Prediction of Nike's Stock Price Based on the Best Time Series Modeling

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Received: 21 September 2024
Revised: 17 April 2025
Accepted: 4 May 2025

ABSTRACT – **Nike is one of the world's largest shoe, clothing, and sports equipment companies. The more modern the development of the era, the more diverse the fashion. Of course, investors can consider this when deciding whether to invest in Nike's brand shares. Stock prices constantly fluctuate up and down, so investors need to implement strategies to minimize losses in investing to achieve economic growth. This supports the Sustainable Development Goals (SDGs) in point 8 regarding the importance of sustainable economic growth and investment in infrastructure development to improve economic welfare. Investors can minimize losses by predicting or forecasting stock prices. Stock prices can be analyzed using specific methods. The update that will be brought in this study is the Nike brand stock price prediction for the 2020-2024 period using the best model from the time series method comparison conducted using classical nonparametric, which consists of the kernel estimator method and the Fourier series estimator method and modern nonparametric using the Support Vector Regression (SVR) method. Based on the analysis method, the best method is selected through the minimum MAPE value. A comparison of the results of Nike brand stock price predictions using several methods shows that the MAPE value of the Nike brand stock price data analysis is the minimum obtained using the kernel estimator approach, which is 1.564%. Thus, the kernel estimator approach predicts the Nike brand stock price much better. Predictions using the best methods can be recommendations and evaluations for economic actors to prepare better economic planning.**

Keywords– **Fourier Series Estimator, Kernel Estimator, Nike's Stock Price, Support Vector Regression, Time Series**

I. INTRODUCTION

The development of the capital market is one of the important indicators that must be monitored in influencing the financial stability of a country. This is due to the two functions owned by the capital market, namely the economic and financial functions. The capital market acts as a meeting place for investors (financiers) with companies or parties that need funds through securities trading [1]. Investments can be made through ownership of shares in the form of assets. In carrying out investment activities, investors need to make investment decisions. The decision in question is buying, selling, or maintaining stock ownership.

Investors often make two types of stock investments, including long-term and short-term investments. Long-term investment will involve buying and selling a stock over more than one year, while short-term investment will be within less than one year. Both types of investments face similar challenges, namely difficulties in predicting stock prices [2]. Stock prices that fluctuate up and down will be a consideration for investors buying shares. Investors need to implement strategies to minimize losses in investing to achieve economic growth. This is included in the Sustainable Development Goals (SDGs), namely in point 8 regarding the importance of sustainable economic growth and investment in infrastructure development to improve economic welfare.

Nike is one of the largest shoe, clothing, and sports equipment companies in the world. In this increasingly modern era, fashion developments are increasingly diverse. For some people, especially young people, the development of the fashion world has become a lifestyle, ranging from clothes, shoes, pants, and many more. Of course, this can be a consideration for investors in determining investment decisions on Nike brand shares. The strategy that investors can do to minimize losses is to predict or forecast stock prices. Stock prices, which are time series data with high activity, can be analyzed using certain methods.

As time goes by, the development of time series data prediction methods is increasingly rapid, resulting in many methods that can be used to predict data according to needs [3]. Stock price prediction can utilize statistical and computational time series analysis techniques [4]. The statistical-based time series data analysis techniques developed to predict stock prices are Autoregressive Integrated Moving Average (ARIMA), Autoregressive Conditional Heteroscedasticity (ARCH), and Generalized Autoregressive Conditional Heteroscedasticity (GARCH) [5]. The development of time series data analysis techniques has been very rapid and significant since the emergence of data mining and machine learning techniques [6]. Some computational-based time series data analysis techniques that have been developed are self-organizing map neural networks, genetic programming [7], conditional predictions [8], genetic algorithms, artificial neural networks, backpropagation neural networks [9], and Support Vector Regression (SVR) [10]. Thus, comparing several methods to get the best prediction results with high accuracy or minor errors is necessary.

Previously, research was conducted on comparing several time series methods, namely the ARIMA and SVR methods in predicting the share price of PT Astra International Tbk [11]. The study produced a better prediction with a Root Mean Square Error (RMSE) value of 0.053294 compared to the ARIMA method [11]. Other research in the field of economics compares predictions using the Fourier series estimator method and SVR [12]. The data used in the study are non-oil and gas export prices in Indonesia [12]. The MAPE value obtained from the prediction results using the Fourier series

estimator and SVR were 15.26% and 9.29% respectively, so it can be concluded that the SVR time series method can predict better [12]. Then, previous research compared several time series methods, namely the ARIMA and GARCH methods, to predict the stock prices of telecommunications companies in Indonesia [13]. The study resulted in the ARIMA method providing better results when compared to the GARCH method to predict the stock price of PT Telekomunikasi Indonesia Tbk with a Mean Average Percentage Error (MAPE) value of 1.93% [13]. The GARCH method produced better price predictions than the ARIMA method for the companies PT Indosat Tbk and PT XL Axiata Tbk with MAPE values of 14.31% and 7.4% respectively [13].

The update that will be brought in this study is the prediction of Nike brand stock prices for 2020-2024 using the best model from a comparison of several time series methods with a nonparametric model approach. The nonparametric model has advantages in applying trial-error learning methods and increasing accuracy values based on iterations [14]. Time series methods will be compared using classical nonparametric and modern nonparametric approaches. The method used in the classical nonparametric approach will use the kernel estimator method and the Fourier series estimator, while the modern nonparametric approach will use the SVR method. Based on the analysis method, the best method is selected through the minimum MAPE value. Predictions with the best method are expected to be recommendations and evaluations for economic actors to prepare better economic planning.

II. LITERATURE REVIEW

A. Kernel Estimator

The kernel estimator is one of the approaches in nonparametric regression curve estimation commonly used because of the flexibility of its form and ease of mathematical calculation [15]. The kernel estimator is an evolution of the histogram estimator method first introduced by Rosenblatt and Parzen, known as the Rosenblatt-Parzen kernel density estimator [16]. The general form of the kernel estimator k with bandwidth h is as follows [17]:

$$\hat{m}_h(t) = \frac{1}{n}\sum_{i=1}^{n} K_h(t - T_i) = \frac{1}{nh}\sum_{i=1}^{n} K\left(\frac{t - T_i}{h}\right) \tag{1}$$

In this research, the kernel function will be used Gaussian for stock price prediction brand Nike with Nadaraya-Watson, a popular kernel regression estimator. Here is the estimator equation Nadaraya-Watson for kernel regression.

$$\hat{m}_h(t) = \frac{\sum_{i=1}^{n} K_h(t - T_i) y_i}{\sum_{j=1}^{n} K_h(t - T_i)} \tag{2}$$

In this equation, two kernel functions are approximated by the Gaussian kernel function as follows.

$$K\left(\frac{t - T_i}{h}\right) = \frac{1}{nh\sqrt{2\pi}} \exp\left(-\frac{1}{2}\left(\frac{t - T_i}{h}\right)^2\right); -\infty < t < \infty \tag{3}$$

B. Fourier Series Estimator

The Fourier series estimator is based on two parameters, namely the oscillation parameter as a representation of bandwidth and the Fourier parameter. One of the advantages of the nonparametric regression approach with the Fourier series estimator is that it can handle data with periodic patterns, which, in this case, are represented by trigonometric functions. Therefore, the Fourier series is defined as a trigonometric polynomial function with a high level of flexibility because it is a curve showing the sine and cosine functions. The Fourier series comprises the cosine and sine functions it is a curve that shows the sine and cosine functions. The complete Fourier series consists of the cosine and sine functions [17]. Given paired data (x_i, y_i) the nonparametric regression equation with the Fourier series estimator is shown as follows.

$$y_i = \frac{a_0}{2} + \gamma t_i + \sum_{l=1}^{L} (a_l \cos l t_i + \beta_l \sin l t_i) + \varepsilon_i \quad ; \varepsilon_i \sim N(0, \sigma^2) \tag{4}$$

C. Support Vector Regression (SVR)

Support Vector Regression (SVR) is an implementation of Support Vector Machine (SVM) used in the context of regression. In regression, SVR outputs in the form of natural or continuous numbers. The main advantage of the SVR method is its ability to overcome overfitting and provide good performance. The SVR model often reduces the Mean Square Error (MSE). The SVR algorithm adapts machine learning theory, originally used to handle classification problems [18].

The SVR algorithm aims to find the best-dividing line, the optimal hyperplane. It does this by measuring the margin to the hyperplane, which refers to the distance from the hyperplane to the nearest data. The data closest to the margin is called the support vector [18].

Suppose you have a training dataset $\{(x_1, y_1), (x_2, y_2), \dots, (x_i, y_i)\}, i = 1,2, \dots, d\ x_i \in \mathbb{R}^d$, where d is the dimension and y_i is the target value [12]. The following is the SVR model equation.

$$f(x) = \boldsymbol{w}^T \varphi(x) + b \tag{5}$$

with:

$\boldsymbol{w}$: n dimension weighting vector

$\varphi(x)$: Function in space n dimensions that map x

b : Bias

The next step is to minimize the value of the criterion w optimally to generalize the regression function $f(x)$ well. Based on this, the solution to the optimization problem is as follows.

$$min_w \frac{1}{2}||\boldsymbol{w}||^2 \quad (6)$$

with $\begin{cases} y_i - \boldsymbol{w}^T\boldsymbol{x}_i - b \leq \varepsilon \\ \boldsymbol{w}^T\boldsymbol{x}_i + b \leq \varepsilon \end{cases}$. Next, optimization problem solving is carried out, obtained in the equation below.

$$w = \sum_{i=1}^{n}(a_i^* - a_i)\varphi(\boldsymbol{x}_i) \quad (7)$$

With the function φ proximated by the kernel function, the SVR function can be shown in equation (8) below.

$$f(x)\sum_{i=1}^{n}(a_i^* - a_i)K(\boldsymbol{x}_i, x) + b \quad (8)$$

D. Mean Absolute Percentage Error (MAPE)

Mean Absolute Percentage Error (MAPE) is obtained as a function of the average absolute percentage error for predictions and final results. This error measure expresses the error as a percentage and can be used in evaluating models for different data sets [19]. This estimator is calculated using equation (9) where Y_t is the actual value and F_t is the estimated value of period t. The equation of MAPE can be shown as follows.

$$MAPE = \frac{1}{n}\sum_{t=1}^{n}\left|\frac{(Y_t - F_t}{Y_t}\right| * 100 \quad (9)$$

III. METHODOLOGY

A. Data Sources and Research Variables

This study used a quantitative approach method focusing on time series data analysis. The data used is Nike brand stock price data obtained from the investing.com website. In this study, the data used is weekly data from May 2020 to August 2024. In this study, the research data is divided into two parts, namely training data and testing data, with a division of 90% training data and 10% testing data. Training data is data used to create a model from the fourth week of May 2020 to the second week of March 2024. The data used to measure the model's accuracy is testing data, which is data from the third week of March 2024 to the second week of August 2024. The variable in this study is the Nike brand stock price.

B. Data Analysis Stages

In full, the following are details of the procedures or stages of several analysis methods used in this research.

1. Determining the characteristics and descriptive statistics of Nike brand stock prices.
2. Divide the research data into two, namely training data and testing data.
3. Performing modeling and prediction of time series data with a classical nonparametric approach using the Kernel estimator analysis method with the following steps.
   a. Determine the best Kernel function between the Gaussian, Cosine, Triangle, Quadratic, and Epanechnikov Kernel functions by selecting the minimum GCV value.
   b. Perform training data estimation by inputting the optimal bandwidth obtained from the best kernel model.
   c. Perform testing data estimation by inputting the optimal bandwidth obtained from the best kernel model.
   d. Making predictions on Nike brand stock price testing data using the best kernel estimator model.
4. Performing time series data modeling and prediction with a classical nonparametric approach using the Fourier series analysis method with the following steps.
   a. Determine the GCV and MSE formulas based on the results of the Fourier series estimator.
   b. Determine the optimal smoothing parameters (λ) based on the minimum GCV value.
   c. Determining the estimator model on training data using the Fourier series estimator based on λ optimal values.
   d. Determine the best model criteria by calculating the value of RMSE, MAPE, dan R^2.
   e. Making predictions on Nike brand stock price testing data based on the best Fourier series estimator model.
5. Performing time series data modeling and prediction with a modern nonparametric approach using the SVR analysis method with the following steps.
   a. Perform the Terasvirta test to detect linearity relationships.
   b. Create a time series plot of Nike brand stock prices and generate a PACF plot to determine significant lags.
   c. Perform initial modeling to determine the best kernel function that has the smallest RMSE and MAPE values.
   d. Tuning parameters using the grid search method in two stages, namely loose grid and finner grid.
   e. Performing SVR modeling on training data using optimal parameters with the grid search method.
   f. Making predictions on Nike brand stock price testing data based on the best SVR model.
6. Calculating the MAPE value of the predicted test data based on the best model obtained from the three analysis methods.

7. Comparing the prediction results of the kernel estimator model, Fourier series estimator, and SVR based on the smallest MAPE value.

Based on the analysis stages that have been explained above, it can be visualized through the following flowchart.

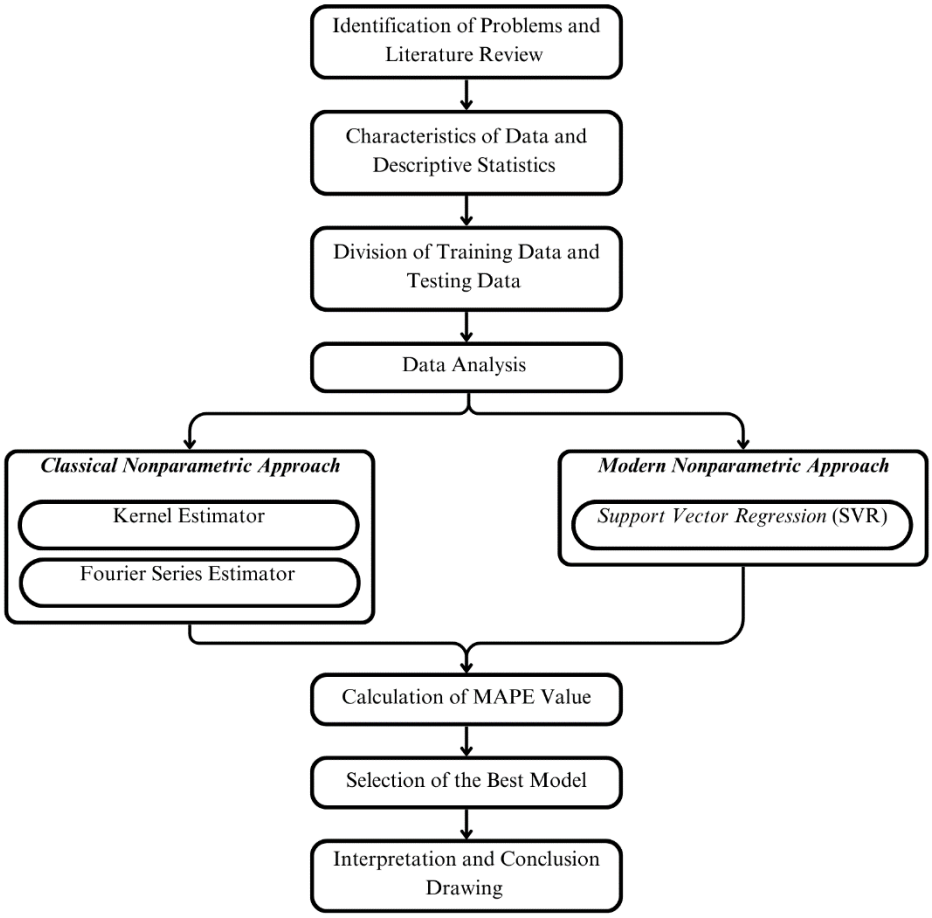


Figure 1 Research Steps Flowchart

IV. RESULTS AND DISCUSSIONS

A. Descriptive Statistics

Descriptive statistics are used to provide a general picture of the data. In this study, descriptive analysis was done by visualizing data using time series plots to show data patterns and descriptive statistical measures such as averages, minimum, and maximum values. Before conducting descriptive statistical analysis, the data obtained will be divided into training and testing data. The proportion of the training and testing data division is subjective to the researcher [20]. In this study, 90% of the training data will be used, and 10% of the testing data. The research data are visualized in Figure 2.

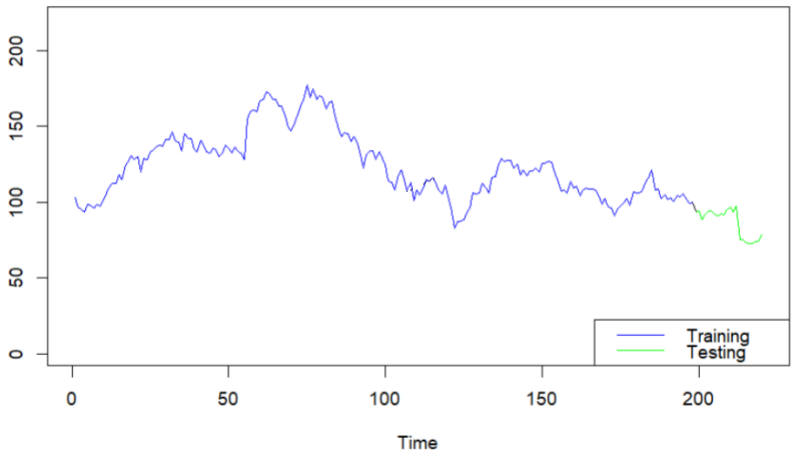


Figure 2 Time Series Plot

Based on Figure 2, the training and testing data are distinguished based on the color of the plot line. It is known that the Nike brand stock price fluctuates up and down every month in the period 2020-2024. The descriptive statistical values of Nike brand stock prices are presented in more detail in Table 1.

Table 1 Descriptive Statistics of Nike Brand Stock Price Data

Data	Amount of Data	Mean	Minimum	Maximum
Training Data	198	123,85	83,12	177,51
Testing Data	22	86,49	72,56	97,18
Overall Data	220	120,11	72,56	177,51

B. Time Series Analysis with Classical Nonparametric Approach

Next, Nike brand stock price data modeling will be carried out using the classical nonparametric approach. In this study, the methods that will be used are the kernel estimator and the Fourier series estimator. Based on the results of the analysis that has been done, by comparing five types of kernel functions, including Gaussian, Cosine, Triangle, Quadratic, and Epanechnikov, the minimum GCV (Generalized Cross Validation) value is found in the Gaussian kernel function with a bandwidth value of 0.975. The following are the results of forecasting the Nike brand stock price using the kernel estimator method with the Gaussian function presented in Figure 3.

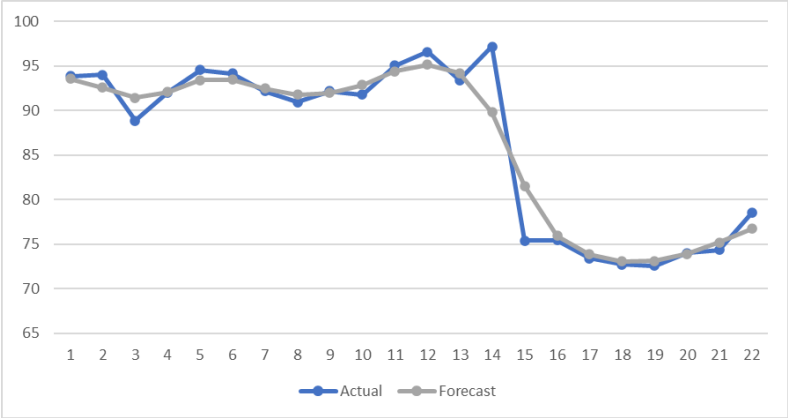


Figure 3 Forecasting Results of Gaussian Kernel Estimator Approach

Based on the plot results in Figure 3, the forecasting results of the kernel estimator model with the visualized Gaussian function are not much different from the testing data. The MAPE value obtained is 1.564%, which means that the model's ability to predict is classified as very good or very accurate.

Next, the Fourier series estimator approach will model Nike brand stock price data. Based on the results of the analysis that has been carried out, by comparing three types of Fourier series functions, including sin, cos, and cosine, with the upper limit of the k-value used being 1 to 100. A comparison of estimation results on training data for each function can be seen in the following table. A comparison of estimation results on training data for each function can be seen in Table 2.

Table 2 Comparison of Estimation Results on Training Data

Mark	*Sin*	*Cos*	*Cosine*
Lamda (λ)	5	2	98
GCV	180,3645	390,2266	1,4884
MSE	1,233915	2.077155	0,008735
R^2	62%	29%	99%
MAPE	0,005032	0,008470	3,562287e-05

The best Fourier series model obtained on the training data is a model with a cosine function because it has a minimum MAPE, MSE, and GCV value, with a R^2 reasonably large one. The cosine function has an optimal k value of 98 with a GCV value of 1.4884, R^2 of 99%, MSE of 0.008735, and MAPE of 3.562287e-05. The following is a plot of the training data estimation results presented in Figure 4.

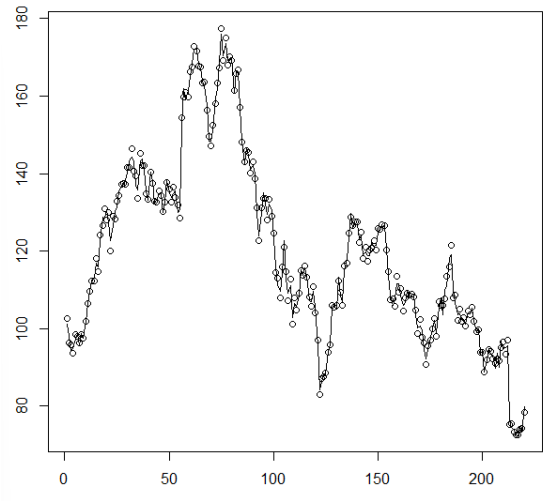


Figure 4 Plot of Training Data Estimation Results

The results of the training data estimation on the Fourier cosine plot model function show no significant difference between the original data pattern and the estimated data pattern. Thus, it can be continued to forecast the Fourier cosine series function on the testing data.

C. Time Series Analysis with Modern Nonparametric Approach

The next stage will be an analysis using SVR, one of the modern nonparametric approach methods, to compare the forecasting results with the classical nonparametric approach. The Support Vector Regression (SVR) approach is perfect for dealing with data problems that indicate symptoms of heteroscedasticity. In addition, the Support Vector Regression (SVR) method can handle data with a nonlinear pattern and overcome overfitting [21]. The white and terasvirta tests can be used to ensure nonlinear patterns and heteroscedasticity symptoms in Nike brand stock price data.

Tabel 3 ResultsLinearity and Heteroscedasticity Test

Test	*P-value*
Terasvirta Test (Linierity)	0,0001041
White Test (Heteroscedasticity)	0,000232

Based on Table 3, there is evidence of nonlinear assumptions and heteroscedasticity symptoms in the data. Thus, the research data has met the assumptions to be analyzed using the SVR method. Before starting the modeling, the next step is to transform the data into time lag form by removing significant lags through the help of Partial Autocorrelation Function (PACF) plots. The PACF plot for the NIKE brand share price is shown in Figure 5

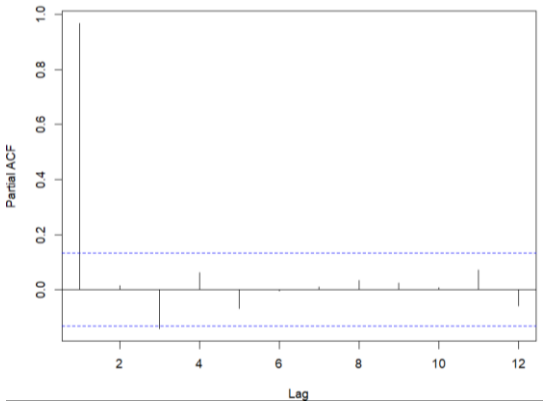


Figure 5 PACF Plot of NIKE Brand Stock Price Data

Figure 5 shows that the significant lag is lag 1, which will be the time lag for data input SVR. In the initial SVR modeling, RMSE and value MAPE will be compared using three kernel functions, including kernel Radial Basis Function (RBF), sigmoid, and polynomial. Table 4 shows the initial modeling results of the SVR method.

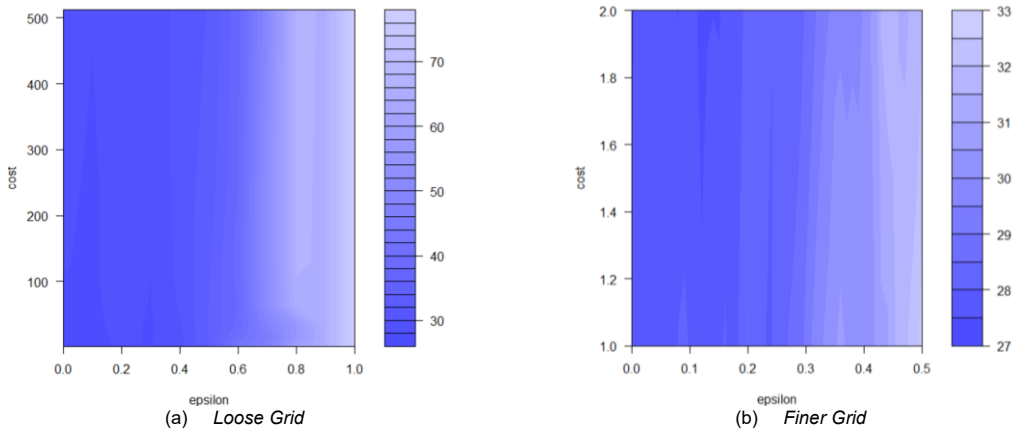
Table 4 Kernel Function Comparison

Kernel	RMSE	MAPE
RBF	5,096	3,207%
Sigmoid	225,456	135,452%
Polynomial	12,45	8,150%

Based on Table 4, the best model is obtained using the RBF kernel function with RMSE and MAPE values of 5.10 and 3.207%, respectively. After building the initial model with the best model, the next step is to carry out the parameter tuning process to improve SVR performance using grid search. In the grid search method, two tuning processes will be carried out: loose grid and finer grid.

Table 5 Comparison of Grid Search Methods

Grid Search Method	Optimal Parameter Combination	
	Cost (*C*)	Epsilon (ε)
Loose Grid	8	0
Finer Grid	2	0,12



(a) *Loose Grid* (b) *Finer Grid*

Figure 6 Plot Tuning Results of Grid Search Method

Based on Table 5, the optimal parameters of epsilon (ε) of 0.12 and cost (C) of 2 were obtained through the finer grid method. After conducting the tuning process with the grid search method and obtaining the optimal combination of parameters, the Nike brand stock price modeling, which is the training and testing data, can be redone using SVR. The following is a comparison of RMSE and MAPE values from the forecasting results through Table 6.

Table 6 Comparison of Training Data and Testing Data

Data Types	RMSE	MAPE
Training Data	5,097	3,2%
Testing Data	4,306	2,805%

Based on Table 6, the prediction results of applying the SVR model on the training data and testing data obtained MAPE values of 3.2% and 2.805%, respectively. The MAPE value means the model's prediction ability is classified as very good or accurate. The following are the results of forecasting the Nike brand stock price using the SVR method on the testing data visualized in Figure 7.

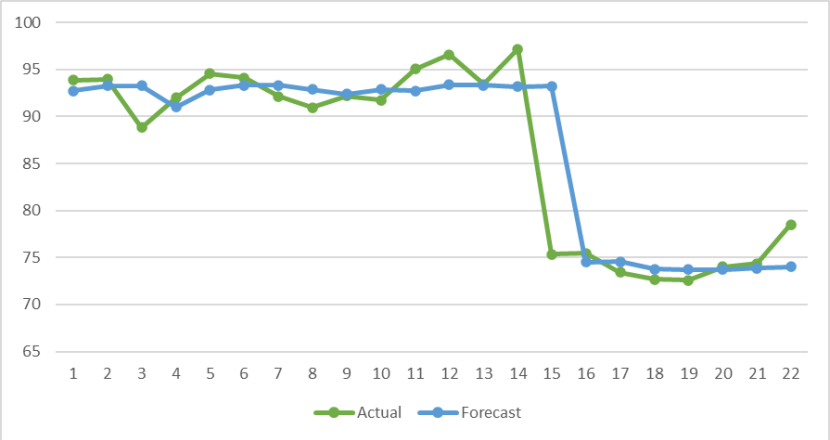


Figure 7 SVR Forecasting Results

C. Best Model Selection

From the results obtained from the four methods, namely the kernel estimator, the Fourier series estimator, and the SVR, a comparison of the results of the Nike brand stock price prediction on the testing data can be made as follows, along with the model evaluation presented in Table 7 and Table 8.

Table 7 Comparison of Prediction Results of Testing Data

Period	Testing Data	Kernel	SVR	Fourier series
17/03/2024	93,86	93,536	92,719	77,678
24/03/2024	93,98	92,534	93,259	77,762
31/03/2024	88,84	91,41	93,274	77,561
07/04/2024	92	92,059	90,996	78,081
14/04/2024	94,53	93,401	92,822	78,186
21/04/2024	94,12	93,452	93,325	78,289
28/04/2024	92,15	92,452	93,290	78,374
05/05/2024	90,94	91,76	92,873	78,475
12/05/2024	92,18	91,941	92,375	77,781
19/05/2024	91,75	92,859	92,883	77,881
26/05/2024	95,05	94,379	92,731	77,981
02/06/2024	96,55	95,121	93,348	78,081
09/06/2024	93,39	94,182	93,295	78,181
16/06/2024	97,18	89,777	93,186	78,280
23/06/2024	75,37	81,529	93,225	78,379
30/06/2024	75,43	75,935	74,521	78,478
07/07/2024	73,42	73,876	74,559	78,577
14/07/2024	72,7	73,06	73,746	78,675
21/07/2024	72,56	73,108	73,700	78,773
28/07/2024	74,01	73,895	73,706	78,871
04/08/2024	74,34	75,216	73,881	78,969
11/08/2024	78,49	76,717	73,995	79,066

Table 8 Model Evaluation

Method	MAPE
Gaussian Kernel Estimator	1,564%
Support Vector Regression	2,805%
Fourier Series Estimator	12,455%

The selection of the best model can be done by looking at the Mean Average Percentage Error (MAPE)from each method. Based on Table 8, it can be seen that the MAPE value of the Nike brand stock price data analysis using the Gaussian function kernel estimator method was obtained at 1.564%, the SVR method obtained was 2.805%, and the Fourier series estimator method obtained 12.455%. Thus, it can be concluded that the kernel estimator and SVR methods are excellent and accurate for predicting Nike brand stock price data because the MAPE value is below 10% [22]. However, since this study aims to compare the three methods, the Gaussian kernel estimator approach is much better at predicting the Nike brand stock price with the minimum MAPE value, a classical nonparametric method. The comparison of all methods can be visualized through the graph in Figure 8.

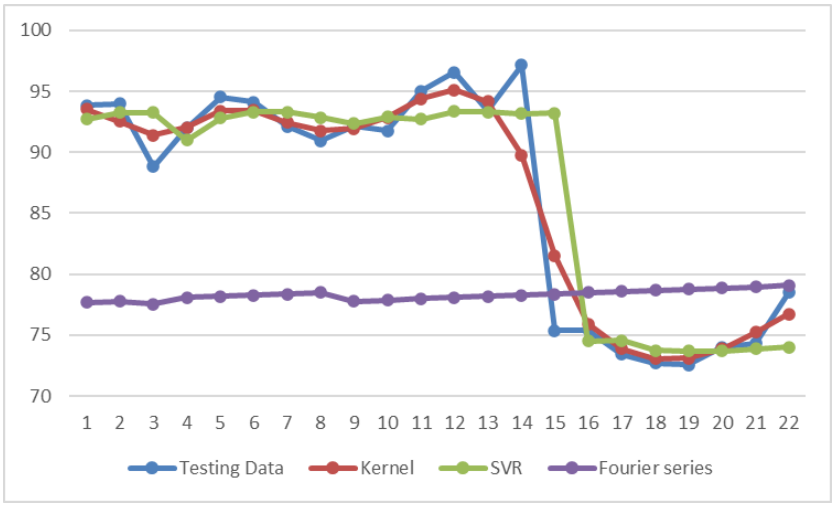


Figure 8 Comparison of Forecasting Data Testing Results

V. CONCLUSIONS AND SUGGESTIONS

Based on the study's results using time series data by comparing the Gaussian kernel estimator method, SVR, and Fourier series estimator for predicting Nike brand stock prices, the best model was obtained, namely the Gaussian kernel estimator method. The Gaussian kernel estimator is the best model because it has the lowest MAPE, compared to the other three methods, which is 1.564%. The Gaussian kernel estimator is a method with a classical nonparametric

approach. Thus, the Gaussian kernel estimator approach predicts Nike brand stock prices significantly better. Understanding and using the correct method in predicting Nike brand stock prices can give investors a better view of managing their investments. Predictions with the best method are also expected to be recommendations and evaluations for economic actors to prepare better economic planning. However, it is essential to remember that many variables can influence financial markets, and stock price predictions cannot eliminate risk. By understanding the limitations and updating the analysis regularly, economic actors can make more intelligent and more adaptive decisions in managing their investments related to Nike brand stocks.

ACKNOWLEDGEMENT

The authors express their deepest gratitude to Mr. M. Fariz Fadillah Mardianto and Mrs. Elly Pusporani for their invaluable guidance, insightful feedback, and continuous support throughout this research. Their expertise has been instrumental in shaping the direction and quality of this study. Furthermore, we extend our appreciation to all individuals and institutions who contributed to the successful completion of this work. Special thanks to our families and colleagues for their unwavering support and encouragement.

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