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Forecasting the Exchange Rate of the IDR Against the USD Using the ARIMA and Exponential Smoothing Models

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ABSTRACT

The exchange rate of the Indonesian Rupiah (IDR) against the US Dollar (USD) is a macroeconomic variable that fluctuates and plays a critical role in maintaining economic stability. Consequently, employing accurate forecasting methods is essential to generate reliable predictions. This study aims to forecast the exchange rate of the Indonesian IDR against the USD. The methods used in this study are Autoregressive Integrated Moving Average (ARIMA) and Exponential Smoothing, and their performance is compared. The analysis uses monthly time-series data on the IDR/USD exchange rate from January 2001 to December 2025, obtained from the Ministry of Trade of the Republic of Indonesia. The analytical procedures include testing data stationarity, selecting the optimal ARIMA model based on parameter significance and diagnostic assumptions (white noise and normally distributed residuals), identifying the best Exponential Smoothing model, conducting forecasting, and evaluating forecasting accuracy. The results show that the optimal ARIMA model is ARIMA(3,1,3), with MAE of 342.5432, RMSE of 396.3468, and MAPE of 2.0624%. In contrast, the Exponential Smoothing model yields an MAE of 211.0704, RMSE of 263.6125, and MAPE of 1.2687%. Comparisons of MAE, RMSE, and MAPE values demonstrate that the Exponential Smoothing model produces lower forecasting errors than the ARIMA model. Therefore, Exponential Smoothing is considered more accurate and more suitable for forecasting the IDR exchange rate against the USD during the study period. The results of this research can serve as a reference for government institutions and economic stakeholders in decision-making processes and help improve the ability to anticipate exchange rate volatility and economic risks.

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A. INTRODUCTION

In this study, the Indonesian Rupiah (IDR) exchange rate against the United States Dollar (USD) is considered a key indicator of national economic stability, as its fluctuations have direct implications for inflation, international trade, capital flows, and overall financial health. Given the high volatility of the IDR/USD exchange rate and its sensitivity to both domestic and global economic conditions, reliable forecasting methods are essential for informing economic decision-making and guiding public policy formulation. Exchange rate instability also affects multiple macroeconomic sectors, including the labor market, investor confidence, and the national economy's resilience. Furthermore, exchange rate movements exhibit characteristics such as short-term volatility, nonstationarity, and complex nonlinear patterns, necessitating a reliable, adaptive, and robust time-series forecasting approach. (Pratiwi et al., 2025). ARIMA is a time series model that combines autoregressive, moving average, and differencing components to capture the stochastic patterns and non-stationary characteristics of data (Juraphanthong & Kesorn, 2025). Meanwhile, the exponential smoothing method is an extension of the moving average method. In this method, forecasting is done through continuous calculations using the latest data. However, it is still relatively rarely applied in the context of the exchange rate of the IDR against the USD (Hutagalung & Nasution, 2022).

Dimas (2022) use of this method is based on the ARIMA model's ability to utilize historical data and current values to produce more accurate short-term forecasts. Another study by Bahuguna et al. (2023) applied the Exponential Smoothing method and found that this method was effective in capturing short-term trend patterns. In addition, Muslimin B et al. (2024) compared ARIMA with the Prophet time-series model in forecasting the USD/IDR exchange rate; however, the study did not specifically compare ARIMA and Exponential Smoothing directly, particularly using more recent data periods.

As an open economy, Indonesia is greatly influenced by international trade dynamics and foreign investment flows. A weakening of the IDR exchange rate can increase the cost of importing raw materials and capital goods, drive up production costs, and trigger inflationary pressures that ultimately reduce people's purchasing power (Nugraha & Agussalim, 2024). Exchange rate instability also increases uncertainty for investors and has the potential to suppress foreign investment flows, while increasing the burden of foreign debt payments denominated in USDs, which can disrupt fiscal stability and the national financial system (Ahmar et al., 2024). In addition, exchange rate fluctuations have a significant impact on the relative price of a product, as these changes affect the cost structure and pricing mechanism, thereby leading to price increases or decreases in the market (Saputera et al., 2023).

The research gap between this study and previous studies is the absence of an explicit comparison of the performance of ARIMA and Exponential Smoothing models in forecasting the exchange rate of the IDR against the USD using long and up-to-date monthly data and consistent accuracy evaluation on out-of-sample data. Most previous studies still focus on a particular model or compare ARIMA with multivariate models, without placing Exponential Smoothing as a major alternative in exchange rate forecasting.

The novelty of this research, relative to earlier studies, is demonstrated by the direct implementation and systematic comparison of the ARIMA and Exponential Smoothing models using Indonesian Rupiah (IDR)–United States Dollar (USD) exchange rate data spanning January 2001 to December 2025. In addition, the study clearly differentiates between in-sample and out-of-sample datasets and evaluates forecasting performance using Mean Absolute Error (MAE), Root Mean Square Error (RMSE), and Mean Absolute Percentage Error (MAPE) to identify the most accurate forecasting model.

The purpose of this study is to forecast the Indonesian Rupiah (IDR)–United States Dollar (USD) exchange rate and to compare the forecasting performance of the Autoregressive Integrated Moving Average (ARIMA) and Exponential Smoothing models based on their accuracy. The contribution of this study lies in providing empirical evidence on the most suitable forecasting model for predicting the IDR exchange rate, as well as offering methodological guidance for future research and practical insights for policymakers and economic stakeholders in managing exchange rate uncertainty.

B. RESEARCH METHOD

This study employs monthly USD/IDR exchange rate data expressed as IDR per USD (IDR/USD), which represents the number of Indonesian IDR required to obtain one USD. An increase in the exchange rate indicates depreciation of the IDR, while a decrease reflects appreciation of the IDR. The exchange rate data represent the middle rate, not the buying or selling rate. The middle rate, calculated as the average of the buying and selling rates, is commonly used in macroeconomic and time-series analyses because it provides a balanced, representative indicator of prevailing market conditions.

The study period from January 2001 to December 2025 was chosen because it spans 25 years and allows this study to capture important economic events affecting Indonesia, such as the global financial crisis, commodity price volatility, the COVID-19 pandemic, and the period of global monetary policy tightening. Methodologically, the long period also provides an adequate number of observations for more robust estimation of time series models, more accurate diagnostic testing, and more reliable out-of-sample evaluation. Therefore, the 2001–2025 period is considered representative of the comprehensive dynamics of the USD/IDR exchange rate in Indonesia. The data set is divided into in-sample data (2001–2024) for model construction and out-of-sample data (2025) for forecasting evaluation, ensuring methodological rigor and statistical validity in model assessment.

1. Model ARIMA (Autoregressive Integrated Moving Average)

In this study, data analysis was conducted to model and forecast the exchange rate of the Indonesian Rupiah (IDR) against the United States Dollar (USD) using a time-series framework. The ARIMA model, which combines autoregressive (AR), moving average (MA), and differencing components, is employed to address nonstationarity in the data (Adenomon et al., 2022; Nugraha & Agussalim, 2024; Sinu et al., 2024). This method only uses historical values of the observed variables and applies an iterative model identification process to determine the most appropriate model specification, so that it is able to represent past patterns and produce reliable forecasts for time series economic data (Liu, 2022).

According to Box et al. (2008), in general, the ARIMA model is denoted as ARIMA $(p,\ d,\ q)$, with the following Equations (1) and (2):

$$\phi_p(B)(1-B)^d Y_t = \theta_q(B)a_t \tag{1}$$

For data showing seasonal patterns, the following model is used:

$$\Phi_P(B^s)(1-B^s)^D Y_t = \Theta_Q(B^s)a_t \tag{2}$$

The stages of ARIMA model formation include:

a. Testing the stationarity of data in terms of both variance and mean.
b. Identifying models based on ACF and PACF plots.
c. Parameter estimation, using the Conditional Least Squares or Maximum Likelihood Estimation method.
d. Diagnostic checking, ensuring that the residuals are white noise using the Ljung-Box test and that the residuals are normally distributed using the Kolmogorov-Smirnov test.
e. Selection of the best model, based on the Akaike's Information Criterion (AIC) value.
f. Forecasting.

2. Model Exponential Smoothing

The Exponential Smoothing model is a time series forecasting technique that assigns greater importance to the most recent observations, while the influence of older data decreases exponentially over time (Erkekoglu et al., 2020; Septiarini et al., 2025). There are several types of exponential smoothing, namely:

a. Single Exponential Smoothing (SES)

This model is used for data without trends and seasonality, with the Equations (3) and (4):

$$L_t = \alpha Z_t + (1-\alpha)\, L_{t-1} \tag{3}$$

$$F_t = \alpha Z_{t-1} + (1-\alpha) F_{t-1} \tag{4}$$

b. Double Exponential Smoothing (Holt)

The Holt model is used for data containing trends, with the Equations (5)–(7):

$$L_t = \alpha Y_t + (1-\alpha)\,(L_{t-1} + T_{t-1}) \tag{5}$$

$$T_t = \beta(L_t - L_{t-1}) + (1-\beta)T_{t-1} \tag{6}$$

$$F_{t+m} = L_t + T_t m \tag{7}$$

c. Triple Exponential Smoothing (Holt-Winters)

For data with trends and seasonality, the Holt–Winters model with a multiplication form is used as Equations (8)–(11):

$$L_t = \alpha \frac{Z_t}{I_{t-s}} + (1-\alpha)\,(L_{t-1} + T_{t-1}) \tag{8}$$

$$T_t = \beta\,(L_t - L_{t-1}) + (1-\beta)\, T_{t-1} \tag{9}$$

$$I_t = \gamma \frac{Z_t}{L_t} + (1-\gamma)\, I_{t-s} \tag{10}$$

$$\hat{F}_t(h) = (L_t + hT_t)\, I_{t-s+h} \tag{11}$$

3. Model Accuracy Evaluation

The performance of the models was assessed using Mean Absolute Error (MAE), Root Mean Square Error (RMSE), and Mean Absolute Percentage Error (MAPE). MAE was applied to quantify the average absolute difference between observed and predicted values, while RMSE evaluated the magnitude of prediction errors in the same units as the original data. MAPE, on the

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other hand, measured forecasting errors in percentage terms, facilitating interpretation and comparison across different models (Adenomon et al., 2022). MAE, RMSE, and MAPE are displayed in Equations (12), (13), and (14).

$$MAE = \frac{1}{n}\sum_{i=1}^{n}|y_i - \widehat{y}_i| \tag{12}$$

$$RMSE = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(y_i - \widehat{y}_i)^2} \tag{13}$$

$$MAPE = \frac{\sum_{t=1}^{n}\left|\frac{y_t - \hat{y}_t}{y_t}\right|}{n} \times 100 \tag{14}$$

Based on evaluations using MAE, RMSE, and MAPE, the model with the smallest combined error values is considered the most appropriate forecasting model (Hyndman & Athanasopoulos, 2021). This selection method ensures that the chosen model exhibits superior predictive accuracy and reliability across multiple error measurement dimensions. By integrating several evaluation criteria simultaneously, the model selection process becomes more robust and reduces the potential for bias arising from reliance on a single performance indicator.

C. RESULT AND DISCUSSION

1. Time Series Analysis

This study uses monthly data on the exchange rate of the IDR against the USD for the period January 2001–December 2025 with a time series approach using the ARIMA and Exponential Smoothing models. The analysis begins with a plot of exchange rate movements over time to observe the pattern. The data is then divided into in-sample data (2001–2024) for model formation and out-of-sample data (2025) for evaluation of the forecast results.

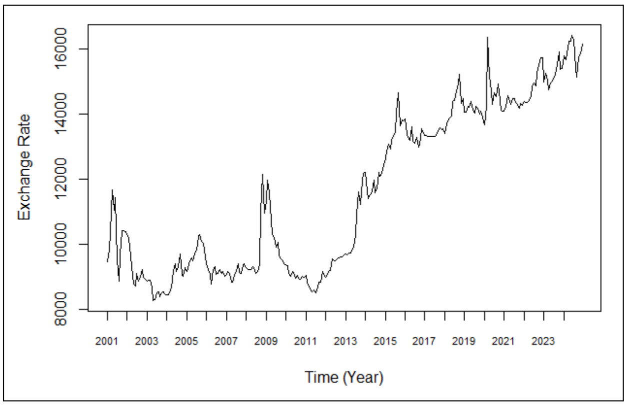

Figure 1. Plot of the exchange rate of the IDR against the USD from 2001 to 2024

Based on the visual pattern, the IDR/USD exchange rate series exhibits noticeable fluctuations and a distinct upward trajectory, indicating a long-term upward trend. This behavior reflects a sustained depreciation of the IDR over time, despite short-term volatility. The dataset is partitioned into in-sample data (2001–2024) for model construction and out-of-sample data (2025) for forecasting evaluation, allowing for an objective assessment of the model's predictive performance.

2. ARIMA Model Analysis

Data analysis in this study was conducted to model and forecast the Indonesian Rupiah (IDR)–United States Dollar (USD) exchange rate using a time series approach. The ARIMA model represents a time series framework that combines autoregressive (AR), moving average (MA), and differencing components to effectively accommodate the non-stationary characteristics of the data (Ibrahim et al., 2023).

a. Model Identification

The modeling procedure began by examining data stationarity with respect to both the variance and the mean. Variance stationarity was assessed using the Box–Cox criterion, while mean stationarity was tested using the Augmented

Dickey–Fuller (ADF) test. The stationarity testing procedure in this study begins with an examination of variance stationarity. This step aims to ensure that the data do not exhibit time-varying dispersion, which would violate the basic assumptions of time series modeling. Stationarity in variance is assessed using the λ value from the Box–Cox transformation, where $\lambda = 1$ indicates the data are already stationary in variance and therefore do not require any transformation. Conversely, if $\lambda \neq 1$, a transformation is required to stabilize the variance before proceeding to subsequent stages of the analysis (Abdullah et al., 2025). Table 1 shows the results of the stationarity test for variance.

Table 1. Stationarity test results in variance

Stationarity Test	**Test Statistics (λ)**	
	Before Transformation	**After Transformation**
Variance	0.6300455	1.014.253

Initial test results indicate that the data is not stationary. This is indicated by the Box–Cox parameter value of $\lambda = 0.6300455$, which indicates that the data variance is unstable, thus requiring the Box–Cox transformation. After the transformation, the data showed more stationary properties, as indicated by a Box–Cox parameter value λ close to 1, namely 1.014253. This condition indicates that the data variance has stabilized and the data is ready for analysis in the next stage.

Once variance stationarity has been established, the subsequent step is to evaluate stationarity in the mean. This stage is intended to determine whether the time series preserves a constant average over time or exhibits systematic trends. Mean stationarity is tested using the Augmented Dickey–Fuller (ADF) test, in which the null hypothesis assumes that the series contains a unit root and is therefore non-stationary in the mean. If the p-value is below the specified significance level, the null hypothesis is rejected, indicating mean stationarity. Otherwise, if the null hypothesis cannot be rejected, the data are differenced to achieve stationarity before proceeding to the subsequent stages of the modeling process (Sathyanarayana & Mohanasundaram, 2025). Table 2 shows the results of the stationarity test for the mean.

Table 2. Results of stationarity tests in the mean

Stationarity Test	**P-value**	
	Before Differencing	**After Differencing**
Mean	0.3031	0.01

The Augmented Dickey–Fuller (ADF) test applied to the original series produced a p-value of 0.3031 (> 0.05), indicating that the null hypothesis could not be rejected and that the data were non-stationary in the mean. Consequently, to satisfy the stationarity assumption, first-order differencing was applied to remove trend components in the series. Following the differencing procedure, the ADF test yielded a p-value of 0.01 (< 0.05), leading to the rejection of the null hypothesis. This result confirms that the series had become stationary in the mean, as it no longer exhibited systematic movements in average values over time.

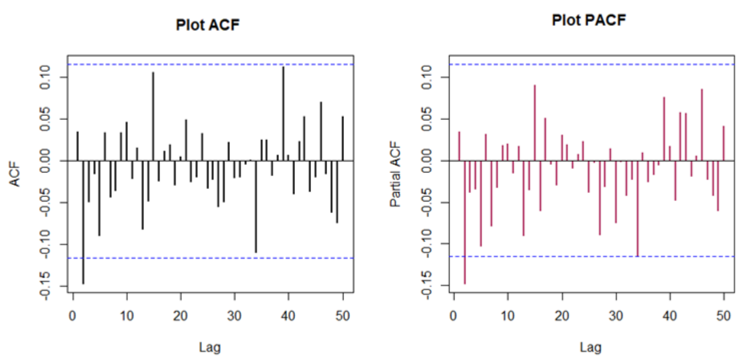

Figure 2. ACF and PACF plots after transformation and differencing

Based on Figure 2, the ACF plot indicates significant autocorrelation up to lag 2, which then diminishes in subsequent lags. In contrast, the PACF plot shows significant spikes at lags 2 and 34, suggesting a direct influence of the exchange rate on the current value at those lags. These ACF and PACF patterns are used to formulate several candidate ARIMA models, which are subsequently tested to identify the most appropriate model for modeling and forecasting the IDR/USD exchange rate. Table 3 shows the proposed candidate ARIMA models:

Table 3. Temporary ARIMA model

No	Model	No	Model
1	ARIMA (0,1,1)	8	ARIMA (2,1,0)
2	ARIMA (0,1,2)	9	ARIMA (2,1,1)
3	ARIMA (0,1,3)	10	ARIMA (2,1,2)
4	ARIMA (1,1,0)	11	ARIMA (3,1,0)
5	ARIMA (1,1,1)	12	ARIMA (3,1,1)
6	ARIMA (1,1,2)	13	ARIMA (3,1,2)
7	ARIMA (1,1,3)	14	ARIMA (3,1,3)

b. ARIMA Model Parameter Estimation

Once the ARIMA model has been provisionally specified, the next step is to estimate its parameters and assess their significance. Parameter significance is tested using a t-test at a significance level of $\alpha = 0.01$, with parameters deemed statistically significant if the p-value is less than 0.01. Based on the results of the parameter significance tests, the following ARIMA models were identified as significant: ARIMA (0,1,3), ARIMA (1,1,2), ARIMA (1,1,3), ARIMA (2,1,1), ARIMA (3,1,1), ARIMA (3,1,2), and ARIMA (3,1,3).

c. Diagnostic Checking and Selection of the Best Model

At this stage, residual diagnostics are conducted to assess white-noise properties and normality. The fulfillment of the white noise assumption in the residuals is indicated by the absence of specific patterns and no statistically significant autocorrelation. This test is performed using the Ljung–Box test on ARIMA models with significant parameters. In the normality test, the residuals from each model are examined to see whether they meet the assumption. If the p-value $>$ α (0.01), then the model meets the normality assumption. The models to be tested are ARIMA (0,1,3), ARIMA (1,1,2), ARIMA (1,1,3), ARIMA (2,1,1), ARIMA (3,1,1), ARIMA (3,1,2), and ARIMA (3,1,3).

Table 4. Diagnostic checking results

	White noise test		Normality test	
Model	Test statistics Ljung -Box	p-value	Test statistics Ljung -Box	p-value
ARIMA (0,1,3)	0.0038581	0.9505	0.110	0.0019
ARIMA (1,1,2)	0.010414	0.9187	0.107	0.0029
ARIMA (1,1,3)	0.0080506	0.9285	0.107	0.00028
ARIMA (2,1,1)	0.000086716	0.9926	0.105	0.0037
ARIMA (3,1,1)	0.00001999	0.9972	0.103	0.0025
ARIMA (3,1,2)	0.0064675	0.9359	0.109	0.0020
ARIMA (3,1,3)	0.23002	0.6315	0.089	0.0202

In the Ljung–Box test, the null hypothesis (H_0) assumes that the residuals follow a white noise process, while the alternative hypothesis (H_0) assumes the opposite, with a significance level of $\alpha = 0.01$. Based on the results reported in Table 4, all models yield Ljung–Box statistics below the critical value and p-values exceeding 0.01, indicating no significant autocorrelation in the residuals. Accordingly, it can be concluded that all models satisfy the white noise assumption. Based on the results of the Kolmogorov–Smirnov test, only the ARIMA (3,1,3) model satisfied the normality assumption, as indicated by a p-value greater than the significance level α.

d. Selection of the Best Model

The ARIMA model was selected using a stepwise process, eliminating models that failed to meet the established criteria. From this procedure, ARIMA (3,1,3) was identified as the optimal model and subsequently employed for forecasting. The ARIMA (3,1,3) model can be expressed as follows:

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$$Y^*_{289} = Y^*_{t-1} - 0.448804Y^*_{t-1} + 0.448804Y^*_{t-2} - 0.061933Y^*_{t-2} + 0.061933Y^*_{t-3} + 0.659062Y^*_{t-3} - 0.659062Y^*_{t-4} + 0 + 0.474871a_{t-1} + 0.051733a_{t-2} + 0.798033a_{t-3} \quad (15)$$

e. Forecasting

Comparison of Actual Data and Forecasts for 2025

A comparison between actual data and forecast results for the IDR exchange rate against the USD in 2025 was conducted to evaluate the model's ability to follow exchange rate movement patterns. The forecast results were obtained from a model built based on historical data from the previous period and are presented in Table 5 and Figure 3.

Table 5. Diagnostic checking results

Year	Month	Actual data	Forecast
2025	January	16.259,00	16.352,08
2025	February	16.431,00	16.252,83
2025	March	16.588,00	16.085,91
2025	April	16.787,00	16.292,07
2025	May	16.255,00	16.144,54
2025	June	16.233,00	16.087,98
2025	July	16.387,00	16258,35
2025	August	16.356,00	16.088,27
2025	September	16.680,00	16.116,67
2025	October	16.640,00	16.226,72
2025	November	16.644,00	16.063,58
2025	December	16.782,00	16.148,65

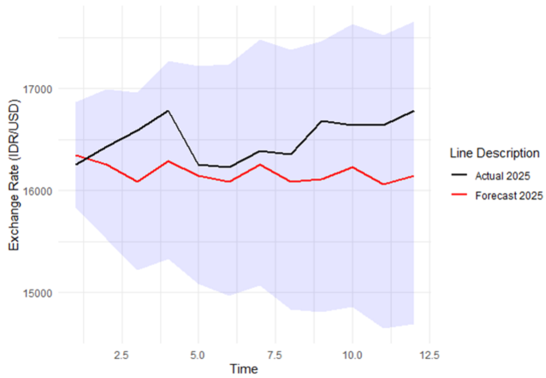

Figure 3. Comparison of actual data and forecasts for 2025

The plot comparing the actual and forecasted values of the IDR/USD exchange rate in 2025 indicates that the forecasts effectively capture the exchange rate's overall trend, although the forecasted series appears smoother than the observed data. This indicates that the model emphasizes medium to long-term trends and is less responsive to sharp, temporary fluctuations.

The largest deviation occurred in April 2025, when the actual IDR exchange rate weakened significantly amid heightened global pressures, particularly uncertainty in international financial markets, triggering risk-off sentiment and capital outflows from developing countries. These circumstances prompted Bank Indonesia to intervene in the foreign exchange market to preserve exchange rate stability. Meanwhile, the forecast line did not show a decline as deep as the actual data because the event was treated as a short-term, non-sustainable shock (Prakoso, 2025). Although the actual values differ from the forecast results in several periods, all actual values remain within the confidence interval. Therefore, the forecasting model used remains adequate for describing the trend in the IDR exchange rate throughout 2025.

Forecast for 2026

The results of forecasting the IDR/USD exchange rate for the 2026 period using the ARIMA (3,1,3) model are presented in Table 6 and Figure 4.

Table 6. Forecast for 2026

Year	Month	Actual data	Forecast
2025	January	16,259.00	16,352,08
2025	February	16,431.00	16,252,83
2025	March	16,588.00	16,085,91
2025	April	16,787.00	16,292,07
2025	May	16,255.00	16,144.54
2025	June	16,233.00	16,087.98
2025	July	16,387.00	16,258.35
2025	August	16,356.00	16,088.27
2025	September	16,680.00	16,116.67
2025	October	16,640.00	16,226.72
2025	November	16,644.00	16,063.58
2025	December	16,782.00	16,148.65

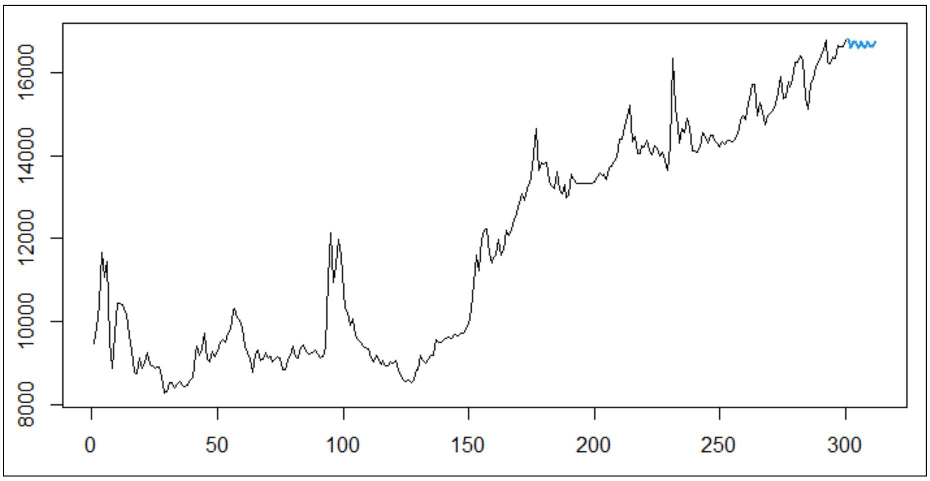

Figure 4. Forecast Plot for 2026

The results of forecasting the IDR/USD exchange rate in 2026 using the ARIMA (3,1,3) model are presented in Table 6. In general, the exchange rate is expected to move relatively steadily throughout the year, with moderate fluctuations between 16,593.00 and 16,750.63. The forecast plot shows a smoother pattern than the historical data, indicating that the model captures the main trends in exchange rate movements, though it is less responsive to short-term fluctuations.

f. Model Accuracy Evaluation

The accuracy of the forecasts was assessed using several error metrics, including Mean Absolute Error (MAE), Root Mean Square Error (RMSE), and Mean Absolute Percentage Error (MAPE). MAE and RMSE quantify forecasting errors in absolute terms, with RMSE expressed in the same units as the original data to facilitate interpretation. MAPE, on the other hand, presents forecasting errors as percentages, enabling clearer interpretation and comparison across models. The MAE, RMSE, and MAPE values were calculated based on the test dataset and are presented in Table 7.

Table 7. Model Accuracy Evaluation

	MAE	RMSE	MAPE
Test set	342.5432	396.3468	2.0624

Based on the evaluation results, the forecasting model produced an MAE of 342.5432, an RMSE of 396.3468, and an MAPE of 2.0624% on the test data. These results indicate that the forecasting errors are relatively small both in absolute terms and as a percentage. Therefore, the model demonstrates a high level of accuracy and can provide reliable forecasts for data outside the sample period.

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3. Exponential Smoothing Model Analysis

a. Model Identification

Data analysis was performed using the Exponential Smoothing method to model and forecast time series data. Based on the classification by Hutagalung and Nasution (2022), Exponential Smoothing consists of Single, Double (Holt), and Triple (Holt–Winters), the selection of which is adjusted to the characteristics of the data. The time series plot of the IDR/USD exchange rate in Figure 1 shows fluctuations alongside a long-term upward trend, with no clear seasonal pattern. Accordingly, the Double Exponential Smoothing (Holt) method is employed in this study, as it can effectively capture both level and trend changes in the data without accounting for seasonal effects.

b. Parameter Estimation

After the Double Exponential Smoothing (Holt) model is established, the next step is to estimate the level (α) and trend (β) parameters, each of which has a value between 0 and 1 (Hyndman & Athanasopoulos, 2021). Parameter estimation is performed automatically in R using the Maximum Likelihood Estimation (MLE) approach, so that optimal parameter values are obtained without subjective initial determination (see Tables 8 and 9).

Table 8. Parameter Estimation

Parameter	Parameter value
Alpha	0.9999
Beta	0.0076

Table 9. Initialization of Initial Values

Initialization	Value
Level (L_t)	10580.1041
Trend (T_t)	-35.6038

The estimation results indicate $\alpha = 0.9999$ and $\beta = 0.0076$. An α value close to 1 indicates that the level component is strongly influenced by the latest data, whereas a relatively small β value indicates that the trend change is gradual. The initial level and trend values were 10,580.1041 and -35.6038, respectively, and were used as the starting point for the Holt model.

c. Forecasting

Comparison of actual data and forecasts for 2025

A comparison was conducted between the actual IDR/USD exchange rate data for 2025 and the forecasts produced by the Exponential Smoothing model to evaluate the model's ability to capture both the data-level and trend dynamics. The results of this comparison between observed and predicted values are summarized in Table 10.

Table 10. Comparison of Actual Data and Forecasts for 2025

Year	Month	Actual data	Forecast
2025	January	16,259.00	16,184.07
2025	February	16,431.00	16,206.16
2025	March	16,588.00	16,228.26
2025	April	16,787.00	16,250.36
2025	May	16,255.00	16,272.45
2025	June	16,233.00	16,294.55
2025	July	16,387.00	16,316.64
2025	August	16,356.00	16,338.74
2025	September	16,680.00	16,360.84
2025	October	16,640.00	16,382.93
2025	November	16,644.00	16,405.03
2025	December	16,782.00	16,427.13

Based on Table 10, the forecast results show a pattern that aligns with actual data and tends to increase throughout the year. However, for most of the period, the forecast value is below the actual value, indicating a tendency for underestimation. Nevertheless, the model still follows the general direction of the exchange rate trend.

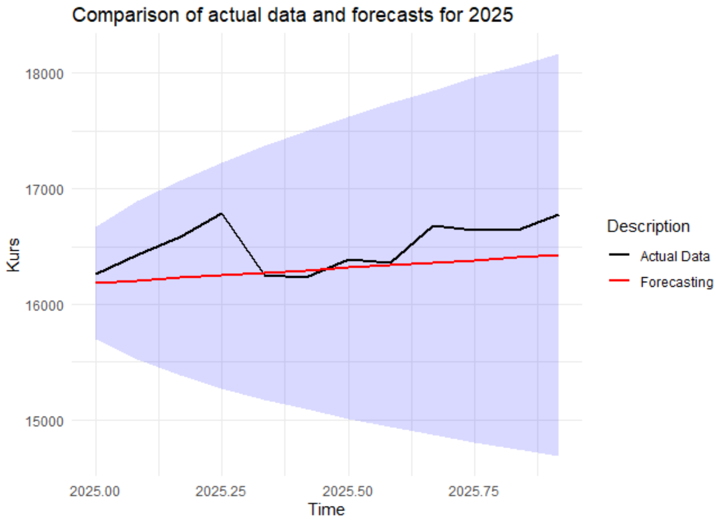

Figure 5. Comparison of Actual Data and Forecasts for 2025

The plot, as seen in Figure 5, shows that the forecast results continue to follow the general direction of the IDR exchange rate throughout 2025, although the forecast line is relatively more stable than the actual data. Despite a sharp decline in actual data around April 2025, the overall pattern still shows a gradual weakening trend until the end of the year. This phenomenon reflects a short-term shock in April 2025 triggered by global external pressures, such as increased uncertainty in international financial markets, risk-off sentiment, and capital outflows from developing countries, which caused a temporary weakening of the IDR before it returned to move in line with its general trend (Prakoso, 2025).

In addition, the visualization of confidence intervals that widen as the time horizon increases indicates increased forecasting uncertainty. However, all actual values remain within the interval. This indicates that although the model does not fully capture sudden short-term spikes, it is still adequate in describing the overall trend and the range of movements of the IDR/USD exchange rate in 2025.

Forecast for 2026

Forecasting of the IDR/USD exchange rate for the period January–December 2026 was carried out using the Exponential Smoothing model based on historical data from previous periods. The point forecast results are presented in Table 11.

Table 11. Forecast for 2026

Year	Month	Forecast
2026	January	16,812.82
2026	February	16,843.64
2026	March	16,874.47
2026	April	16,905.30
2026	May	16,936.12
2026	June	16,966.95
2026	July	16,997.78
2026	August	17,028.61
2026	September	17,059.43
2026	October	17,090.26
2026	November	17,121.09
2026	December	17,151.91

Based on Table 11, the IDR/USD exchange rate is projected to range between 16,812.82 and 17,151.91, exhibiting a gradual upward trend throughout 2026. The relatively steady increase, without sharp fluctuations, suggests a tendency for the Rupiah to weaken against the US Dollar during this period

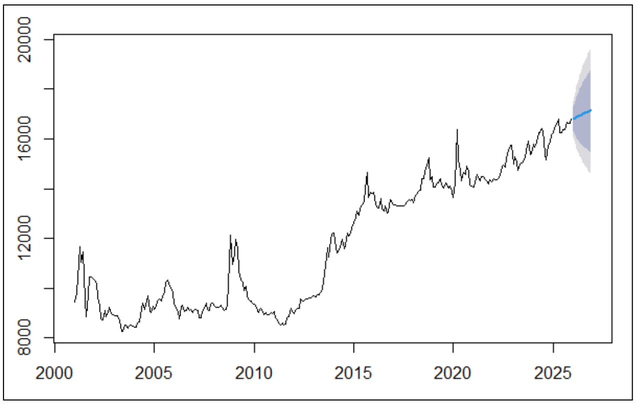

Figure 6. Plot Forecast for 2026

The forecast plot in Figure 6 shows that the forecast line follows the historical upward trend with a smoother pattern. The widening confidence interval at the end of the period reflects increasing uncertainty as the forecast horizon lengthens, but the forecast value remains within a reasonable range. Overall, the Exponential Smoothing model is considered effective in capturing the overall direction of the IDR/USD exchange rate in 2026.

d. Model Accuracy Evaluation

The accuracy of the forecasting results was evaluated using several error metrics, including Mean Absolute Error (MAE), Root Mean Square Error (RMSE), and Mean Absolute Percentage Error (MAPE). MAE and RMSE were used to assess the magnitude of forecasting errors in absolute terms, with RMSE expressed in the same unit as the original data, thereby facilitating easier interpretation. Meanwhile, MAPE presents the forecasting error as a percentage, facilitating interpretation and comparison across models. The values of MAE, RMSE, and MAPE were computed from the errors over the entire test data period, as presented in Table 12.

Table 12. Model Accuracy Evaluation

	MAE	RMSE	MAPE
Test set	211.0704	263.6125	1.268733

Based on Table 12, the forecasting performance of the Exponential Smoothing model on the test data is reflected by an MAE of 211.0704, an RMSE of 263.6125, and a MAPE of 1.268733%. The MAPE value, which is below 10%, indicates that the forecasting results achieve a very high level of accuracy. Therefore, the Exponential Smoothing model is a reliable and appropriate method for forecasting the IDR/USD exchange rate.

4. Comparison Of ARIMA and Exponential Smoothing Model Forecasting Results

The findings of this study indicate that the Exponential Smoothing (Holt) model exhibits greater forecasting accuracy compared to the ARIMA (3,1,3) model in predicting the IDR/USD exchange rate for the 2025 testing period. This is evidenced by the Exponential Smoothing model producing lower error values, with an MAE of 211.0704, an RMSE of 263.6125, and a MAPE of 1.2687%, compared to the ARIMA model, which records an MAE of 342.5432, an RMSE of 396.3468, and a MAPE of 2.0624%. Therefore, based on all evaluation metrics (MAE, RMSE, and MAPE), the Exponential Smoothing model provides more accurate forecasts of the IDR/USD exchange rate in the out-of-sample data.

The results of this study are consistent with previous research, particularly Amalia et al. (2022), which found that the Exponential Smoothing method outperforms the Moving Average method in forecasting the IDR/USD exchange rate. In that study, Exponential Smoothing achieved lower Mean Absolute Deviation (MAD) and Mean Squared Error (MSE) values than the comparison method, indicating its superior ability to capture short-term trend patterns.

The results of this study are also consistent with those of Pujiharta et al. (2022), which likewise indicate that the Exponential Smoothing method provides better forecasting performance than the ARIMA model. In their study, the analyzed variable was the number of car requests used as the basis for inventory control, whereas in the present research, the variable is the number of car requests. The study by Pujiharta et al. (2022) found that the Holt-Winters Additive Exponential Smoothing method produced lower error values than the ARIMA (2,0,2) model, with a Mean Squared Error (MSE) of 490.567 and a Mean Absolute

Percentage Error (MAPE) of 23.06%, compared to higher errors in the ARIMA model (MSE = 592.428 and MAPE = 24.96%). These findings reinforce that Exponential Smoothing tends to provide more accurate forecasts than ARIMA across various data types, even when the variables differ. Table 13 compares this study with previous studies.

Table 13. Comparison with Previous Research

Aspect	This Study	Amalia et al. (2022)	Pujiharta et al. (2022)
Compared Methods	ARIMA vs Exponential Smoothing	Moving Average vs Exponential Smoothing	ARIMA vs Exponential Smoothing
Best Model	Exponential Smoothing (Holt)	Exponential Smoothing	Exponential Smoothing (Holt-Winters Additive)
Accuracy of Best Model	MAE = 211.0704 RMSE = 263.6125 MAPE = 1.2687%	MAD = 29.105 MSE = 1564.619	MAPE = 23.06% MSE = 490.567
Conclusion	Exponential Smoothing demonstrates higher forecasting accuracy	Exponential Smoothing demonstrates higher forecasting accuracy	Exponential Smoothing demonstrates higher forecasting accuracy

D. CONCLUSION AND SUGGESTION

Based on the analysis and discussion, this study concludes that the Exponential Smoothing (Holt) method achieves higher forecasting accuracy than the ARIMA method for predicting the IDR/USD exchange rate. This conclusion is supported by the lower MAPE value produced by the Exponential Smoothing model (1.2687%) compared to the ARIMA(3,1,3) model (2.0624%), thereby achieving the research objective of comparing the performance of the two forecasting approaches. This study has several limitations, including the use of monthly data, which does not capture short-term fluctuations in detail, and an accuracy evaluation limited to one error measure, namely MAPE, and not considering external factors such as macroeconomic variables that can affect the movement of the IDR exchange rate. Further research is recommended to use higher-frequency data, add other accuracy evaluation measures such as RMSE or MAE, and combine time-series forecasting methods with machine-learning-based models or economic variables to obtain more comprehensive and robust forecasting results.

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DECLARATIONS

AUTHOR CONTRIBUTION

The first author was involved in data collection, data processing and analysis, modeling, and manuscript writing. The second author served as the research supervisor, providing methodological guidance, evaluating results, and reviewing and revising the manuscript.

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COMPETING INTEREST

The authors state that there are no conflicts of interest associated with the publication of this article.

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