Application of Wavelet Fuzzy Model to Forecast the Exchange Rate IDR of USD

Tri Wijayanti Septiarini, Agus Maman Abadi, and Muhammad Rifki Taufik

***Abstract*—The exchange rate of IDR of USD can be the indicator to analyze Indonesian economy. The exchange rate which is an important factor has big effect in Indonesian economy overall. The government gives attention to the movement of exchange rate. So, it needs a mathematics model to forecast the exchange rate of IDR of USD. The model that used is fuzzy wavelet model. Fuzzy wavelet model is the combination of fuzzy Mamdani model and Discrete Wavelet Transforms (DWT). DWT is used to transform a function with the time domain into the frequency domain. This model is very effective to identify the case, have high accurate result, and have simple structure. In this paper, data of exchange rate that are used are weekly data taken from January 1, 2012 until November 9, 2014. The result of forecasting gives a level of accuracy of MAPE of 3.45% for training data and 1.74% for testing the data.**

***Index Terms*—Discrete wavelet transforms, forecasting, fuzzy Mamdani, the exchange rate.**

I. Introduction

The value of exchange rate is determined by the currency exchange rate against other currencies. The exchange rate has wide implications in the domestic and international economic, considering almost all countries in the world do the international transactions. Similarly, the prices in the economy are determined by agreement between the seller and buyer, the exchange rate is also formed by an agreement between the buyer and seller of foreign exchange for international transactions. The activity of foreign exchange is often implemented by everyone in the world, when traveling abroad so we exchange currency in the currency of the country that our destination country. Another example result of export-import activities, the needs of the market and banking institutions, must do currency exchange. Therefore everyone require foreign currency in international transactions.

Indonesia as a country that many imported raw materials industry suffered the impact of exchange rate fluctuation, which can be seen from the increase of cost production, causing the price of goods in Indonesia has increased. So we need a good method to determine the exchange rate fluctuations. USD is chosen in this prediction of the exchange rate because USD as a hard currency, especially for developing countries such as Indonesia, so if there is a change in the US dollar value so rupiah is also change. In other wise, the exchange rate of IDR of USD is one of the important indicators to analyze the Indonesian economy. The exchange rate is important because it has a broad impact on the national economy as a whole. To keep stability of the exchange rate, Indonesian Bank sterilizes in the foreign exchange market at certain times, especially in the event of excessive exchange rate volatility.

According Sudjana [1], the prediction is an approximate (measurement) process about the amount of something in the future based on past data that be analyzed scientifically, especially using statistical methods. The purpose of the currency prediction is to determine the possibility of currency exchange rates in the future. After the data predicted is obtained, everyone who has interest in this case, can take action to reduce significant losses. For example, the multinational company can be determined short-term financing decisions, short-term investment decisions, capital budgeting decisions, long-term financing decisions and judgments that all decisions profit is influenced by changes in currency exchange rates.

Research for prediction has been carried out, that is Leung [2] who predicts the movement of the GBP, CAD and JPY with the method of General Regression Neural Network (GRNN), Mittnik [3] predicted the exchange rate countries in East Asia against the USD with GARCH method. Kamruzzaman [4] talked about the exchange rate prediction of six different currencies against the Australian dollar to the method of Support Vector Machine (SVM), Yu [5] predicted the exchange rate with a model integrating Generalized Linear Auto-Regression (GLAR) and Artificial Neural Networks (ANN). Hardyanti [6] modeled and predicted the price of USD of JPY and EUR of USD with a method ARCH, GARCH and TARCH. Setiaji [7] predicted about the prediction of exchange rate EUR of USD with wavelet neuro fuzzy models.

The using of appropriate methods to predict have several influence factors, that are time, the pattern of data, the relationship between the previous data and the accuracy of prediction. There is a new method that combines wavelet transform and Mamdani fuzzy model called wavelet fuzzy models. There are some researches that have been conducted using wavelet fuzzy models, including Romadhon [8] that concerned the introduction of power quality disturbances, Hsieh [9] that discussed about the use of wavelet based watermarking and fuzzy logic, Motwani [10] that discus about the perceptual mask images using wavelet-based fuzzy. According to Karatepe [11] who introduces wavelet fuzzy model, based on the results of the model he shows that this method is very effective in identifying the problem, give the results with a high degree of accuracy, and has a simple structure. Therefore, in this paper, the researchers are

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interested in using the same method by applying it to predict the exchange rate against the USD. The data used in this study comes from the Insta Trade Investment Holding Company, Kaliningrad, Russia.

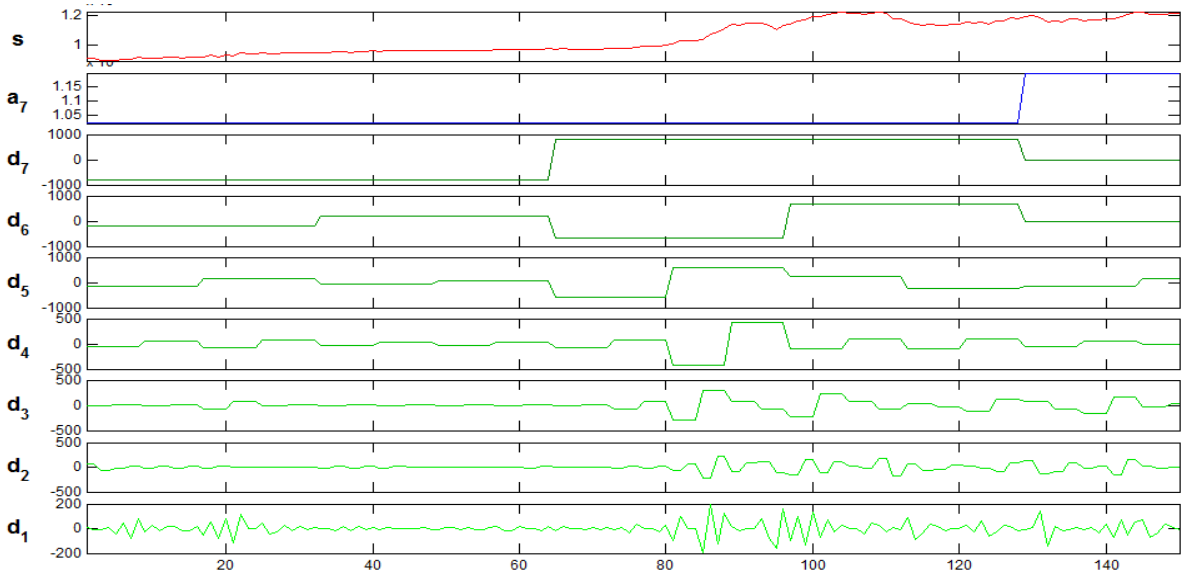

Fig. 1. The plot of original Data and DWs.

II. The Wavelet Transform

The wavelet transform is a conversion function that used to divide the function or signal into different frequency components, which further its components can be studied according to the scale. In simple, the wavelet transformation is used to transform a function with the time domain into the frequency domain. There are two types of wavelet transform: Continue Wavelet Transform (CWT) and Discrete Wavelet Transform (DWT). CWT is used for functions that domain is real numbers on the x-axis, while the DWT is used for functions that domain is integer numbers on the x-axis.

Wavelet analyzes the time series data to the dilation and translation of discrete data using the mother wavelet ψ (t). One of the mother wavelet functions is haar wavelet, Haar wavelet for level 1 is formulated as follows:

$$f \overset{H_1}{\rightarrow} (a_1|d_1) \tag{1}$$

For $f = (x_1, x_2, \dots, x_N)$ with $N = 2^n$ is the number of f`members and n is a positive constant. The result of decomposition level 1 is as follows:

$$a_1 = \left(\frac{x_1+x_2}{2}, \frac{x_3+x_4}{2}, \dots, \frac{x_{N-1}+x_N}{2}\right) \tag{2}$$

$$d_1 = \left(\frac{x_1-x_2}{2}, \frac{x_3-x_4}{2}, \dots, \frac{x_{N-1}-x_N}{2}\right) \tag{3}$$

A is the approximation data while b is the result of decomposition.

III. Wavelet Fuzzy Model

The purpose of wavelet fuzzy models is to predict the data of the components Discrete Wavelet subseries (DWS) obtained by using DWT on original data. Each DWS form of time series data and has a different effect and frequency with the original data. DWS corresponding selected as input into this model. The authors use this model based on the research of [8].

IV. The Forecasting of Exchange Rate IDR of USD with Wavelet Fuzzy Model

The steps to forecast the exchange rate of IDR of USD using wavelet fuzzy models are given as follows:

Step 1. Decompose Data

The data transformation use Haar mother wavelet level 7 by the DWT on actual data. Data of the exchange rate is decomposed to some certain number of DWS that has different correlation to original data. DWS that significant obtained based on the value of the correlation coefficient.

In Fig. 1, we can see that d1, d2, d3, d4, d5, d6, and d7 as the data result from decomposition, while a7 as the approximation data. Then, let we check the correlation coefficient of the resulting data.

TABLE I: The Correlation Coefficient of DW and the Original Data

DW	The correlation coefficient
DW1	0.999
DW2	0.997
DW3	0.992
DW4	0.983
DW5	0.946
DW6	0.850
DW7	0.523

Based on Table I, we can see that DW1, DW2, DW3, DW4, and DW5 have a high and significant correlation coefficient so it can be the component of Discrete Wavelet subseries (DWS) that can be used as an input in this model.

Step 2. Determine the model input

Autocorrelation function is used to determine the number of inputs that used in this model. The number of input is determined by the amount of input lag out exceeds the

significance of the line.

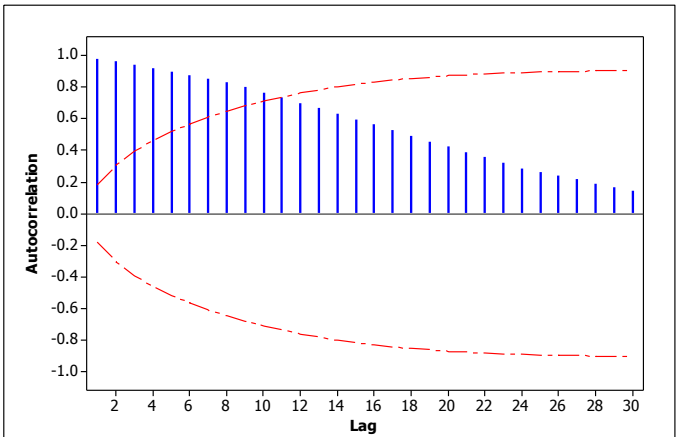

Fig. 2. The Plot of ACF.

Based on Fig. 2, it can be determined the number of inputs that can be used in the fuzzy model is 11 inputs, because there are 11 lacks which turn out.

Step 3. Define the universal set Based on the data DWS is obtained the smallest and largest data are 45300 and 60576.53, so the universal set of input is U = [45300 60576.53]. Based on the original data, the smallest and largest data are 8940 and 12245, so that the universal set of output is V = [8940 12245].

Step 4. Define fuzzy set on each input and output.

The next step is defining the fuzzy sets for input and output, in this research will be used three linguistic variables, that are low, medium, and high.

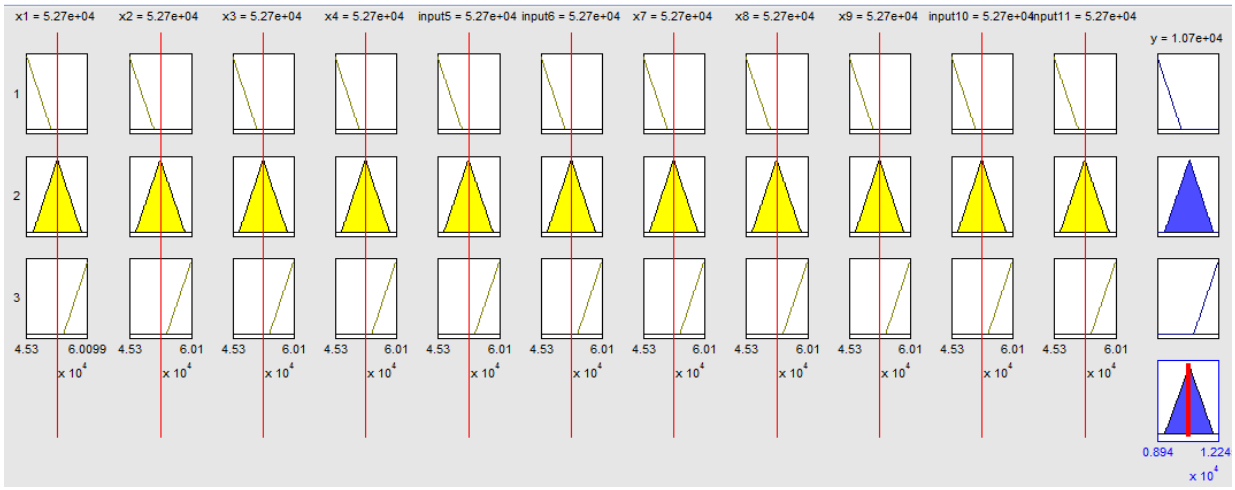

Fig. 5. The plot of defuzzification result.

Step 5. Determine membership function

This model uses triangular membership functions for input and output.

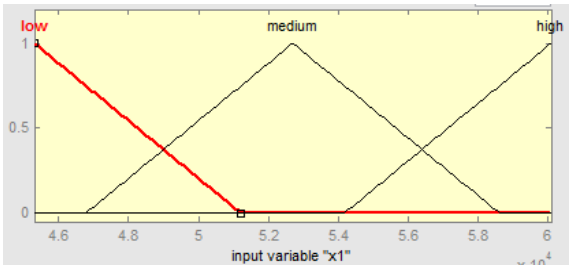

Fig. 3. The plot of input membership function.

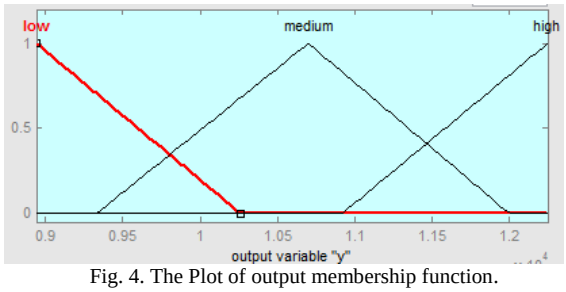

Fig. 4. The Plot of output membership function.

Based on Fig. 3 and Fig. 4, we can see that there are 3 fuzzy set in this membership function, which are "low", "medium", and "high".

Step 6. Determine the relation of fuzzy logic (rules)

The relation of fuzzy logic that used in this method is if x_i low then y low

If x_i medium then y medium

If x_i high then y high

Step 7. Defuzzification and Forecasting

This is the one of results defuzzification for 11 input in this model.

TABLE II: THE RESULTING DATA OF PREDICTION FOR TESTING DATA

Week	Yt	Yt'	Week	Yt	Yt'
1	11562	11700	16	11785	11800
2	11510	11700	17	11670	11800
3	11535	11700	18	11685	11800
4	11410	11300	19	11685	11800
5	11605	11300	20	11763	11800
6	11660	11500	21	11818	11800
7	11830	11500	22	11965	11800
8	11800	11600	23	12128	11800
9	11968	11600	24	12240	11800
10	11990	11800	25	12215	11800
11	11870	11800	26	12065	11800
12	11580	11800	27	12055	11800
13	11610	11800	28	12120	11800
14	11575	11800	29	12170	11800
15	11771	11800	30	12153	11800

Based on Fig. 5, we can see the example of defuzzification for all data in this model.

After defuzzification, we can arrange the resulting data of prediction for testing and training data, where Yt is a orign data in t week and Yt' is a result data in t week.

TABLE III: THE RESULTING DATA OF PREDICTION FOR TRAINING DATA

Week	Yt	Yt'	Week	Yt	Yt'
1	9090	*	61	9675	10100
2	9075	*	62	9682	10100
3	8940	*	63	9702	10100
4	8960	*	64	9738	10100
5	8960	*	65	9715	10100
6	9050	*	66	9745	10300
7	8990	*	67	9710	10300
8	9150	*	68	9708	10300
9	9070	*	69	9716	10300
10	9130	*	70	9730	10300
11	9120	*	71	9730	10300
12	9150	9370	72	9752	10300
13	9138	9370	73	9770	10300
14	9105	9370	74	9790	10400
15	9135	9370	75	9800	10400
16	9175	9370	76	9870	10500
17	9183	9370	77	9917	10500
18	9290	9380	78	9920	10500
19	9180	9380	79	9940	10500
20	9338	9380	80	9990	10500
21	9280	9380	81	10070	10500
22	9505	9390	82	10260	10700
23	9375	9390	83	10280	10700
24	9380	9390	84	10280	10700
25	9480	9390	85	10380	10700
26	9385	9400	86	10770	10700
27	9395	9400	87	10910	10700
28	9450	9400	88	11150	10700
29	9445	9400	89	11380	10700
30	9488	9400	90	11340	10700
31	9460	9400	91	11525	10700
32	9475	9400	92	11520	10700
33	9500	9400	93	11480	10700
34	9500	9420	94	11320	10700
35	9530	9420	95	11010	10700
36	9560	9530	96	11330	10700
37	9500	9530	97	11405	10700
38	9540	9530	98	11605	10600
39	9565	9530	99	11685	10600
40	9582	9600	100	11955	11600
41	9575	9600	101	11948	11600
42	9590	9610	102	12095	11600
43	9615	9610	103	12200	11600
44	9610	9990	104	12245	11600
45	9615	9990	105	12160	11600
46	9620	10000	106	12155	11600
47	9610	10000	107	12085	11600
48	9588	10000	108	12175	11800
49	9615	10000	109	12205	11800
50	9630	10000	110	12155	11800
51	9650	10000	111	11820	11800
52	9630	10100	112	11800	11800
53	9655	10100	113	11603	11800
54	9630	10100	114	11431	11800
55	9620	10100	115	11345	11800
56	9645	10100	116	11420	11800
57	9700	10100	117	11355	11800
58	9665	10100	118	11316	11700
59	9665	10100	119	11415	11700
60	9708	10100	120	11420	11700

Based on Table II and Table III, we can compare the value of original data and forecasting data. And in this Fig. 6, we can see the comparation point between original data and forecasting result of the exchange rate IDR OF USD from January 1, 2012 until November 9, 2014.

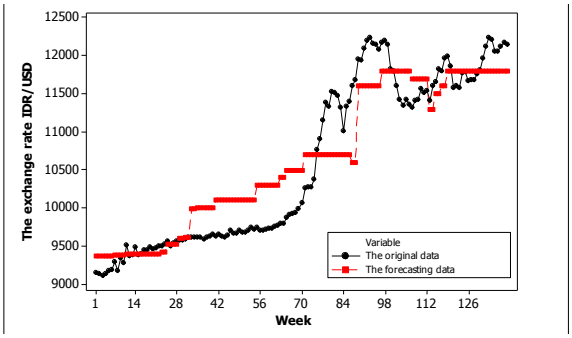

Fig. 6. The plot of original data and forecasting result.

TABLE IV: THE VALUE OF MAPE AND MSE

Training		Testing	
MAPE	MSE	MAPE	MSE
3.45%	185172	1.74%	57314.83

Mean Squared Error (MSE) is one of many ways to quantify the difference between values implied by an estimator and the true values of the quantity being estimated. Mean Absolute Percentage Error (MAPE), also known as mean absolute percentage deviation (MAPD), is a measure of accuracy of a method for constructing fitted time series values in statistics, specifically in trend estimation. This is the result of MAPE and MSE of the exchange rate IDR of USD, so we can know the estimation accuracy value of our data.

Based on Table IV, MAPE and MSE values on the testing of data have a lower value than the value of MAPE and MSE on the training data.

V. Conclusion

By using the wavelet fuzzy modeling to predict the value of exchange rate IDR OF USD the predicting results obtains a level of accuracy MAPE of 3.45% for training data and 1.74% for testing the data. It means that the prediction accuracy of a model is considered excellent because its MAPE value is lower than 10%. The wavelet fuzzy modeling is a good forecast model.

The forecasting in this research based on the data time seris of the exchange rate IDR OF USD. To improve the accuracy of prediction, then further research attention to the factors that influence the exchange rate as changes in a country's financial policy, interest rates, political changes in the country, and the others unpredictable factor.

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