Comparison of Extreme Learning Machine Methods and Support Vector Regression for Predicting Bank Share Prices in Indonesia

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Abstract

Investing is the practice of postponing current consumption to obtain more significant value in the future. One profitable form of investment is stock investment, where investors buy company shares to benefit from appreciation in share value or dividend payments. Before investing in shares, investors need to pay attention to movements in the Composite Stock Price Index (IHSG), which reflects the performance of the Indonesian stock market. The Indonesian Stock Exchange (BEI) recorded around 740 companies listed in 2021. The BEI also compiled the LQ45 list of 45 stocks with the largest market capitalization, including the four largest banks in Indonesia. However, investing in bank shares only sometimes produces profits due to share price fluctuations. Stock price analysis and price movement predictions are important steps before investing. Extreme Learning Machine (ELM) and Support Vector Regression (SVR) methods are techniques used to predict time series data. This research compares the performance of the two methods in predicting stock prices of the big 4 Indonesian banks. The dataset used in this research comes from the Yahoo Finance site, which was taken since the market crash recovery period due to the Covid-19 pandemic. Based on the evaluation conducted, both the ELM and SVR methods are effective for predicting the share prices of the big four Indonesian banks. The average MAPE for the ELM method is 8.5% and SVR is 2.64%. However, when considering computing time, the ELM method is more efficient with an average computing time of 0.006 seconds, than the SVR method with an average computing time of 0.694 seconds.

Keywords: Extreme Learning Machine, Support Vector Regression, Stocks Prediction, Banking Indonesia, MAPE.

I. INTRODUCTION

Investment is an activity carried out to postpone current consumption to generate higher value in the future. Investment is an activity carried out to postpone current consumption, with the hope that the investment value in the future will be higher than the current value. Investment also involves taking risks for better results or profits [1]. There are various kinds of investments; one of the most profitable is stock investment. Stock investment is buying company shares as part of ownership to make a profit. This involves buying and selling shares in the capital markets to profit from appreciation in share value or dividend payments. Stock investment is studied as a strategy to gain wealth gradually [2].

Before buying or selling shares, investors or traders must pay attention to movements in the Composite Stock Price Index (IHSG). IHSG is the leading stock market indicator on the Indonesia Stock Exchange (BEI). IHSG reflects the average performance of share prices from various industrial sectors listed on the IDX. IHSG is often used as a benchmark to measure the performance of the Indonesian stock market as a whole. Changes in the IHSG value usually reflect market sentiment and economic and political factors that influence stock price movements in Indonesia [3]. In 2021, BEI noted that there will be around 740 companies registered and listed on the stock exchange. However, this figure may change from time to time due to the addition or reduction of companies conducting an initial public offering (IPO) or being removed from the trading list for various reasons, including mergers, acquisitions, or bankruptcy [4].

IDX has also published and grouped a list of shares with high liquidity and market capitalization into LQ45 [5]. LQ45 is a list of 45 stocks that have the largest market capitalization, including the big 4 Indonesian banks, namely BCA (BBCA), BRI (BBRI), Mandiri (BMRI), and BNI (BBNI) [6]. Investors who want to invest in banking issuers also cannot be careless in purchasing shares without carrying out an analysis because of the high level of liquidity and fluctuations in the share prices of the Big Four banks. Even though investing in Big Four banking with a large market capitalization does not mean that you will always make a profit, there is the possibility of a loss due to needing to be corrected in taking a position to buy

shares, which is a resistance area. Resistance is an area where the price has reached that price several times but has not been penetrated. So, stock price movements will experience a decline over the next few days [7].

Based on these problems, analyzing the share price movements within a certain period is necessary depending on how long the investor will invest. Time series data can be used to model patterns in stock prices so that they can be used to predict stock price movements. Methods that can be used to make good predictions on time series data are Extreme Learning Machine (ELM) and Support Vector Regression (SVR) [8] [9]. Therefore, this research aims to compare the two methods in predicting share prices for Indonesia's big four banks. Comparisons are not only made on the accuracy of the resulting prediction model, but also the computing time required to produce the prediction output.

II. RELATED WORKS

Research comparing several methods for predicting stock prices has been carried out before. Research conducted by Fitri and Riana [10] compared linear regression, random forest regression, and multilayer perceptron methods, where the data used was historical stock prices by taking data samples on three issuers from the Indonesian capital market. Testing was carried out with two data models: partitioning, validated with cross-validation, and data modeling with cross-validation without partitioning. In this research, the linear regression prediction model was able to produce relatively low error prediction values with the lowest RMSE value of 0.010 and the highest RMSE of 0.012, the lowest MAPE of 1.2%, and the highest of 1.9%, the lowest MAE of 0.006 and the highest of 0.009, and The highest R2 value was 99.8%, and the lowest was 99.6%.

Another research by Ramadhan and Pamuji [11] compared linear regression and neural network methods to predict the LQ45 share price of PT Bank Mandiri Sekuritas (BMRI). By using four attributes, namely open, high, and low values as predictors and close as a class, this research focuses on determining accuracy values, namely Root Mean Squared Error (RMSE), by optimizing parameter values. Based on the results of the tests, the Neural Network method has a lower error rate with an RMSE value of 0.034 compared to the Linear Regression method with an RMSE value of 0.052.

In contrast to previous research, Laksono et al. [12] compared linear and polynomial regression methods to predict BCA Bank share prices. The data used is 1252 BCA Bank share data for five years. The MAPE value calculation is used for prediction testing. This research shows that both methods are good criteria because the MAPE value is less than 10%, and the polynomial regression method gets a better score than the linear regression method. The test results for the Linear Regression method get a MAPE value = 6.55%, while the Polynomial Regression method gets a MAPE value = 6.54%.

Research on BMRI share price predictions was also carried out by Pratama and Banowosari [13]. To determine the best method, this research compared the Extreme Gradient Boosting (XGBOOST) and Long Short-Term Memory (LSTM) methods. After testing, the results obtained from the XGBoost method were obtained, namely a Coefficient of Determination (R2) value of 89.09%, which indicated that the prediction results were good and the Mean Absolute Percentage Error (MAPE) was 3.21%. Meanwhile, the LSTM method's R2 value is 98.44%, and MAPE is 1.77%, indicating a low error percentage.

Different from the research discussed previously, this research compares the ELM and SVR methods in predicting share prices for the big 4 Indonesian banks. The stock price dataset was taken from the Yahoo Finance site. This site was chosen because several researchers have used it in their research related to stock predictions [14]. Apart from that, the data displayed on Yahoo Finance is also real data that describes current stock movements [15]. The evaluation was carried out by comparing the Mean Absolute Percentage Error (MAPE) values resulting from the two prediction models of the ELM and SVR methods.

III. RESEARCH METHODS

This research is divided into several stages, including dataset collection, preprocessing, training process, evaluation. The flow of these stages can be seen in Figure 1.

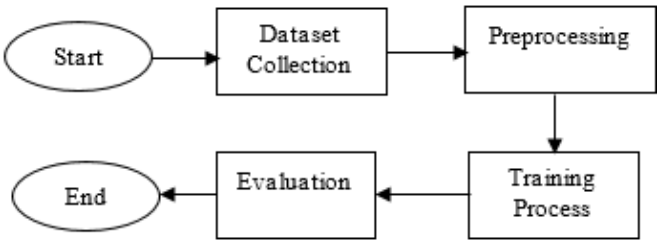

Figure 1. The Flow of Research Stages

A. Dataset Collection

This research will use the Yahoo Finance site's stock price time series dataset. Data was collected starting March 24 2024, on that date the stock index declined sharply due to the market crash, but then rose fluctuatingly [16]. A market crash is a condition where the stock market experiences a significant price decline quickly due to particular sentiments, in this case, the lockdown due to COVID-19 [17].

In this research, the features used are open, high, low, and close. Each column has varying values, and to get a more accurate prediction model, a new feature, namely, an average, is created. The average feature is the average value of the open, high, low, and close prices. Other features such as date, adjusted close, and volume are not used to form the prediction model. This is because these features do not influence the process of predicting stock prices in the short term [18]. The number of datasets in this research is 868, which comes from the Yahoo Finance site. The dataset that has been collected is divided into two parts, namely training data and testing data. The division of the dataset used is 80:20, meaning 80% of the data will be training data, while 20% will be used as testing data.

B. Preprocessing

In this preprocessing stage, missing values are checked to see whether the dataset has empty data. If there is empty data, the data column will be filled with the mean value from the previous and the following columns. The following preprocessing is data normalization to equalize the units in the data so that the range of values in the data is not too wide to provide a balance of values between one another using the Min-Max Scaling method [19].

Min-Max Scaling will change the range of values from 0 to 1. Min-max scaling calculates new values using the maximum and minimum values of the data so that the range of values formed from the calculation is more relevant to the original data than other normalization methods [19]. The calculation of Min-Max Scaling is shown in equation (1), where x is the sample value, min(x) is the minimum value of the set of values x, max(x) is the maximum value of the set of values x, and x' is the scaled value [20].

$$x' = \frac{x - \min(x)}{\max(x) - \min(x)} \quad (1)$$

C. ELM Training Process

After preprocessing, the next stage is to conduct the training process to build a prediction model from the ELM method. ELM is a method of feedforward neural networks that only has one hidden layer, known as single hidden layer feedforward neural networks (SLFNs). ELM's learning speed is often faster than other feedforward network algorithms, such as back-propagation, and it will perform better. The weighting on the input and hidden layers will be initialized randomly so that ELM does not require repeated optimization, such as back-propagation [21].

Neurons in ELM's input, hidden, and output layers are connected. Connecting the input layer with the hidden layer uses a weight vector w, whose values are taken randomly. The bias value is also determined randomly. Randomly determined weighting of w values and bias can increase the model learning speed and overcome unstable prediction values. After that, calculations are done to get the vector in the hidden layer using the activation function, as seen in equation (2) [22].

$$g(xi) = \frac{1}{1 + e^{(-(x_i * w^T + b))}} \quad (2)$$

Where *g(xi)* is the value of the hidden layer in row *i*, *e* is the Euler number, *x* is the data value, w^T is the transposed weight value, and *b* is the bias value determined randomly. After obtaining the value from the hidden layer, calculations are carried out to obtain the output weight value using equation (3) [22].

$$\beta = (g^T * g)^{-1} * g^T * y \quad (3)$$

Where β is the output weight value, g is the hidden layer value, g^T is the transposed hidden layer value, and *y* is the target matrix value (expected output). The output layer calculation in the ELM model results from multiplying the vector produced in the hidden layer with the input data and the weight vector in the hidden layer with the output weight, as shown in equation (4) [22].

$$f(x) = g(x) * \beta \quad (4)$$

Where *f(*x) is the value in the output layer, *g(x)* is the value in the hidden layer, and β is the output weight value. ELM will train the model until it gets a bias weight value output with the minimum error value [22].

D. SVR Training Process

Apart from the ELM method, the training process to build a prediction model will also use the SVR method. SVR is an application of a Support Vector Machine to solve regression problems. In SVR, the output is a continuous number, and the aim is to obtain a function f(x) as a hyperplane (dividing line) that fits the data and allows for some deviations from a predicted value. The equation used to determine the hyperplane can be seen in equation (5) [23].

$$y = w * x + b \quad (5)$$

Where *y* is the resulting hyperplane value, *w* is the weight value, *x* is the input value, and *b* is the intersection point value when x = 0 [23]. SVR has several hyperparameters that must be determined to improve its performance, such as C, Kernel, Epsilon, and Gamma. C limits the error level from exceeding a predetermined tolerance value. The C value must be positive; by default, it is 1.0. The kernel will perform non-linear transformations on the input data so that the input data has higher dimensions that make it easier to separate. Commonly used kernels are rbf, linear, polynomial, and sigmoid [24]. This research will use the Radial Basis Function (RBF) as the kernel function, with the equation shown by equation (6) [25].

$$\exp\left(-\gamma \left|\left|x - x'\right|\right|^2\right) \quad (6)$$

Where *x* is the actual data value, *x'* is the predicted data value, and γ is the value obtained from the gamma parameter. The RBF kernel is used because stock price data is a type of non-linear data whose price movements tend to be irregular. The RBF kernel is very suitable for handling non-linear problems in data, so it is suitable for the data used and is easier to implement [25]. Next, the predicted output value of SVR is calculated using equation (7) [23].

$$f(x) = \sum_{i=1}^{n} a_i K(x_i, x) + b \quad (7)$$

Where *f(x)* is the prediction output value, *n* is the amount of data, and α is the Lagrange coefficient value. Meanwhile, $K(x_i,x)$ is a kernel function that measures the closeness between x_i and *x*, and *b* is the bias value [23].

E. Evaluation

After the training process, the next stage is to evaluate the prediction model resulting from the ELM and SVR methods. In this research, evaluation was carried out by calculating the

Mean Absolute Percentage Error (MAPE) value. MAPE is the average absolute percentage error measures the magnitude of the average error produced by a prediction model. The MAPE calculation is obtained from the average absolute differential of the predicted value with the actual value. It is displayed as a percentage of the actual value, as shown in equation (8) [26].

$$MAPE = \frac{1}{n}\sum_{i=1}^{n}\left|\frac{y'_i - y_i}{y_i} * 100\right| \quad (8)$$

Where y'_i is the predicted value of the ith data, y_i is the actual value of the i-th data, and n is the amount of data tested. A small MAPE value indicates better prediction accuracy by the model, indicating a minimal error rate [26].

IV. RESULTS AND DISCUSSIONS

Based on the dataset collection process, the number of datasets in this research is 868, which comes from the Yahoo Finance site. The dataset that has been collected is divided into two parts, namely training data and test data. The division of the dataset used is 80:20, meaning 80% of the data will be training data, while 20% will be used as testing data. The prediction model is formed using the training data and the MAPE value calculation is carried out using the testing data.

Based on advice from an investment expert certified by *Badan Pengawas Perdagangan Berjangka Komoditi* (BAPPEBTI), the system is developed to predict a maximum of 10 days ahead of the price of a stock. The aim is to make the stock price predictions produced more accurate for a short period. It will be reflected that the stock prices are in a strengthening or weakening trend in recent years.

In training the prediction model using the ELM method, the hyperparameter values for the number of hidden neurons were experimented with, ranging from 1 to 20. Then, the number of hidden neurons will be selected based on the best evaluation value for each hidden neuron value. Figure 2 shows a graph of MAPE values for evaluation of prediction models using the ELM method for shares in BCA, BRI, Mandiri, and BNI banks.

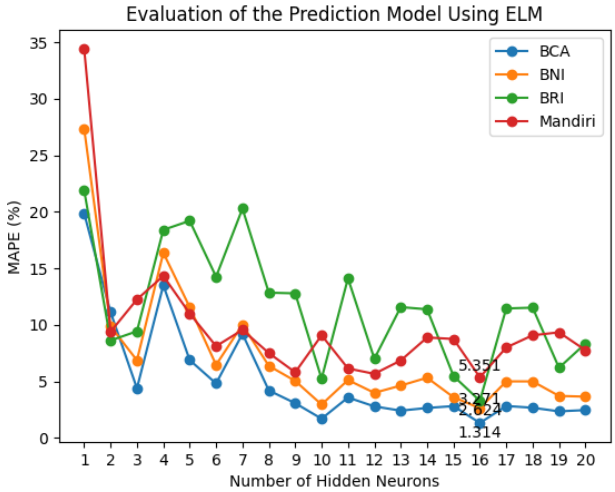

Figure 2. Evaluation of the Prediction Model Using ELM

Based on the evaluation results, the ELM method's most optimal number of hidden neurons is 16. This is because the number of neurons has the smallest MAPE value for BCA, BRI, Mandiri, and BNI bank shares. Of the four banks, the BCA bank share prediction model has the smallest MAPE value, namely 1.314%, while the highest MAPE value occurs in the Mandiri bank share prediction model, at 5.351%, as shown in Table 1. Based on Table 1, it can be seen that the best average MAPE is in the BCA stock prediction model with a MAPE value of 5.221%.

Table 1. MAPE for ELM Prediction Model for Each Bank

Bank Name	MAPE (%)		
	Min	Max	Avg
BCA	1.314%	19.839%	5.221%
BNI	2.624%	27.345%	7.268%
BRI	3.271%	21.888%	11.656%
Mandiri	5.351%	34.417%	9.855%

The following prediction model training process is carried out using the SVR method. To determine the hyperparameter values gamma and epsilon, experiments were carried out using a combination of gamma values 0.1, 0.01, 0.001, and 0.0001, while the epsilon values used were 0.1, 0.01, 0.001, and 0.0001. Epsilon represents the margin width tolerance value around the hyperplane line and the value must be non-negative, by default 0.1. While Gamma aims to control how much curvature is desired in decision limit making. Determination of gamma values is only required when using RBF kernel functions. It will affect the partitioning outcome in the feature space. Too large gamma value will result in over fitting while too small value will lead to under fitting [27]. Table 2 shows the evaluation results of combining gamma and epsilon values for implementing the SVR method for predicting BCA, BRI, Mandiri, and BNI bank shares.

Table 2. Evaluation of the Prediction Model Using SVR

Bank Name	Gamma	Epsilon	MAPE (%)
BCA	0.1	0.1	3.894
		0.01	2.061
		0.001	1.479
		0.0001	1.484
	0.01	0.1	4.386
		0.01	0.619
		0.001	0.595
		0.0001	0.595
	0.001	0.1	1.753
		0.01	**0.569**
		0.001	0.575
		0.0001	0.584
	0.0001	0.1	1.509
		0.01	0.796
		0.001	0.789
		0.0001	0.789

Bank Name	Gamma	Epsilon	MAPE (%)
BNI	0.1	0.1	8.091
		0.01	3.244
		0.001	2.870
		0.0001	2.636
	0.01	0.1	2.476
		0.01	1.086
		0.001	1.028
		0.0001	0.987
	0.001	0.1	1.980
		0.01	0.833
		0.001	0.813
		0.0001	**0.800**
	0.0001	0.1	2.515
		0.01	1.231
		0.001	1.191
		0.0001	1.187
BRI	0.1	0.1	9.488
		0.01	2.120
		0.001	2.234
		0.0001	2.190
	0.01	0.1	5.234
		0.01	0.828
		0.001	0.889
		0.0001	0.903
	0.001	0.1	3.843
		0.01	0.803
		0.001	0.790
		0.0001	**0.786**
	0.0001	0.1	4.495
		0.01	1.185
		0.001	1.126
		0.0001	1.121
Mandiri	0.1	0.1	6.236
		0.01	11.330
		0.001	9.389
		0.0001	9.464
	0.01	0.1	7.342
		0.01	2.126
		0.001	1.991
		0.0001	2.041
	0.001	0.1	4.172
		0.01	1.271
		0.001	**1.078**
		0.0001	1.112
	0.0001	0.1	13.215
		0.01	1.822
		0.001	1.570
		0.0001	1.573

Table 2 above shows that the gamma value that produces the best MAPE value for implementing the SVR method is 0.001 for all banks. However, three epsilon values produce the best MAPE values, namely 0.01 for BCA bank share predictions, 0.001 for Mandiri bank, and 0.0001 for BNI and BRI banks. The best test results for the SVR method from the four banks were from BCA bank, which had a MAPE value of 0.569%. Meanwhile, the worst MAPE value occurred in the Bank Mandiri stock prediction model at 13,215% with a gamma value of 0.0001 and an epsilon of 0.1.

Based on the two evaluation results, the SVR method had a better MAPE value than the ELM method. In addition to measuring the MAPE value of the prediction model produced by the ELM and SVR methods, testing was also done by calculating the computing time. Table 3 compares computing time for implementing the ELM and SVR methods for predicting shares for each bank.

Table 3. Computation Time of ELM and SVR Methods

Bank Name	Method	Computation Time (seconds)
BCA	ELM	0.001
	SVR	0.222
BNI	ELM	0.002
	SVR	0.189
BRI	ELM	0.001
	SVR	0.204
Mandiri	ELM	0.002
	SVR	0.079

Based on the results of testing the computing time of the ELM and SVR methods to predict the share price of each bank, the ELM method has a faster computing time than the SVR method. The average computing time of the ELM method is 0.0015 seconds, while the SVR method is 0.694 seconds.

V. CONCLUSION

Based on the evaluation that has been carried out, the ELM and SVR methods can be used to predict the share prices of the big 4 Indonesian banks. This is because both methods have the best MAPE value of less than 2% and have an average computing time of less than 1 second. This also proves that the ELM and SVR methods are no less than the linear regression, neural network, polynomial regression, LSTM, and XGBOOST methods in the case of forecasting [10] [11] [12] [13].

Based on the level of accuracy, the SVR method is better than the ELM method because it has the best MAPE value. Meanwhile, judging from the computing time, the ELM method is better than the SVR method. Based on the advantages of each method, in future research, we can combine the ELM and SVR methods in order to obtain a prediction model that is computationally accurate and faster.

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