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Linear Regression Method Predicting BMRI *Stock Price Using Machine Learning*

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Abstract

Investing in stocks carries considerable risk as stock prices fluctuate depending on market conditions and company performance. Therefore, it is necessary to analyze stock price movements so that investors can use the analysis results to make investment decisions. In this study, using the linear regression method, machine learning is used to predict the closing price of Bank Mandiri Tbk (BMRI) shares*. The attributes used in this research are Open, High, and Low as inputs and Close labels to determine the prediction value. The data obtained is processed using Visual Studio Code tools with the Python programming language. This research focuses on assessing the value of error and precision, mean absolute error (MAE), mean square error (MSE), root mean square error (RMSE), and mean absolute percentage error (MAPE). Based on the tests conducted, the results obtained an error value of 960.97 for the MSE value, 30.9995 for the RMSE value, and 0.57% for the MAPE value.*

Keywords: *BMRI; Linear Regression; Stock Price Prediction*

1. Introduction

Stock investment is one of the most popular forms of investment in Indonesia and continues to increase yearly [1]. Investing in stocks involves significant risk as stock prices fluctuate depending on market conditions and corporate performance [2]. Current movements in stock prices can be determined as rising or falling through a stock index. The perfindex's performance is a very important indicator for investors to determine whether to sell, hold or buy stocks [3].

The Indonesia Stock Exchange (IDX) is a financial institution operating as a capital market in Indonesia [4]. Bank Mandiri shares are listed and traded on the Indonesia Stock Exchange (IDX) under the BMRI ticker. Quoted from the page [5], in Q2/2022, PT Bank Mandiri (Persero) Tbk still holds the title of the largest bank in Indonesia. Or BMI. On a consolidated basis, the bank's assets stood at IDR 1,785.71 trillion, representing a year-over-year growth of 12.98%. Indonesia's economic development has slowed down in recent years. This caused index volatility of several stocks listed on IDX, one of which is Bank Mandiri (BMRI) which also saw ups and downs [6].

Investing in Bank Mandiri shares can offer investors an attractive return opportunity, but it also carries certain risks, such as stock market volatility, operational risk, and risk. Government policy risk. As an investor, it is important to conduct a detailed analysis of the company's performance and market conditions before deciding to purchase shares or shares of Bank Mandiri. Therefore, investors must analyze stock price movements to use the analysis results to make investment decisions. One possible solution to the stock price inconsistency problem is to predict the stock prices of banking companies, in this case, PT Bank Mandiri Tbk (BMRI).

Given these problems, this study uses machine learning using Python programming language to predict the stock price of PT Bank Mandiri (Persero) Tbk. or BMRI, knowing the possible opening and closing prices. Machine learning is a branch of artificial intelligence (AI) widely used to replace or mimic human behavior to solve or automate a problem.

2. Literature Review

Previous research by Irvan Himawan, Odi Nurdiawan and Gifthera Dwilestari [7]. Applying linear regression to predict BRI Bank (BBRI) reserves by a rapid miner in 2022. The

data used are annual data for t last five years in the time series, fowiththra a split of 60/40. This search produces the best original of RMSE of 27,780 and MAE of 19,780. The relative error of 0.57 n means prediction is 3,607,646.

In the same year, Evita Fitri and Dwiza Riana [8] conducted a rapid mining study comparing linear regression, random forest regression, and multilayer perceptron algorithms. The data used is a 5-year data collection period from September 1, 2015, to September 1, 2020, with a total data retention and data audit ratio of 80/20. Therefore, the linear regression method is better than random forest and multilayer perceptron, with low prediction error. The value obtained corresponds to the lowest RMSE value of 0.010 and the highest RMSE value of 0.012. The lowest MAE value obtained was 0.006, the highest was 0.0009, the highest R2 value was 99.8'n, and the lowest was 99.6%.

To dig deeper, compare linear regression and ARIMA for stocks in the PT case study. BSI Confirmation (BRIS) [9]. The data used is the data for the period 2018 to 2011. The results of this study provide a linear regression method to predict the stock price of PT BSI. Tbk provides a linear regression equation model. Multiplied with a high accuracy of 98.9% with a MAPE value of only 1.1%. While applying the ARIMA method to predict the stock price of PT BSI, Tbk offers the ARIMA equation model with a high accuracy of 97.64% with a MAPE value of only 2.36%. The linear regression model and ARIMA comparison results show that the highest correct value is 97.64%, with the MAPE value of only 2.36%.

Another study [10] used Rapidminer linear regression. The dataset used is the period January 2016 - March 2021 with a case study of PT Aneka Tambang Tbk or ANTM, resulting in an RMSE value of 17,135, an MSE value of 293,599, and an RMSE value of 293,599. MAPE is 1.87%.

The linear regression method with the described studies can predict well with high accuracy. This led the researchers to use linear regression for the BMRI stock dataset with varying amounts of data. This study also used machine learning with Python programming language to predict the stock price of PT Bank Mandiri (Persero) Tbk. or BMRI, where the opening and closing prices can be found. Machine learning is a branch of artificial intelligence, which is a set of software algorithms used to optimize the performance of a computer or system based on existing data patterns [11].

3. Methodology

This study focuses on stock price forecasting in the banking sector using PT Bank Mandiri Tbk. (BMRI) stock market index. Machine learning uses linear regression to learn how to predict stock prices. Linear regression is a statistical technique used to study the relationship between one variable (independent variable) and another variable (dependent variable) [12]. The independent variables for this study are the date, open, high and low attributes as long as the dependent variable is close.

The dataset used is 1745 records. The data taken is from January 2016 to December 2022. The data used is the daily data for the last six years in time series form with a split ratio of 90/10, namely five years of data as training data and one year as control data check.

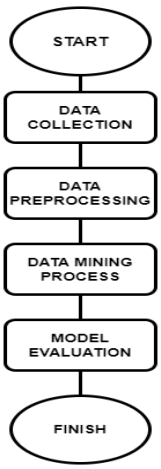

Figure 1. Stages of Research Method

Data analysis techniques in data mining applications use the Knowledge Discovery in Databases (KDD) process, which consists of Database, Data Selection, Data Cleaning, Data transformation, Data mining, and interpretation. With KDD, the process has six steps or phases [13]. The stages of the data mining process using the KDD method are described in Figure 2 below:

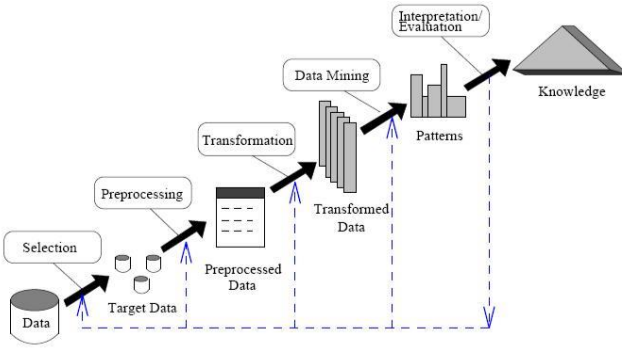

Figure 2. Stages of the KDD Process

To increase the success of this research, it was carried out using the KDD method, with the research steps including:

1) Database

The data used in this study is taken from a set of BMRI stock datasets downloaded from the finance.yahoo.com page from January 2016 - December 2022, with 1745 data.

2) Data Selection

After receiving the data set, the next step is to set the parameters to model the required algorithm.

3) Data Cleaning

Once the data has been extracted according to the required parameters, the next step is to clean the data from typos, misspellings, and irrelevant data.

4) Data Transformation

Perform a classification process to create data groups in the form of tables.

5) Data Mining

Applying an appropriate and attractive model with the data and algorithms used. At this stage using, data in CSV format and imported into the visual studio code tool with the Python language.

6) Interpretation/Evaluation

Mean squared error (MSE), root mean squared error (RMSE), and mean absolute percentage error (MAPE) values are calculated to measure the accuracy of the method used. The formula is as follows:

$$MSE = \Sigma\frac{(Y'-Y)^2}{n} \quad \text{..... (1)}$$

Y' is the Predicted Value, Y is the Actual Value, and n is the Number of Data.

$$RMSE = \sqrt{\Sigma\frac{(Y'-Y)^2}{n}} \quad \text{.....(2)}$$

Y' is the Predicted Value, Y is the True Value, and n is the Number of Data.

$$MAPE = \frac{1}{n}\sum_{t=1}^{n}\frac{|\hat{y_t}-y_t|}{y_t}X100 \quad \text{.....(3)}$$

Y' is the Actual Value, and Y is the Predicted Value.

The machine learning method in this research uses linear regression and programming language using Python. Linear regression is an algorithm for measuring the relationship between the correlation of two or more variables used in prediction with a straight line [14]. Variables are metrics with changing values [6]. A variable is a metric whose value can change. There are two types of variables in linear regression: Influencing variables and affected variables. The cause is the influencing variable, and the influenced variable is the effect [15].

$$\mathbf{Y = a + bX} \quad \text{..... (4)}$$

Y is the dependent variable, X is the independent variable, a is the constant, and b is the regression coefficient.

Python is an object-oriented scripting language. Python is used in many development programs and on many operating systems. Python is a free programming language or free software itself. There are no restrictions on copying or distributing. Includes source code, debugger and profiling, integrated interface to front-end services, system functions, graphical user interface (GUI), database [16], and prediction modeling using machine learning in Python. Python has one or more libraries that contain modules and packages with functions that make it easy to write program code [17]. The library that is used is as follows:

1) Pandas is an open-source data analysis and transformation tool that is fast, powerful, flexible, and easy to use. Pandas were used in the study to download or process files in .csv format.
2) Numpy is an open-source project aiming to enable numerical computation with Python. Numpy was created in 2005 based on an early use of the Numeric and Numarray libraries. Researchers use Numpy to manage array, matrix, and vector functions.
3) Matplotlib is a comprehensive library for creating visualizations, animations, and interactions with Python. In this research, Matplotlib is used to create data visualization in graphs.
4) Scikit-learn is an open-source library that supports supervised and unsupervised learning. Scikit-learn also provides various tools for model loading, data manipulation, model selection, evaluation, and other utilities. The scikit-learn library was used in the study to model the algorithm [17].

4. Results and Discussion

4.1. Data Collection

At this stage, the author collects information for the final research project. The data used by the author in this work is the stock price of Bank Mandiri Tbk. The source to get information about the stock price of Bank Mandiri Tbk. is [18] from Jan 2016 to Dec 2022, with 1754 records with seven attributes. Below are the stock records of Bank Mandiri Tbk.

yahoo! finance — Search for news, symbols or companies

Date	Open	High	Low	Close*	Adj Close**	Volume
Dec 30, 2022	10,000.00	10,050.00	9,925.00	9,925.00	9,443.01	20,327,900
Dec 29, 2022	9,900.00	9,975.00	9,875.00	9,975.00	9,490.58	28,490,700
Dec 28, 2022	10,000.00	10,000.00	9,850.00	9,975.00	9,490.58	15,129,200
Dec 27, 2022	10,050.00	10,050.00	9,875.00	9,950.00	9,466.80	21,641,000
Dec 26, 2022	9,975.00	10,050.00	9,950.00	10,050.00	9,561.94	9,789,400
Dec 23, 2022	9,900.00	10,000.00	9,900.00	9,925.00	9,443.01	19,285,600
Dec 22, 2022	10,100.00	10,100.00	9,950.00	9,950.00	9,466.80	39,418,100
Dec 21, 2022	10,125.00	10,125.00	10,000.00	10,000.00	9,514.37	18,972,600
Dec 20, 2022	10,000.00	10,050.00	9,950.00	10,050.00	9,561.94	28,316,900
Dec 19, 2022	10,000.00	10,075.00	9,900.00	10,000.00	9,514.37	50,435,700
Dec 16, 2022	9,825.00	10,100.00	9,825.00	10,100.00	9,609.51	385,126,200
Dec 15, 2022	9,900.00	10,025.00	9,900.00	9,900.00	9,419.23	41,336,700
Dec 14, 2022	10,075.00	10,100.00	9,950.00	9,950.00	9,466.80	81,344,600
Dec 13, 2022	9,775.00	10,000.00	9,775.00	9,900.00	9,419.23	112,088,000
Dec 12, 2022	9,825.00	10,000.00	9,775.00	9,950.00	9,466.80	91,858,800

Figure 3. BMRI Stock Price Data

The following is an explanation of the above attributes [19]:

1) Date indicates the date the stock price was recorded during the day.
2) Open indicates the stock's opening price that is first issued when the stock transaction activity opens in one day.
3) High shows the highest price when stock transactions occur in one day.
4) Low shows the stock's lowest price on the event day.
5) Close shows the stock's closing price that last occurred when the stock transaction activity was closed on one day.
6) Adj Close is the closing price of shares adjusted to the Close price when corporate actions such as dividends and stock splits occur.
7) Volume shows the total number of transactions in one day.

4.2. Data Preprocessing

At this stage, the process carried out for the "attributes" section process in the stock dataset there are seven attributes. This research removes the adj close and volume attributes, so there are only five attributes: date, open, high, low, and close.

Table 1. Data Preprocessing

No	Date	Open	High	Low	Close
0	2016-01-04	2300	2337.5	2268.75	2312.5
1	2016-01-05	2312.5	2387.5	2312.5	2343.75
2	2016-01-06	2362.5	2381.25	2337.5	2337.5
3	2016-01-07	2287.5	2312.5	2275	2275
4	2016-01-08	2275	2318.75	2275	2318.75
5	2016-01-11	2275	2287.5	2250	2275
6	2016-01-12	2300	2318.75	2275	2300
7	2016-01-13	2318.75	2362.5	2300	2337.5
8	2016-01-14	2275	2368.75	2275	2337.5
9	2016-01-15	2337.5	2356.25	2318.75	2318.75

4.3. Import Data

BMRI stock data that has been preprocessed to determine the attributes used and cleared of data that has null data will be stored in CSV format. The data will be read with the Python library pandas. The following is the data import code and data display results.

```
def read_data():
    return pd.read_csv("./BMRI.2016-2022.csv")[["Date", "Open", "High", "Low", "Close"]]


df = read_data()

if w1:
    st.title("Dataset BMRI")
    df["Date"] = pd.to_datetime(df["Date"])
    df["Date"] = df["Date"].dt.strftime("%Y-%m-%d")
    st.dataframe(df)
```

Figure 4. Source Code Import Data

Dataset BMRI

	Date	Open	High	Low	Close
0	2018-01-01	8,000	8,000	8,000	8,000
1	2018-01-02	7,975	8,050	7,825	7,850
2	2018-01-03	7,850	7,850	7,650	7,700
3	2018-01-04	7,750	7,825	7,725	7,825
4	2018-01-05	7,725	7,850	7,725	7,825
5	2018-01-08	7,875	7,950	7,825	7,925
6	2018-01-09	7,975	8,000	7,775	7,900
7	2018-01-10	7,925	7,925	7,800	7,900
8	2018-01-11	7,925	8,075	7,925	8,075
9	2018-01-12	8,075	8,250	8,000	8,100

Figure 5. BMRI dataset

4.4. Dataset Sharing

BMRI data is divided into two parts, namely training data and test data. Training and test data are two subsets of the dataset used to build and evaluate machine learning models. The BMRI dataset is used in the training data from 01/01/2018 to 30/12/2021. The number of data sets used in the training data is 1007 data. As for the test data, the BMRI dataset from 03/01/2022 to 29/12/2022 has 245 data. Below is the source code for separating training and test data.

```
# Mengonversi kolom 'date' menjadi tipe data datetime
    data['DateTime'] = pd.to_datetime(data['Date'])

    # Memisahkan data menjadi train dan test berdasarkan tanggal
    train_start_date = pd.to_datetime('2016-01-04')
    train_end_date = pd.to_datetime('2021-12-30')
    test_start_date = pd.to_datetime('2022-01-03')
    test_end_date = pd.to_datetime('2022-12-30')

    # Data Train
    train_data = data.loc[(data['DateTime'] >= train_start_date)
                          & (data['DateTime'] <= train_end_date)]
    X_train = train_data[['Open', 'High', 'Low']].values  # Fitur
    y_train = train_data['Close']  # Target

    # Data Test
    test_data = data.loc[(data['DateTime'] >= test_start_date)
                         & (data['DateTime'] <= test_end_date)]
    X_test = test_data[['Open', 'High', 'Low']].values  # Fitur
    y_test = test_data['Close']  # Target
```

Figure 6. Dataset Distribution Source Code

4.5. Data Modeling

Stock data is divided into training and test data and then given an algorithm to model the data using the Python library, namely sci-kit-learn—calculations using Scikit-Learn, a Python library for machine learning with linear regression. The data set consists of dependent variables (y) and independent variables (x). The following is the source code for data modeling.

```
from sklearn.linear_model import LinearRegression
lrgr = LinearRegression()
lrgr.fit(X_train, y_train)
pred = lrgr.predict(X_test)
lrgr = LinearRegression()
lrgr.fit(X_train, y_train)
pred = lrgr.predict(X_test)
```

Figure 7. Data Modeling Source Code

4.5. Evaluasi

All data calculated using the Python programming language is the final result of this thesis. The results of linear regression calculations are generated by statistical figures showing data on the Streamlit website. Here is the source code to perform and the results of the data accusation test.

```
def hitung_mape(y_true, y_pred):
    y_true, y_pred = np.array(y_true), np.array(y_pred)
    return np.mean(np.abs((y_true - y_pred) / y_true)) * 100


def hitung_rmse(y_true, y_pred):
    from sklearn.metrics import mean_squared_error
    return math.sqrt(mean_squared_error(y_true, y_pred))


def hitung_mse(y_true, y_pred):
    from sklearn.metrics import mean_squared_error
    return mean_squared_error(y_true, y_pred)
```

Figure 8. Data Modeling Evaluation Source Code

Figure 9. Data Modeling Evaluation Results

Description of model testing results using the Linear Regression algorithm:

1) MSE (Mean Squared Error):

The MSE value is 960.97. MSE measures the average squared error between the prediction and the actual value. In this case, the MSE value indicates a significant deviation between the forecast and the true value.

2) RMSE (Root Mean Squared Error):

The RMSE value is 30.9995. RMSE is the square root of MSE and provides the same interpretation as MSE. The smaller the resulting RMSE value indicates that the accuracy of this algorithm is suitable for prediction methods.

3) MAPE (Mean Absolute Percentage Error):

MAPE measures the average absolute percentage error between the prediction and the actual value. In this case, the MAPE value shows that the average fundamental percentage error between the forecast and the real value is about 0.57%. The parameters generated from testing by evaluating show that Linear Regression gets outstanding predictive value on Bank Mandiri Tbk (BMRI) stock data.

4.5. Visualization of Prediction Result

Modeled BMRI stock data are visualized using graphs comparing actual and predicted data. The Python library used for data visualization is the matplotlib library. BMRI stock data used as a pre-prediction comparison is 1 () year data, from 03-01-2022 to 30-12-2022. The graph shows the comparison data. Graphs with orange color are actual data; actual data is recorded in stock data on the IDX. While the blue color is the prediction data, the prediction data is the data generated by the machine learning model. Graph Figure. 11, generated by machine learning, is almost identical to the actual data graph. With this graph, the results have a good level of accuracy. The prediction results are also displayed in tabular form in Figure. 12. The following is the source code and visualization of the prediction result.

```
# menampilkan hasil pred dalam plot dengan x = tanggal dan y = prediksi
    fig = plt.figure()
    plt.plot(test_data['Date'].values, pred, label="Prediksi")
    plt.plot(test_data['Date'].values, y_test.values, label="Aktual")
    plt.legend()
    plt.xlabel("Tanggal")
    plt.ylabel("Prediksi")
    plt.show()
    st.plotly_chart(fig)
    df_pred = pd.DataFrame(columns=["Tanggal", "Aktual", "Prediksi"])
    df_pred["Tanggal"] = test_data['Date']
    df_pred["Aktual"] = y_test.values
    df_pred["Prediksi"] = pred.round(1)
    html = df_pred.to_html(index=False)
    st.markdown(html, unsafe_allow_html=True)
```

Figure 10. Prediction Result Visualization Source Code

Figure 11. Prediction Result Chart

Figure 12. Localhost View

Through this visualization, the research results will make it easier for investors to gain insights from the initial data used to the graphs and tables of the predicted results. Visualizations can run on streamlet frameworks that can be opened on their respective devices. Different from research in that [8]–[10] only model and only test on Excel and rapid manner.

5. Conclusions

Based on the results of research and testing of the Linear Regression algorithm to predict BMRI stock prices, it can be concluded that the results of predicting stock prices using the Liner Regression Algorithm with machine learning can facilitate and provide complete information through simple visualization for investors to predict BMRI stock prices. A model trained for 245 testing data was obtained for the MSE value of 960.97, the RMSE value of 30.9995, and the MAPE value of 0.57%. Linear Regression Algorithm in analyzing and predicting, showing the prediction results of Bank Mandiri Tbk (BMRI) stock price data in a very good category.

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