The export forecasting model in Indonesia by using ANFIS model

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Abstract
Indonesia's economy is significantly influenced by its export activities, necessitating accurate forecasting models to inform policy and business strategies. The objectives of this study are to propose the model for predicting export using Adaptive Neuro Fuzzy Inference System (ANFIS) and to evaluate the performance model by using RMSE. This study explores the performance of Adaptive Neuro-Fuzzy Inference System (ANFIS). The research utilizes monthly export data from 2014 to 2024. In this study, the dataset will be grouped into training and testing data by 75%:25%**.** The performance of ANFIS models is evaluated by using Root Mean Square Error (RMSE). The RMSE value for ANFIS model is 13199.55 This study contributes to the literature on economic forecasting and provides valuable insights for policymakers and businesses in Indonesia aiming to enhance their strategic planning and decision-making processes. A combination fuzzy inference system and neural network is implemented to propose forecasting model of export in Indonesia.

Keywords: ANFIS, Export, Forecasting, Indonesia

1. Introduction

Economic growth in Indonesia is one of the macroeconomic goals, which is able to provide social welfare (Sultan et al., 2023). Indonesia experienced an economic crisis in 1998. Economic improvement emerged in 2013 driven by the performance of the export sector, especially in Eastern Indonesia and Sumatra. There is a relationship between the influence of inflation and interest rates on Indonesia's economic growth for the 2005-2015 period (Sultan et al., 2023). Exports are defined as sending and selling domestically made goods to other countries in compliance with applicable regulations. Exports are the accumulation of goods and services sold by a country to other countries, including goods, insurance and services in a particular year. Exports are an influential factor in economic growth in Indonesia (Ngatikoh & Isti'anah, 2020). Exports will expand a country's consumption capacity, increase world output, and provide access to scarce resources and potential international markets for various export products, without which poor countries would not be able to develop activities and national economic life. Exports can help Indonesia carry out its development efforts through promoting and strengthening economic sectors that contain comparative advantages, whether in the form of the availability of certain production factors in abundant quantities, or efficiency advantages, aka labor productivity (Hartono et al., 2023). Exports can also help all countries take advantage of the economies of scale they have.

Forecasting is the study of historical data to discover systematic relationships, trends and patterns. Forecasting can be said to be the activity of applying a model that has been developed in the future (Muhartini et al., 2021). Financial, business, and economic data are very often collected

over equal time intervals such as days, weeks, months, or years. In some cases, such time series data may be available on several related variables. There are several reasons for analyzing and modeling time series together: (1) to understand the dynamic relationships between variables and (2) to increase forecast accuracy and knowledge of dynamic structures so as to produce good forecasts.

To solve the forecasting of export problems, many researchers have constructed various methods. The results of the decomposition method show that the results of forecasting export values from the agricultural, industrial and mining sectors tend to increase in the period January 2011 to December 2017. However, the level of accuracy still low, namely 11% MAPE, meaning that the forecasting model, decomposition exceeds the tolerance limit, namely 5% (Barus & Ramli, 2013). The ARIMA and Bootstrap methods have been applied to predict the value of exports in Indonesia from April to December 2015 (Cynthia et al., 2016). Meanwhile in Thailand, a comparison of forecasting methods between statistical models and artificial neural networks (ANN) has been developed to forecast rice exports (Co & Boosarawongse, 2007). Warsono et al. (Warsono et al., 2019) have conducted research on modeling and forecasting using the Vector Autoregressive Moving Average (VARMA) model for coal and oil data in Indonesia in the period 2002-2017. The goals of this paper are applying the adaptive neuro-fuzzy inference system (ANFIS) for predicting the export in Indonesia, and evaluating the ARIMA (Autoregressive Moving Average) techniques using root mean square error (RMSE).

2. Research Method

Neuro-fuzzy is a combination of two systems, namely a fuzzy logic system and artificial neural networks(T. W. Septiarini & Musikasuwan, 2018). Neuro-fuzzy systems are based on fuzzy inference systems that are trained using learning algorithms derived from artificial neural network systems. Thus, neuro-fuzzy systems have all the advantages possessed by fuzzy inference systems and artificial neural network systems. From its ability to learn, neuro-fuzzy systems are often referred to as ANFIS. Adaptive Neuro-Fuzzy Inference System (ANFIS) is an adaptive neural network based on a fuzzy inference system (Fuzzy Inference System). By using a hybrid learning method, ANFIS can map input values to output values based on knowledge trained in the form of fuzzy rules (Tri Wijayanti Septiarini & Musikasuwan, 2018). According to (Rosadi, 2013), there are three main steps to construct ANFIS which are preprocessing data, establishing rule, and evaluating performance. And the architecture of ANFIS is consist of five layers such as fuzzy layer, product layer, normalized layer, de-fuzzy layer, and total output layer as illustrated in Figure 1.

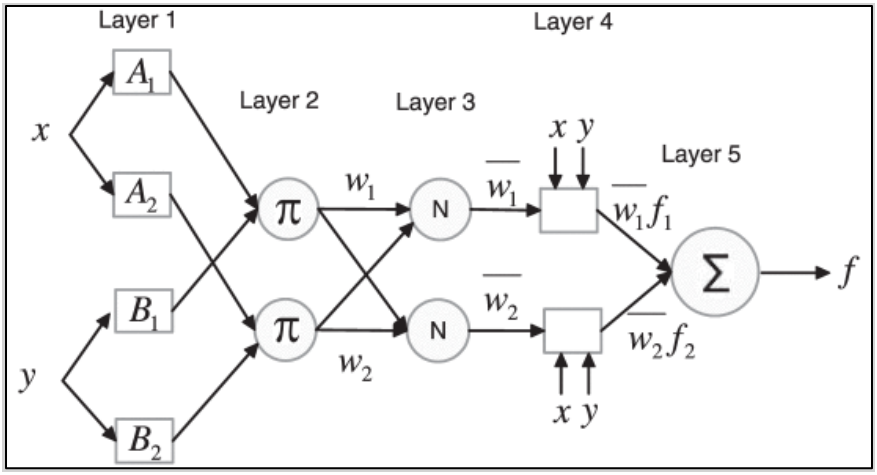


Figure 1.The Architecture of Adaptive Neuro-Fuzzy Inference System (Wang & Ning, 2015)

3. Results and Discussions

The implementation of ANFIS for forecasting export in Indonesia can be described as follows:

Data Collection

The data source is from https://www.bps.go.id/id/ and collected from January 2009-August 2024. The total data is 188 monthly data as shown in Figure 2. The plot of time series export data indicate fluctuation along the time set. Thus, it is needed the transformation in order to adjust the stable data set.

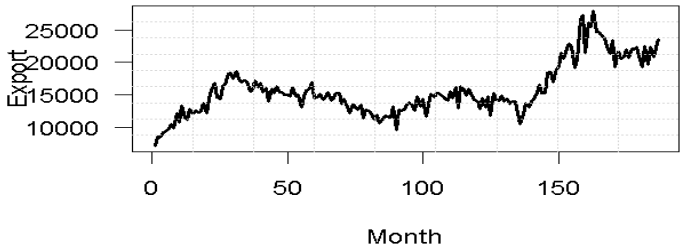


Figure 2. The Plot of Time Series The Actual Data

Preprocessing data

The data is separated into two groups which are training and testing dataset. This study applied 75% data for training and 25% data for testing. After that, differencing transformation is implemented in order to get stationary data. Figure 3 shows the stationary data after differencing

process. The universal set of stationary data is $[-3556.6,3475]$. The universal set will be implemented to construct the ANFIS model.

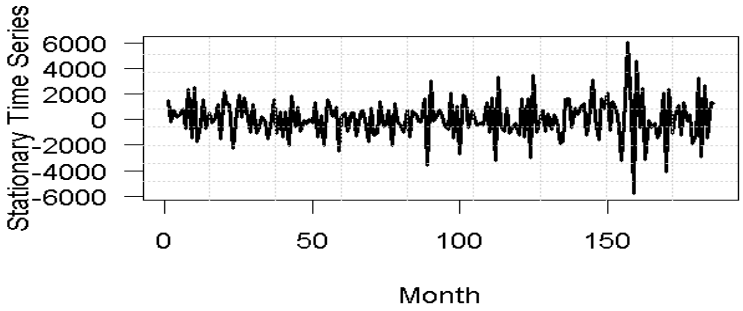


Figure 3. The Time Series Plot of The Stationary Data

Determine The Type and Number of The Membership Function

It has been examined ANFIS model in order to find the optimal model. Finally, it has been constructed ANFIS which has five gaussian membership function as shown in the Figure 4. The gaussian membership function will be considered as transformation tools of data into fuzzy set. In this study, ANFIS model has 4 inputs and a constant output.

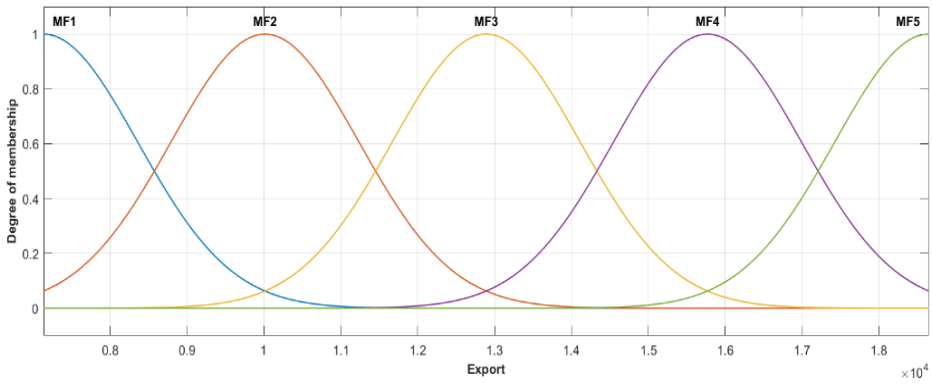


Figure 4. The Membership Functions

Generate Fuzzy Rules

Fuzzy rules connect inputs and output in fuzzy inference systems. Figure 5 depicts the ANFIS architecture in this study. According to the fuzzy inference system, the are 200 fuzzy rules. And the number of outputs equal to the number of rules.

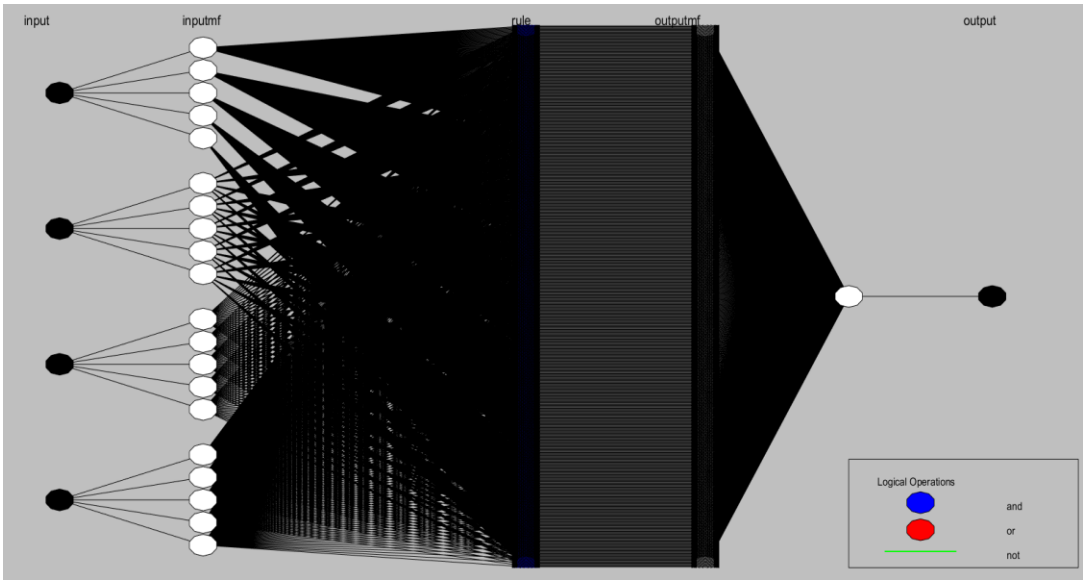


Figure 5. The ANFIS Architecture

Determine The Learning Algorithm

The learning algorithm deploy the hybrid method. The architecture of ANFIS model in this study can be seen in Figure 5. In this model, fuzzy layer is represented by input, product layer is represented by *inputmf*, normalized is represented by rule, defuzzy layer is represented by *outputmf*, and total output layer is represented by output.

Tune The Parameter of The Fuzzy Inference System

The parameters set had been estimated in this step. Fuzzy inference system is used for reasoning rule to get the fuzzy output. The training data set has been run 100 epochs in order to get the smallest error or optimal solution. Figure 6 shows the plot of epoch against errors which indicates decreasing errors.

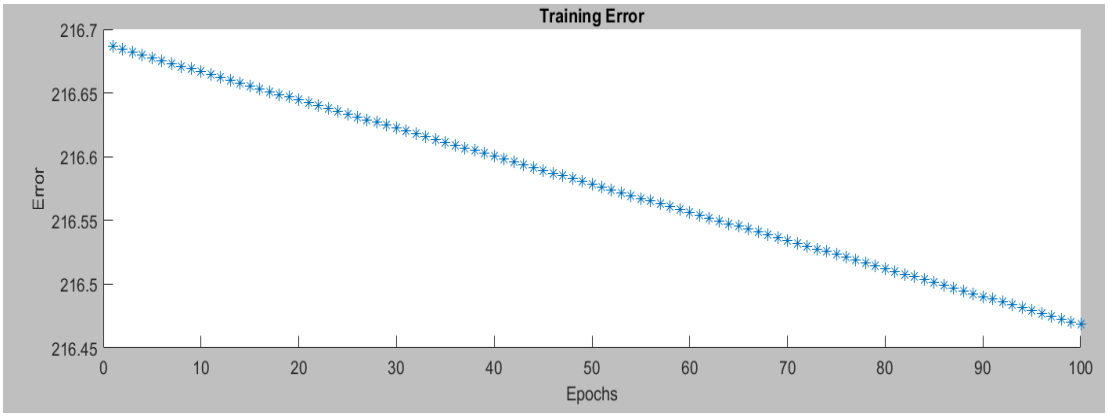


Figure 3. The Training Error Plot of ANFIS Model

Forecasting and Evaluate

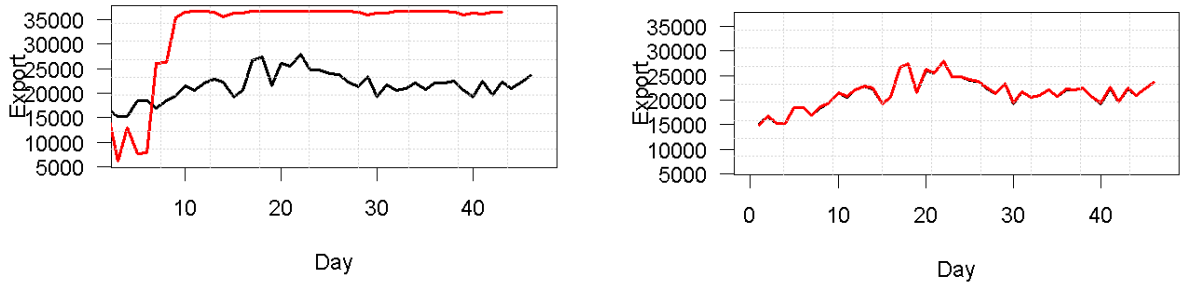
After achieving the significant model, the predicted values from the testing data will be calculated and then used to calculate the root mean square error (RMSE) as follows

$$RMSE = \sqrt{\sum_{t=1}^{s} \frac{\left(actual\ (t) - predict\ (t)\right)^2}{s}}$$

where,
s = the number of predicted data
t = the time step (hourly)

Once, the ANFIS model has been constructed, the ARIMA methods will be implemented to construct the statistical forecasting model in order to compare the performance with ANFIS.

Figure 7 depicts the forecasting result of ANFIS and ARIMA model. It can be seen that the forecasting result of ANFIS model has a quite big different with the actual data. And Table 1 shows the evaluation results for all of models with testing data. The evaluation results show that the ANFIS model has bigger value of RMSE than ARIMA model which is 13199.55. The higher value of RMSE then it has contradiction meaning with the performance of model. In another words, it is indicated that the ANFIS model should be optimized by considering another parameter in model for example tuning the membership function, the number of membership function, the type of output, etc.



(a) (b)

Figure 4. (a) The predicting results plot of ANFIS model and (b) the predicting results plot of ARIMA model

Tabel 1. The RMSE value

	ANFIS	ARIMA
RMSE	13199.55	1096.52

4. Conclusions

The aims of this study are to construct the model for predicting export in Indonesia using Adaptive Neuro-Fuzzy Inference System (ANFIS) and to evaluate the performance of model by using RMSE as evaluation tool. The procedures to construct the ANFIS are collecting data, pre-processing data, selecting input, determining membership function, generating fuzzy rules, training fuzzy inference system, and forecasting. The accuracy of the ANFIS model is influenced by many factors such as the number of the membership function, the type of membership function, the selection of input, the number of iterations, and the type of output. In this study, the dataset has been separated into two groups which 75% and 25%, training and testing dataset, respectively. According the results oh this study, the ANFIS model has been constructed with five gaussian membership function. And the optimal ANFIS model has been compared with ARIMA method. The result stated that the ANFIS has 13199.55 evaluation value of RMSE. It needs to optimize for the future research.

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