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Comparison of Nonparametric Regression Nadara - Watson Estimator Kernel Function And *Local Polynomial Regression* In Predicting USD Against IDR

Isni Rahma [a,1,*] , Junaidi [a,2] , Iman Setiawan [a,3]

[a] Study Program of Statistics, Department of Mathematics, Faculty of Mathematics and Natural Sciences Tadulako University, Jl. Soekarna Hatta, Palu, 94118, Indonesia
[1]isnnirahma19@gmail.com*;[2]
*corresponding author

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ABSTRACT

Introduction: Macroeconomic problems such as inflation and exchange rates are often highlighted as benchmarks for achieving economic progress. The stability of both must be monitored by the government in order to control the inflation rate and exchange rate. This instability is a phenomenon of fluctuation, namely the phenomenon of the rise and fall of the exchange rate of a currency based on demand and supply. Given the large impact of exchange rate fluctuations on the economy, the prediction of the wage exchange rate against the US dollar is considered necessary because it is useful to anticipate and minimize bad possibilities that arise. **Method**: Methods that can be used to analyze fluctuating currency exchange rate data are nonparametric regression, Nadaraya-Watson estimator, Gaussian kernel function, and Local Polynomial Regression. **Results and Discussion**: The results of a nonparametric regression comparison between the Nadaraya-Watson estimator, Gaussian kernel function, and local polynomial regression were obtained by MAPE of 2.508% and 0.179%, respectively. This shows that the best model uses the local polynomial regression method and predicted USD exchange rate data against IDR using the best model, namely Local polynomial Regression where the MAPE value is less than 10%, which means the prediction rate is very good. **Conclusion:** The nonparametric regression method of the Nadaraya-Watrson estimator, Gaussian kernel function, and local polynomial regression shows that the best model uses the local polynomial regression method.

1. Introduction

The economic welfare of a country is an important thing that encourages economic activity and creates national economic growth. In realizing this, macroeconomic issues such as inflation and exchange rates are often highlighted as benchmarks for achieving economic progress, the stability of both must be monitored by the government in order to control inflation and exchange rates [1].

The relationship between the exchange rate and inflation can be visualized if Indonesia experiences inflation

Higher than the US, it will cause the price of exported goods and services to be relatively more expensive and unable to compete with goods and services from abroad. If the Indonesian exchange rate (IDR) is unstable against the United States Dollar (USD), it will often disrupt trade activities, because trade activities are valued in USD, which can cause economic losses. Therefore, the fluctuation phenomenon reflects that the ability to influence the increase and loss in trade activities that also affect the economic conditions in the country so that it requires serious handling [2].

Methods that can be used to analyze currency exchange rate data Nonparametric regression in statistics is used to estimate the conditional expected value of random variables, which aims to find a nonlinear relationship between a pair of random variables Y and X to obtain and use appropriate weights. In nonparametric regression, there are several approach techniques, one of which is kernel regression which is fast and easy to calculate [3].

Some previous studies have been conducted by Nuzulul, namely using simple linear regression methods and nonparametric kernel Nadaraya-Watson estimators [4], in Susianto's research using kernel and polynomial function estimators by comparing polynomial regression models and Nadaraya-Watson kernel regression models [5], in John's research using Nadaraya-Watson kernel estimators and Local Polynomial Regression [6].

2. Methods

2.1 Data Sources and Research Variables

The population in this study is the economic conditions in Indonesia, while the sample used in this study is monthly data on the USD exchange rate against IDR in Indonesia from 2020 to 2022.

2.2 Analysis Method

Data analysis in this study used Nadaraya-Watson nonparametric regression and Local Polynomial Regression with the help of the R application. The following are the steps that will be taken:

1. Data retrieval
2. Data exploration
3. Determination of Optimum Bandwidth and Degree
4. Nadaraya-Watson parameter estimation using Gaussian kernel function and Local Polynomial Regression
5. Determining MAPE (Mean Absolute Percentage Error) to find out how much error an estimator has.
6. Selection of the best model for prediction based on MAPE value
7. Prediction

3. Results and Discussion

3.1 Nadaraya-Watson Optimum *Bandwidth* Determination

The degree of *smoothness* is determined by the kernel function K and window (*Bandwidth* or h), the effect of window width h is more significant than the effect of the kernel function. K. *Bandwidth* serves to balance the bias and variance of the function. If the *bandwidth* value is small, it will produce a curve that is less smooth but has a small bias. If the *bandwidth* value is too large, it will produce a curve that is too smooth so that it has a low variance and a large bias [7].

Table 1. Optimum *Bandwidth* Determination Estimation Results

MAPE	*Bandwidth Value* (h)
3,635	0,5
3,545	1,0
3,492	1,5
3,463	2,0
3,396	2,5
3,292	3,0
3,176	3,5
3,062	4,0
2,959	4,5

2,877	5,0
2,812	5,5
2,764	6,0
2,729	6,5
2,701	7,0
2,681	7,5
2,664	8,0
2,650	8,5
2.639	9,0
2,631	9,5
2,623	10,0
2,617	10,5
2,612	11,0
2,608	11,5
2.604	12,0

The minimum *bandwidth* value is at the MAPE value of 2.603 so it can be seen that the best *bandwidth* value is 12.0.

3.2 Determination of Optimum Degree of Local Polynomial Regression

In addition to selecting the optimum *bandwidth*, it is also important to select the appropriate polynomial order. Higher order polynomials allow for proper fitting meaning the bias is small but the order increases, as does the variance and only increases at any time when p changes from odd to even. An adaptive method is suggested to be used to select the correct order of the polynomials based on local factors, allowing p to vary for different points in the data support. This means that if the *bandwidth chosen is* too large a high order will be chosen conversely if the *bandwidth* chosen is too small then a low order will be suitable to make the approximation numerically stable and reduce the variance [8].

Table 2. Simulation Results of Optimum *Degree* Determination

Degree	**MAPE**
Degree 0	1,307
	1,620
	1,743
	1,774
	1,830
	1,882
	1,901
	1,942
	1,953
Degree 1	0,179
	1,524
	1,649
	1,720
	1,767
	1,801
	1,849
	1,929
	1,928
Degree 2	0,236
	1,263
	1,561
	1,635
	1,709
	1,749
	1,744
	1,802
	1,873

The most optimal *degree* value for *degree* 0 with a MAPE value of 1.307, *degree* 1 with a MAPE value of 0.179, and *degree* 2 with a MAPE value of 0.236 so the optimum degree used is *degree* 1.

3.3 Nadaraya-Watson Estimator

Estimation value $m(x)$. The Nadaraya-Watson estimator equation contains K which is the kernel function chosen by the author. In this study, the kernel function used is *Gaussian* [7,8].

The nonparametric regression model by substituting the Gaussian kernel function of the Nadaraya-Watson estimator in predicting the exchange rate will produce the following equation:

$$Y_i = m(x_i) + \varepsilon_i$$

$$= \frac{\sum_{i=1}^{n} K\left(\frac{X_i - x}{h}\right) Y_i}{\sum_{i=1}^{n} K\left(\frac{X_i - x}{h}\right)} + \varepsilon_i$$

$$= \frac{\sum_{i=1}^{n} \frac{1}{\sqrt{2\pi}} exp\left(-\frac{1}{2}\left(\frac{X_i - x}{12,0}\right)^2\right) Y_i}{\sum_{i=1}^{n} \frac{1}{\sqrt{2\pi}} exp\left(-\frac{1}{2}\left(\frac{X_i - x}{12,0}\right)^2\right)} + \varepsilon_i$$

$$= Y_i + \varepsilon_i$$

3.4 Local Polynomial Regression

In this discussion about *Local Polynomial Regression*, there are two parameters that will be simulated, namely the *degree of* the *polynomial* and the *bandwidth (h)* of the *polynomial.*

Table 3. *Degree* and *Bandwidth* Simulation Results

Degree	***Bandwidth (h)***	**MAPE**
	0,1	1,307
	0,2	1,621
	0,3	1,743
	0,4	1,774
Degree 0	0,5	1,830
	0,6	1,882
	0,7	1,901
	0,8	1,942
	0,9	1,953
	0,1	0,179
	0,2	1,524
	0,3	1,649
	0,4	1,720
Degree 1	0,5	1,767
	0,6	1,801
	0,7	1,849
	0,8	1,929
	0,9	1,928
	0,1	0,236
	0,2	1,263
	0,3	1,561
	0,4	1,635
Degree 2	0,5	1,709
	0,6	1,749
	0,7	1,744
	0,8	1,801
	0,9	1,873

3.5 Parameter Estimation

The optimum *degree* and *bandwidth* for each *degree* and *bandwidth* are *degree* 0 and *bandwidth* 0.1 with a MAPE value of 1.307, *degree* 1 and *bandwidth* 0.1 with a MAPE value of 0.179, and *degree* 2 and *bandwidth* 0.1 with a MAPE value of 0.236. Based on the comparison of each *degree* and *bandwidth, the* optimum *degree* and *bandwidth are* obtained at *degree* 1 and *bandwidth* 0.1 with a

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MAPE value of 0.179.

Table 4. Prediction Results of *Local Polynomial Regression*

No.	Rates	No.	Rates
1	13801	19	14584
2	13845	20	14389
3	15271	21	14328
4	15947	22	14269
5	14981	23	14335
6	14267	24	14401
7	14655	25	14407
8	14798	26	14423
9	14776	27	14420
10	14823	28	14440
11	14389	29	14681
12	14320	30	14762
13	14293	31	15059
14	14278	32	14925
15	14489	33	15047
16	14776	34	15495
17	14319	35	15737
18	14410	36	15693

3.6 MAPE Calculation

To find out the model, it is necessary to evaluate the accuracy of the model to predict the exchange rate in the future. Evaluation of the accuracy of the model can be seen by looking at how large the resulting MAPE value is [9,10]. The following are the results of the MAPE calculation of the nonparametric regression method Nadaraya-Watson estimator Gaussian kernel function and *Local Polynomial Regression* in predicting the USD exchange rate against IDR

$$MAPE = \frac{\left(\sum_{i=1}^{n} \left|\frac{A_t - F_t}{A_t}\right|\right)}{n} \times 100\%$$

$$MAPE = 2{,}604\ \%$$

Table 5. MAPE Value Results

MAPE	
Nadaraya-Watson estimator Gaussian kernel function	*Local Polynomial Regression*
2,604 %	0,179 %

The MAPE value of the Nadaraya-Watson estimator Gaussian kernel function is 2.604% and the MAPE value of *local polynomial regression is* 0.179% so *local polynomial regression is* better at predicting USD against IDR exchange rate data compared to the Nadaraya-Watson estimator Gaussian kernel function.

3.7 Prediction

Prediction results for *local polynomial regression* using the MAPE value.

Table 6. Prediction results using the MAPE value

No.	Rates	No.	Rates
1	13801	19	14584

2	13845	20	14389
3	15271	21	14328
4	15947	22	14269
5	14981	23	14335
6	14267	24	14401
7	14655	25	14407
8	14798	26	14423
9	14776,5	27	14420
10	14823	28	14440
11	14389	29	14681
12	14319,5	30	14762
13	14292,62	31	15059
14	14277,62	32	14925
15	14489	33	15047
16	14776	34	15495
17	14319	35	15737
18	14410	36	15693

From the presentation of the predicted values, the following plot is obtained:

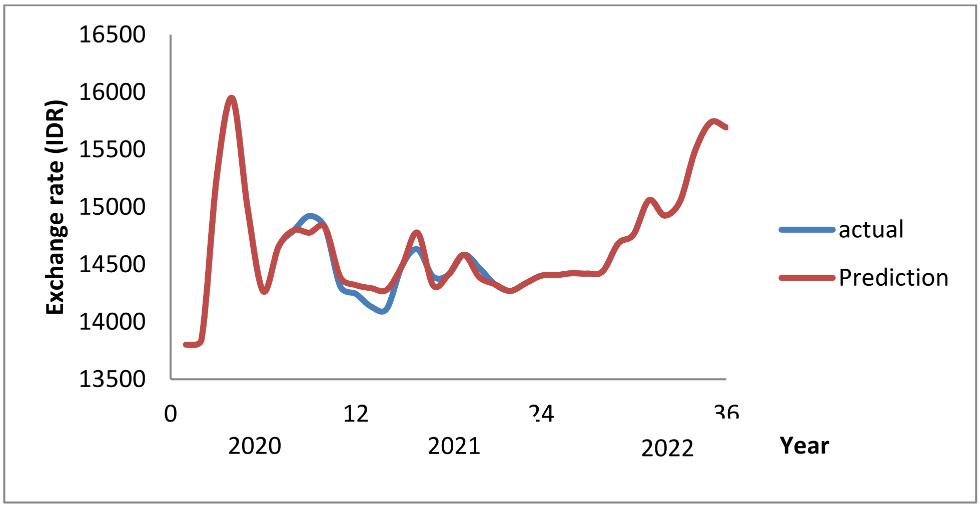

Fig. 1 Scatter Plot of Prediction Results

4. Conclusions

Based on the results of the previous analysis and discussion, it is concluded that the nonparametric regression method Nadaraya-Watrson estimator Gaussian kernel function and *local polynomial regression* shows that the best model uses the *local polynomial regression* method. The prediction results of USD against IDR exchange rate data using *local polynomial regression* obtained a MAPE value of 0.179% which means that the method has a very good prediction rate.

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