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Empirical Study of Sukuk Investment Forecasting Using Artificial Neural Network Base Algorithm

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Abstract- Accuracy estimation is an important issue in time series forecasting field, for example Islamic investment namely sukuk. In order to provide the accuracy estimation of forecasting, the statistical estimator has to be unbiased and has minimum error. In this study, the statistical estimator of moving average model is applied to forecast the sukuk series data. However, the accuracy of this model is questionable and in order to improve the accuracy, this study proposed a hybrid approach using artificial neural network (ANN) algorithm for moving average model. Noted that, the parameter of moving average is selected by considering the AIC, AICc and BIC criterion values, and the selected parameter eventually to be used as input layer of ANN algorithm. In order to examine the forecasting performance, the proposed algorithm used to calculate the 10 days ahead and 15 days ahead forecasting. Based on empirical result, it has shown that, the proposed algorithm helps to reduce the error estimation and eventually improve the forecasting of sukuk investment.
Keywords – Neural Network, ARIMA, Sukuk, Islamic Investment

I. INTRODUCTION

Accuracy estimation is an important issue in time series forecasting and has been discussed all the years by researchers, see for example [1-4]. In order to yield accuracy estimation, researchers proposed efficient yet unbiased estimator in which it minimized the inherent variance or error. Many researchers has proposed hybrid the statistical model of auto-regresive integrated moving average onto artificial neural network learning algorithm, and found that the neural network helps to increase the forecasting performance [1] [5-6].

Motivated by this advantages of artificial neural network learning algorithm, this study proposed to construct a hybrid statistical model of Moving Average (MA(p)) onto the artificial neural network in order to improve its performance of forecasting. Instead of directly generate the information data in the learning algorithm of artificial neural network, this study has considered parameters of MA(p) to be treated as nodes in input layer for training sample and test sample of the learning process [4]. The information data used in this study is a set of time series of Islamic investment namely sukuk. The sukuk is an alternative investment in this modern world with considering the basic Islamic regulation of prohibition of any transaction of usury and any uncertainty transaction involve in the investment portfolio.

In this paper, second section is discussed about the proposed algorithm which involve the base algorithm of artificial neural network, and the proposed of Moving Average ANN algorithm. The proposed algorithm applied to sukuk information data and the result of Moving Average ANN forecasting performance is discussed in section third. The conclusion can be referred in fourth section.

II. PROPOSED ALGORITHM

2.1 Artificial neural network

Artificial neural network (ANN) is one type of machine learning that can imitate the class of functions with high level of accuracy especially in forecasting time series field [7]. The strength of ANN algorithm is the processing information does not need the initial assumption of data distribution and the processing algorithm always align with the information data. ANN has three basic layers, according to [4], the relationship between processing units can be distinguish by input layer, hidden layer and output layer. These layers can be refereed to Figure 1.

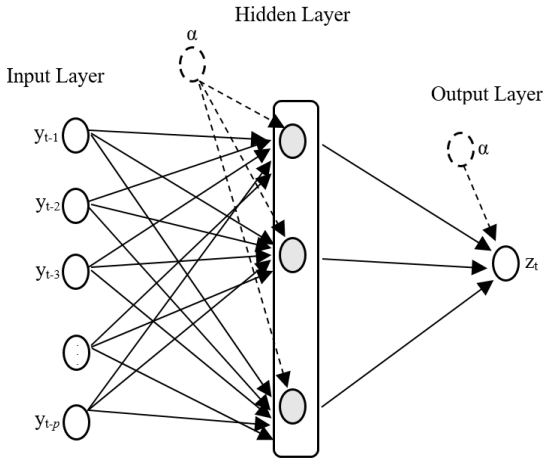

Figure 1 Artificial neural network's layers

By refereed to Figure 1, the learning algorithm used is a forward propagation. The yt-p refers to list of information data imported to the input layer, the grey nodes in hidden layer is refers to neuron nodes and the relationship between the input and nodes of hidden layer is connected by weights of α. Each nodes has its own weights. While zt represents an output nodes of processing algorithm and it has the weight which is also known as bias estimation. In this study, the connection in Figure 1 is activate by tanh activation function which follows the research of [5] [8] [9-10].

2.2. Moving Average ANN algorithm

In investment analysis, the moving-average (MA) model is a basic and standard approach for modelling univariate time series data. Statistically, the form of MA denotes as MA(q) where q represent the order of model and can be write as following equation:

$$yt = \mu + wt + \theta 1\ wt\text{-}1 + \theta 2wt\text{-}2 + \ldots + \theta q\ wt\text{-}q \quad (1)$$

where μ is refers to the mean of the data series, the θ1, ..., θq are refers to the parameters of the MA (q) model, and the w1, ..., wt-q refers to the white noise error terms of MA(q) model. The parameter values of q obtained by examine the criteria of Akaike Information Criterion (AIC), Akaike Information Criterion of small sample equivalent (AICc) and Bayesian Information Criterion (BIC) calculations which are based on the maximum likelihood estimation of MA model. This model will be used in analyses the sukuk investment information and in order to better forecasting, MA(q) model will eventually hybrid onto ANN algorithm process. The hybridization algorithm can be explain the steps as follows:

Step 1 : Generate input data of sukuk information data
Step 2 : Fit and formulate the MA(q) equation (1)
Step 3 : Randomly split the model in Step 2 for train and test sample
Step 4 : Fit ANN using the train data, in order to construct the hybrid Moving Average ANN
Step 5 : Predict the n point ahead for model in Step 4 using test sample
Step 6 : Estimate the traditional hybrid model performance using root mean square error (RMSE), mean absolute error (MAE) and mean absolute percentage error (MAPE).

In step 4 of algorithm, a single ANN hidden layer is considered in this study and by referring to [11], the neurons nodes in this hidden layer is obtained by using rule of thumb of 2/3 size of the input layer plus with the size of the output layer. The algorithm is ran using R-Studio statistical software.

III. EXPERIMENT AND RESULT

The sukuk is important to be forecasted due to its compatible and stability invested in Bursa Saham Malaysia. In this study, a daily observation data of 2010 until 2013, given 400 data point in the time series. The information of sukuk data can be found at www.bondinfo.bnm.gov.my also www.bursamalaysia.com. In order to construct the hybrid

Moving Average ANN, about 220 information data set is treat as training data while 180 information data is treated as test sample and proceed to the evaluation of hybrid Moving Average ANN statistical model performance.
The sukuk series data is further be fitted onto MA(p) in order to find the best parameter of p. The best fit of MA(p) statistical model is selected by examine the AIC, AICc and BIC criterion result which can be referred in Table 1.

Table -1 Best fit model according to Akaike and Bayesian criterion

Best fit MA model	Information Criterion		
	AIC	AICc	BIC
MA(1)	-4451.2	-4451.14	-4439.21
MA(4)	-4446.45	-4446.24	-4422.47
MA(6)	-4442.51	-4442.14	-4410.54

According to the Table 1, it is shown a decreasing result of criterion as the parameter p value is greater. It is found that the best parameter of model selection for sukuk are MA(6) which yield to the smallest criterion numbers, i.e. AIC = -442.51, AICc = -4442.14 and BIC = -4410.54, compare to MA using the parameter of p =1 and p = 4.
By considering a single hidden layer with 4 neuron nodes, the MA(6) information of sukuk data can be hybrid onto ANN algorithm learning process. The input information is generated from parameter's information of MA(6). Thus, a complete training sample plot of this learning process can be referred to Figure 2.

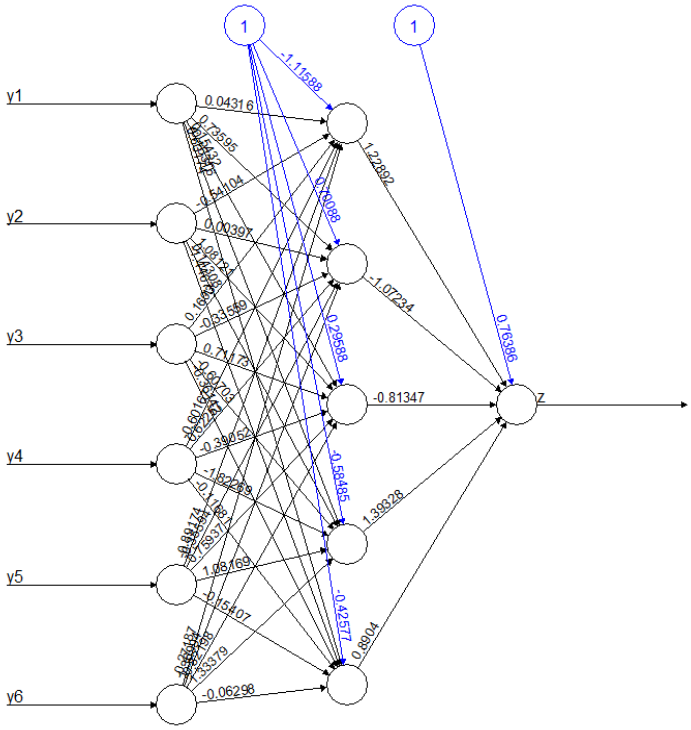

Figure 2. Training sample for hybrid Moving Average ANN learning process using sukuk information data

From Figure 2, the blue line with number "1" refers to weights of α in hidden layer and output layer. In hidden layers, the first weight value of first neuron node is α1 = -1.115, second node is α2 = 0.700, continue with α3 = 0.295, α4 = -0.584 and α5 = -0.425. While the weight for output layer is αoutput = 0.763.
In order to examine the Moving Average ANN learning algorithm in terms of statistical performance of forecasting, this hybrid model is estimated for RMSE, MAE and MAPE calculation for 10 days ahead and 15 days ahead forecasting. The forecasting is calculated using the test sample information. The result can be referred in Table 2. For comparison, MA(6) is considered to be forecasted and examine its performance for 10 days ahead and 15 days ahead.

Table -2 Performance of forecasting using hybrid Moving Average ANN

Statistical Model	10 Days Ahead			15 Days Ahead		
	RMSE	MAE	MAPE	RMSE	MAE	MAPE
MA(6)	0.0009588	0.0009249	0.0103777	0.000909	0.0008764	0.0100911
Moving Average ANN	0.0009172	0.0009146	0.0101269	0.0008488	0.0008427	0.0096735

A quantitative results of the sukuk information data set of forecasting (Table 2) revealed that Moving Average ANN gives smaller vale of RMSE, MAE and MAPE in both period of forecasting. For example, for 10 days ahead, it gives RMSE = 0.0009172, MAE = 0.0009146 and MAPE = 0.0101269, compare to MA(6) which having greater value of RMSE = 0.0009588, MAE = 0.0009249 and MAPE = 0.0103777. This means that, hybrid Moving Average ANN is more accurate to be used in forecasting the sukuk compare to traditional statistical model itself. The algorithm from ANN helps to increase the accuracy of 10 days and 15 days ahead forecasting of MA(6).
Furthermore, for 15 days ahead forecasting calculation, both statistical model give decreasing value of performance. For example, MAPE calculation of Moving Average ANN, 10 days ahead = 0.0101269 while 15 days ahead = 0.0096735. This means that Moving Average ANN can be more reliable for middle term period forecasting of sukuk as the RMSE, MAE and MAPE values decrease.

IV. CONCLUSION

The application of moving average (MA(p)) statistical model is well known in forecasting filed, especially in investment. Hybrid the MA(p) onto artificial neural network (ANN) processing algorithm is recognized as an alternative approach in order to help improving the accuracy of forecasting the investment of a portfolio, for example Islamic investment namely sukuk. Thus, in this study, the proposed algorithm is hybrid Moving Average ANN.
The hybrid algorithm, or so called hybrid statistical model, is applied to sukuk information data. By using the train sample, Moving Average ANN learning process can be plotted, and by using test sample of sukuk information data, the statistical performance calculated by considering the 10 days ahead and 15 days ahead of forecasting. Based on the empirical result, it shown that the Moving Average ANN gave the best performance in terms of accuracy and more reliable to be used in middle terms of forecasting the sukuk investment.

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