult to see relationships between events. Weakness in the ANN model include the need for large amounts of data, which is used to recognize patterns in the information available, apart from that there is an element of trial and error in the ANN that resulted in the possible use of parameters that do not conform to the conditions expected.

According to Gonzalez (2000), among other advantages of ANN models is the ability to model a non-linear conditions; ANN model does not require a priori information to identify relationships between variables; its architecture is relatively flexible to various conditions of input and output values, and the mapping of input and outputs through weight adjustment process makes the relationship between inputs and outputs can be found, the network more adaptable and fault tolerance can be determined from the beginning. Meanwhile, the weakness is the complexity of the ANN raises the possibility of 'black box' condition.

Giovanis (nd) using the ARIMA and ANN to predict the rate of economic growth in the United States. This study, used four forecasting models, namely ARIMA, Generalized Regression Neural Network (GRNN), Radial Basis Function (RBF) and Multi Layer Perceptron (MLP). The results of this study indicate that the neural network model produces better predictions than the ARIMA model.

Moshiri and Ghadimi (2004) apply ANN combined with genetic algorithm in forecasting GDP in Iran, using data from period 1936 to 2002. In this study, using three models Econometric calculations, namely the structural, univariate time series and multivariate time series, were compared with ANN and Genetic Algorithm. ANN model used the back propagation and gradient descent learning, with one hidden layer. Comparison results show that the ANN model, genetic algorithm has performed relatively better than other models.

In Indonesia, there are several studies about economic growth, with a variety of methods. Wijono and Amir (2005) in their research on economic growth in Indonesia in 2006, using constant price data in the base year 2000, with consideration of the effect of inflation has been eliminated, resulting in numbers that reflect the real growth is expected to happen; growth sectors in the economy year 2005, in accordance with the UN international reference. Supriana (2004) stated that Indonesia's macro economy more in line with Keynesian than monetarist model. Economic growth in Indonesia is strongly influenced by the exchange rate, while fiscal and monetary policies, both short and long term, not much affect economic growth in Indonesia.

3. THEORITICAL FRAMEWORK

3.1 Current GDP Forecasting

Macroeconomic performances such as overall consumer action, overall business activity or changes in overall economic activity are closely monitored by both government and businesses alike (Mankiw, 2006, p4). Among the overall economic performance indicators faced by a country include the problem of economic growth, volatility in economic activity, unemployment, inflation and balance of trade and payments. Economic growth can be defined as the development of activities in the economy that cause the increasing of goods and services produced within a country (Sukirno, 2008, p9).

One of the benchmarks that can be used to assess a country's economy is national income or Gross Domestic Product (GDP). GDP is the market value of all final goods and services produced within a country in a period (Mankiw, 2006, P6), including factors of production owned by their own citizens and foreign citizens who carry on production in that country.

In Indonesia GDP growth has been traditionally forecasted by the National Planning Agency (Badan

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Perencanaan Pembangunan Nasional – Bappenas). The model that is used to forecast is a macro-econometric model of the economy of the country. The model is essentially a set of equations that represent the working of the economy, composed of macroeconomic variables - endogenous and exogenous variables. The parameters of the equations are estimated statistically and are updated regularly. Once the parameters are estimated, the model then is used to simulate the working of the economy represented by the endogenous variables given a particular scenario on the exogenous variables. In including in the exercise is the determination of the GDP forecast.

3.2 The ANN Model

Artificial Neural Network (ANN) is an information processing system that has characteristics similar to biological neural networks. According to Fauset (1994), a neuron in the neural network as analogous to biological neurons in which had three types of components that are part of the understanding of artificial neurons: dendrites, synapses and axons. According to Gonzalez (2000), ANN is a mathematical model that is structured like the way the human brain works to identify patterns in a number of variables. Analytically an ANN can be written in an equation such as in (1).

$$Y = h\left(\sum_{j=1}^{J} \alpha_j g\left(\sum_{i=1}^{I} \beta_{ij} X_i\right)\right). \quad (1)$$

Summations represent dendrites, while functions g and h represent axons and α and β represent synapses. Equation (1) then represent an ANN with I input neurons, one hidden layer with J neurons, and one output Y. This model or "machine" specified in (1) is uniquely determined by α and β. The objective then is to estimate them (or having the "machine" learned) by minimizing the sum of squared of errors (SSE) between the output and the actual data until a specified level of convergence is achieved. Let Z_t be the actual t-th state of nature. Then the minimization can be stated as in (2).

$$\min_{\alpha_j \beta_{ij}} SSE \sum_{t=1}^{T}\left[Z_t - h\left(\sum_{j=1}^{J} \alpha_j g\left(\sum_{i=1}^{I} \beta_{ij} X_i\right)\right)\right]^2. \quad (2)$$

For this study, the activation functions $g(.)$ and $h(.)$ are chosen to be sigmoid and the back-propagation method. The inputs to the model are one and two years lag GDP, population growth, inflation rate, exchange rate, and political situation.

4. THE RESULTS

Searching ANN model that is suitable for data was done by changing the learning rate, momentum, number of hidden layers and number of neurons in each hidden layer. In a network with three hidden layer structure, the level of learning rate 0.01 and momentum 0.9, the network showed movement toward the target Mean Squared Errors (MSE) of 0.0001. The training was conducted by increasing the maximum number of epochs to be 100 thousands. In this condition, the network managed to achieve the expected MSE.

Tests accuracy of the results of research by ANN modeling was done by comparing the result with the prediction made by the government every five years, delivered in Repelita, Propenas and RPJMN. Graph comparing the results of ANN training, the value of real GDP growth and Bappenas estimates can be seen in Fig. 1, while data can be seen in Table I.

The validation process was carried out by taking six samples at random. In this case, the data taken were 1983, 1989, 1993, 2000, 2002 and 2006. Comparison of the results in graphical form can be seen in Fig. 2 and the results of the comparison in the form of data can be seen in Table II. Validation process was carried out to ensure that the ANN can generate value forecasts as expected. This validation process shows the ANN is generating value which approximates the value of real GDP growth, with MSE of 0.496403 and the result is better than the estimates submitted by the Government, which reached a value of MSE 11.24678.

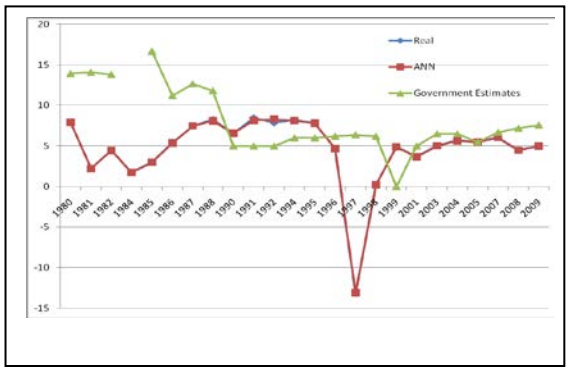

Figure 1. Comparison Chart Training Results

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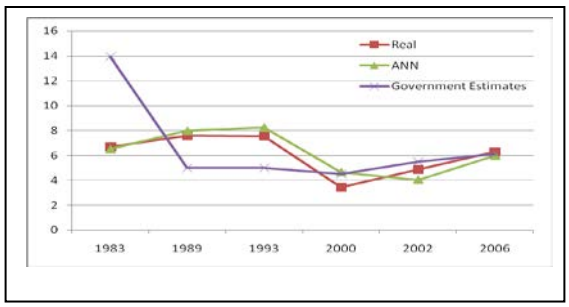

Figure 2. Comparison Chart Validation Results

5. CONCLUSION

This research shows the advantages and disadvantages of forecasting techniques with the ANN model. The main advantage of ANN is its ability to overcome problems of non-linear data and pattern recognition to the data. Neural network is capable of overcoming the problem of non-linear, because it is able to adjust to the available data, irrespective of the nature of the data, such as the distribution of data. This is shown by the results MSE achieved in the validation process the ANN compared with estimates published by the government.

In addition, with ANN model, a researcher does not need to look for certain values or assuming something like when done with a model of macroeconomic forecasting. This helps a researcher, because in the case of wrong assumptions, the forecast result will be far from satisfactory. ANN is a very flexible model, where a researcher can use the same application model for several cases at once, by changing the identification of its initial value, such as hidden layer structure, the value of momentum or learning rate. In the ANN model, the data used is relatively free, because the ANN did not pay attention to the relationships among data as well as in the statistical calculation. Therefore, ANN can be referred to the network with 'intelligent systems that learn ' (Gonzalez, 2000).

Table 1. COMPARATIVE DATA RESULTS TRAINING

Year	Real (%)	ANN (%)	Government Estimates (%)
1980	7.93	7.927603	13.94
1981	2.25	2.247308	14.08
1982	4.47	4.470408	13.83
1984	1.76	1.757799	86.08
1985	3.01	3.013562	16.70
1986	5.39	5.376006	11.20
1987	7.44	7.501409	12.67
1988	8.25	8.104828	11.82
1990	6.53	6.559073	5
1991	8.45	8.190274	5
1992	7.83	8.308482	5
1994	8.22	8.138512	6
1995	7.82	7.829225	6
1996	4.7	4.700507	6.2
1997	-13.2	-13.0919	6.4
1998	0.23	0.230157	6.2
1999	4.92	4.919892	-
2001	3.66	3.660702	5
2003	5.03	5.032417	6.5
2004	5.69	5.685594	6.5
2005	5.5	5.501145	5.5
2007	6.06	6.055477	6.7
2008	4.5	4.49905	7.2
2009	5	5.002369	7.6

Table 2. Comparative Data Validation Results

Year	Real (%)	ANN (%)	Government Estimates (%)
1983	6.68	6.49706	13.945023
1989	7.59	7.97054	5
1993	7.54	8.24267	5
2000	3.44	4.66559	4.5
2002	4.88	4.03958	5.5
2006	6.28	5.96692	6.1

The disadvantages of ANN is an appropriate ANN model searches for a particular problem sometimes takes a long time, through trial and error technique. Trial and error is about trying different possible model of network structure, learning rate,

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the value of momentum, and the value of the given constraints, such as the maximum epoch and maximum MSE. In many studies, this weakness is called the 'black box' problem, because the network was built to process the output in which the researcher never knows where the existing weight values came from. This can happen, because there were no definite rules in modeling of ANN. In this study, an appropriate ANN model was found after the experiment to 24, which made changes in the structure of hidden layers, both the number of layers and the number of neurons, learning rate, momentum, target MSE and epoch.

In addition, the network structure often recognizes the value of local minima as global minima. If the value of local minima far enough from the global minima, the network can produce an inaccurate prediction value. This reason is the basis of disuse MATLAB toolbox provided in this study. Some experiments were performed using the toolbox often produce values with local minima, where the training process stops before it reaches the desired value. In general, ANN models require large amounts of data. This study used data during the last 30 years (1979-2009) in the form of annual data. If the variables that are used less or too many, it can build a structure that over fit. For the case of forecasting GDP growth in Indonesia, the biggest obstacle is the lack of sufficient data, both in terms of expenditure period of data, data consistency and availability of data itself. Another disadvantage is the independent nature of the ANN and the data led to the ANN is not connected at all with existing economic theory.

GDP growth in this research obtains results of the prediction with a smaller error rate. MSE on the ANN model reached a value of 0.496403. While the estimates submitted by the Government has MSE value of 11.24678. In general, the ANN model has better ability in forecasting the macroeconomic indicators.

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