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Modelling the Indicative Rate of the USD/LKR SPOT Exchange Rate in Sri Lanka

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Abstract

This study develops and validates a time series model to forecast Sri Lanka's daily indicative USD/LKR spot exchange rate using ARIMA and ARCH methods using data from 1st of January 2021 to 4th of June 2025, sourced from Central Bank of Sri Lanka. The original series was first differenced to achieve stationarity since it is not stationary. According to the sample ACF and PACF of stationary series, three candidate models were augmented with an ARCH(2) variance specification based on residual diagnostics. After comparing AIC, SIC, Hannan Quinn metrics and log likelihood, the ARIMA(1,1,1)+ARCH(2) was identified as the best possible model. The diagnostic tests confirmed that residuals are identically and independently distributed without remaining heteroskedasticity. In-sample forecasting yielded a MAPE of 0.32% and a Theil U statistic of 0.0036, while out-of-sample validation (June 5 to July 4, 2025) produced a MAPE of 0.087% and a bias proportion near zero, highlighting the model the model's predictive accuracy. By focusing only on the internal pattern of the exchange rate, this research creates a strong short term forecasting tool for Sri Lanka's volatile currency environment laying ground work for adding outside factors in future improvements.

Keywords: Exchange rate, Indicative exchange rate, Time series forecasting, ARIMA/GARCH models

Introduction

The exchange rate is the worth of a foreign nation's currency against the home nation's currency. An appropriate exchange rate value is the key to economic growth without an obstacle for developing nations such as Sri Lanka. (Basnayake & Chandrasekara, 2022). The indicative rate of the USD/LKR spot exchange rate is defined by the Central Bank of Sri Lanka (CBSL) as "the weighted average rate of all actual USD/LKR Spot transactions executed in the domestic inter-bank foreign exchange market, including the CBSL spot interventions carried out via Request for Quote (RFQ) method throughout the previous/latest available business day". (Central Bank of Sri Lanka, 2025).This serves as the primary benchmark for importers, exporters, financial institutions and policy makers who manage the currency risk in Sri Lanka's economy. From mid-2021 to early 2022 Sri Lanka faced its most severe economic crisis which drove the rupee from LKR 185/USD to peaks above LKR 350/USD before gradually stabilizing under the International Monetary Fund (IMF) guidance. Although stabilization has followed, volatility remains pronounced, highlighting the need for a reliable short-term forecasting tool.

In comparable emerging-market contexts, researchers have commonly used ARIMA models for level/point forecasts and ARCH/GARCH-family models to capture volatility clustering. Islam and Chowdhury (2022) apply the ARIMA time series model to forecast the exchange rate of seven currencies (United States Dollar, Euro, Pound sterling, Australian Dollar, Japanese Yen, Canadian Dollar and

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Swedish Krona) in terms of Bangladeshi Taka while Verberi (2021) investigated real effective exchange rate forecasting during the COVID-19 pandemic for Turkey and found that ARIMA–ARCH and ARIMA–GARCH models delivered the best accuracy.

Local studies have applied time series forecasting models to predict the Daily Exchange rate. However, their analysis did not focus solely on the daily indicative USD/LKR rate. To address this gap, this study develops a time series model tailored to Sri Lanka's daily indicative USD/LKR exchange rate with the model diagnostics to guide policymakers and market participants in Sri Lanka. Accordingly, this study seeks to answer the following research question: Can a univariate model using only historical daily values of the USD/LKR indicative rate produce accurate and reliable short-term forecasts for policymakers and market participants in Sri Lanka? This is univariate approach and nor external factors like interest rates, foreign reserves, or remittances are considered.

Materials and Methodology

Secondary Data

The daily Indicative Rate of the USD/LKR SPOT Exchange Rate from 1st of January 2021 to 4th of July 2025 was obtained from the official website of Central Bank Sri Lanka (Central Bank of Sri Lanka, 2025). The data set does not include holidays and weekends values. The data from 1st of January 2021 to 4th of June 2025 was used as the training data set and other data used to validate the model.

Methodology

In this study, the time series Auto Regressive Moving Average (ARIMA) model was used as shown in Equation 01, which contains both autoregressive (AR) and moving average (MA) parameters. ε_t is the error series and it assumes that the errors are white noise.

$$Y_t = \mu + \emptyset_1 Y_{t-1} + \emptyset_2 Y_{t-2} + \ldots + \varepsilon_t - \theta_1 \varepsilon_{t-1} - \theta_2 \varepsilon_{t-2} \quad \ldots\ldots\ldots (1)$$

If the original series is not stationary, the differencing technique is used to make series stationary. It is denoted by ARIMA (p, d, q). Where p and q are the orders of the autoregressive part and moving average part respectively. The d is the differencing step used to achieve stationarity.
However, in most financial time series, the errors are heteroscedastic. Hence, to capture the volatility observed in the exchange rate the ARCH model was used. The ARCH model of order q is described in (2). This is known as the variance equation. The order of the ARCH model was determined based on the ACF/PACF plots of the residual squared.

$$\sigma_t^2 = \propto_0 + \propto_1 \varepsilon_{t-1}^2 + \propto_2 \varepsilon_{t-2}^2 + \cdots + \propto_q \varepsilon_{t-q}^2 \quad \ldots\ldots\ldots (2)$$

The statistical analysis was performed using EViews 8 and Microsoft Excel.

Results and Discussion

Figure 1 represents the temporal variability of daily indicative USD/LKR spot exchange rate from early 2021 to mid-2025. The exchange rate stayed stable during the time period, 2021 to early 2022, and a sudden depreciation occurred in early 2022. After that, there was a fluctuation in exchange rate with stabilization in 2023 to mid-2025. The exchange rate varies between minimum of Rs.185 to maximum Rs.364.76. The average daily exchange rate is Rs.289.13 with a standard deviation of 58.91. The data set represents a slight left skewness and the Jarque-Bera test confirms that the series is significantly deviated from normality.

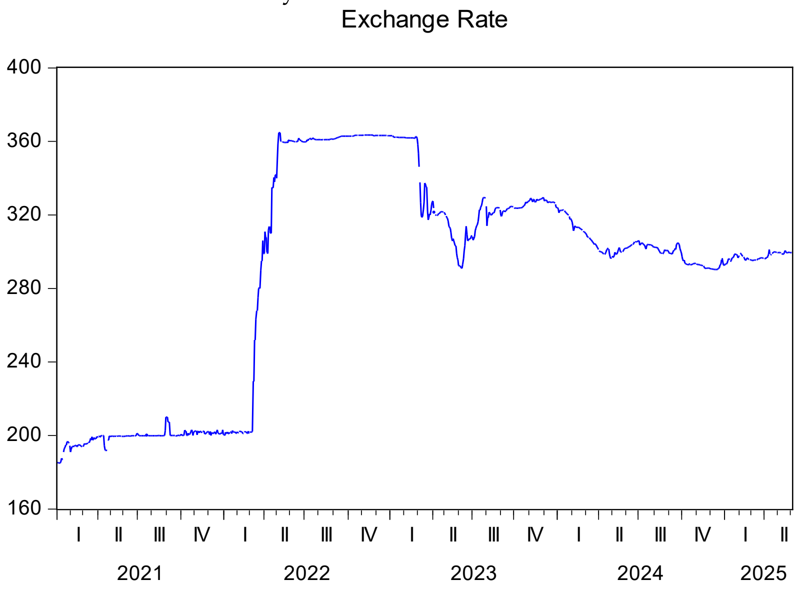


Figure 1: *Temporal Variability of the Daily Exchange Rate*

Model selection

Table 1: ADF test results of the original series

Null Hypothesis: EXCHANGE RATE has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 10 (Automatic - based on SIC, maxlag=21)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.422404	0.8542
Test critical values:	1% level	-3.966795	
	5% level	-3.414090	
	10% level	-3.129146	

*MacKinnon (1996) one-sided p-values.

According to Table 1, the Augmented Dickey Fuller (ADF) test statistics for the original series is not significant (t= -1.422, p= 0.854) since the p-value is greater than the significance value (0.05), confirming the original series is non-stationary.

Table 2: *ADF test results of the 1st differenced series*

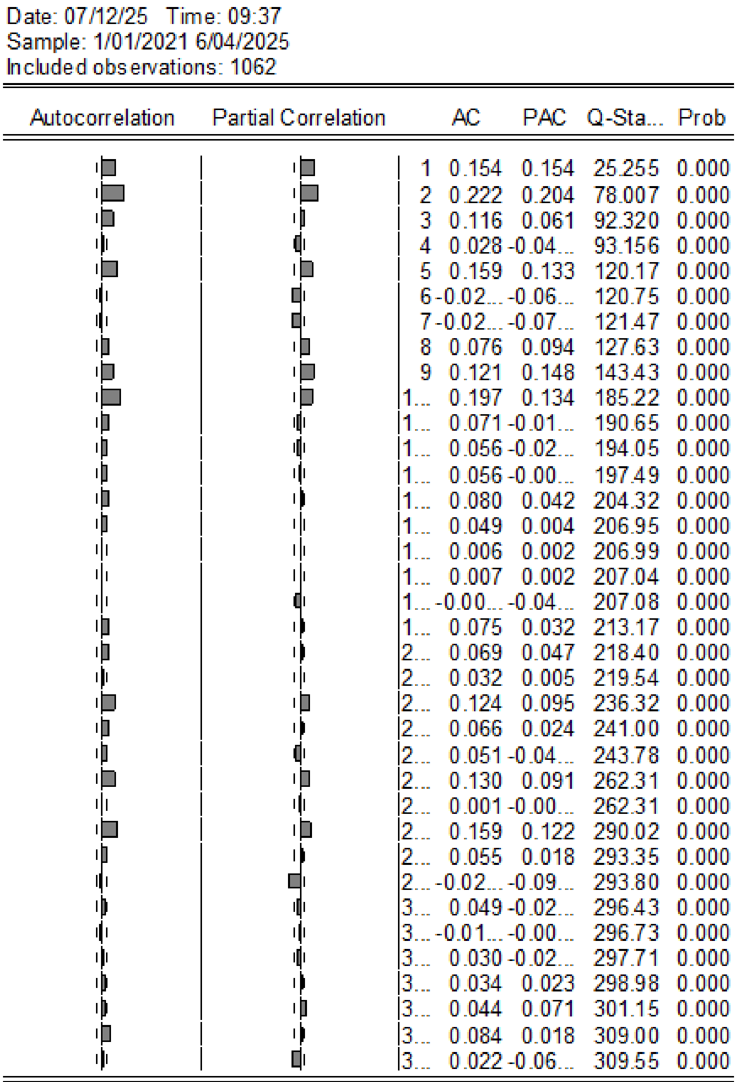
Null Hypothesis: D(EXCHANGE RATE) has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 9 (Automatic - based on SIC, maxlag=21)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-6.880329	0.0000
Test critical values:	1% level	-3.966795	
	5% level	-3.414090	
	10% level	-3.129146	

*MacKinnon (1996) one-sided p-values.

To ensure the stationarity of the series' first difference was calculated and the ADF test for the 1st difference series revealed that this series is stationary, as the corresponding test statistics is significant (p = 0.000) (Table 2)

Properties of the Stationary Series


Date: 07/12/25 Time: 09:37
Sample: 1/01/2021 6/04/2025
Included observations: 1062

Autocorrelation	Partial Correlation		AC	PAC	Q-Sta...	Prob
		1	0.154	0.154	25.255	0.000
		2	0.222	0.204	78.007	0.000
		3	0.116	0.061	92.320	0.000
		4	0.028	-0.04...	93.156	0.000
		5	0.159	0.133	120.17	0.000
		6	-0.02...	-0.06...	120.75	0.000
		7	-0.02...	-0.07...	121.47	0.000
		8	0.076	0.094	127.63	0.000
		9	0.121	0.148	143.43	0.000
		1...	0.197	0.134	185.22	0.000
		1...	0.071	-0.01...	190.65	0.000
		1...	0.056	-0.02...	194.05	0.000
		1...	0.056	-0.00...	197.49	0.000
		1...	0.080	0.042	204.32	0.000
		1...	0.049	0.004	206.95	0.000
		1...	0.006	0.002	206.99	0.000
		1...	0.007	0.002	207.04	0.000
		1...	-0.00...	-0.04...	207.08	0.000
		1...	0.075	0.032	213.17	0.000
		2...	0.069	0.047	218.40	0.000
		2...	0.032	0.005	219.54	0.000
		2...	0.124	0.095	236.32	0.000
		2...	0.066	0.024	241.00	0.000
		2...	0.051	-0.04...	243.78	0.000
		2...	0.130	0.091	262.31	0.000
		2...	0.001	-0.00...	262.31	0.000
		2...	0.159	0.122	290.02	0.000
		2...	0.055	0.018	293.35	0.000
		2...	-0.02...	-0.09...	293.80	0.000
		3...	0.049	-0.02...	296.43	0.000
		3...	-0.01...	-0.00...	296.73	0.000
		3...	0.030	-0.02...	297.71	0.000
		3...	0.034	0.023	298.98	0.000
		3...	0.044	0.071	301.15	0.000
		3...	0.084	0.018	309.00	0.000
		3...	0.022	-0.06...	309.55	0.000

Figure 2: *ACF and PACF for the Stationary Series*

Possible Models

To identify possible ARIMA models the plot of sample ACF and PACF of the stationary series (Fig. 2) was compared with their theoretical ones. Though the 1st differenced series is stationary, as many of both ACF and PACF at different lags are significant, it is not easy to identify the possible models. Therefore, by comparing many possible models, the following three models were selected as the best possible models: ARIMA (0,1,1), ARIMA(1,1,0) and ARIMA(1,1,1). However, it was found that the errors of each model are not random. Therefore, ACF and PACF of the squared residuals were taken. Despite an absence of significant autocorrelation at lag 1 in the squared residuals, the pronounced spike at lag 2(in possible models), confirmed by a highly significant ARCH LM test (for all three possible models), indicates the presence of conditional heteroskedasticity best captured by an ARCH(2) specification. Therefore, the three mean equations and the same variance equation were compared to identifying the best possible model (Table 3).

Table 3: *Summary of the Estimated Possible Model With ARCH*

Indicator	ARIMA(0,1,1)+ ARCH(2)	ARIMA(1,1,0)+ ARCH(2)	ARIMA(1,1,1)+ .ARCH(2)
Significant Parameters – Mean	1	1	2
Significant Parameters – Variance	2	2	2
Mean Constant	Significant	Significant	Significant
Variance Constant	Significant	Significant	Significant
Log Likelihood	-1873.922	-1756.956	-1737.736
Akaike Information Criterion (AIC)	3.538	3.321	3.287
Schwarz Criterion (SIC)	3.562	3.345	3.315
Hannan-Quinn Criterion (H-QC)	3.547	3.330	3.298

According to Table 3, ARIMA(1,1,1).ARCH(2) has all significant coefficients, the lowest AIC, the lowest SIC, the lowest H-QC and the maximum likelihood. Thus, compared to the other possible models, ARIMA(1,1,1).ARCH(2) is the best fitted model. The model can be written as;

Mean equation,

$$\Delta Z_t = Y_t - Y_{t-1}$$
$$\Delta Z_t = -0.2674 + 0.7672\Delta Z_{t-1} + \varepsilon_t + 0.3937\varepsilon_{t-1}$$
$$(1 - 0.7672B)(1 - B)Y_t = -0.2674 + (1 + 0.3937)\varepsilon_t \qquad \text{where B is such that } BY_t = Y_{t-1}$$

Variance equation,

$$\sigma_t^2 = 0.14 + 0.4767\varepsilon_{t-1}^2 + 6.3326\varepsilon_{t-2}^2$$

Model Diagnostics of the selected model

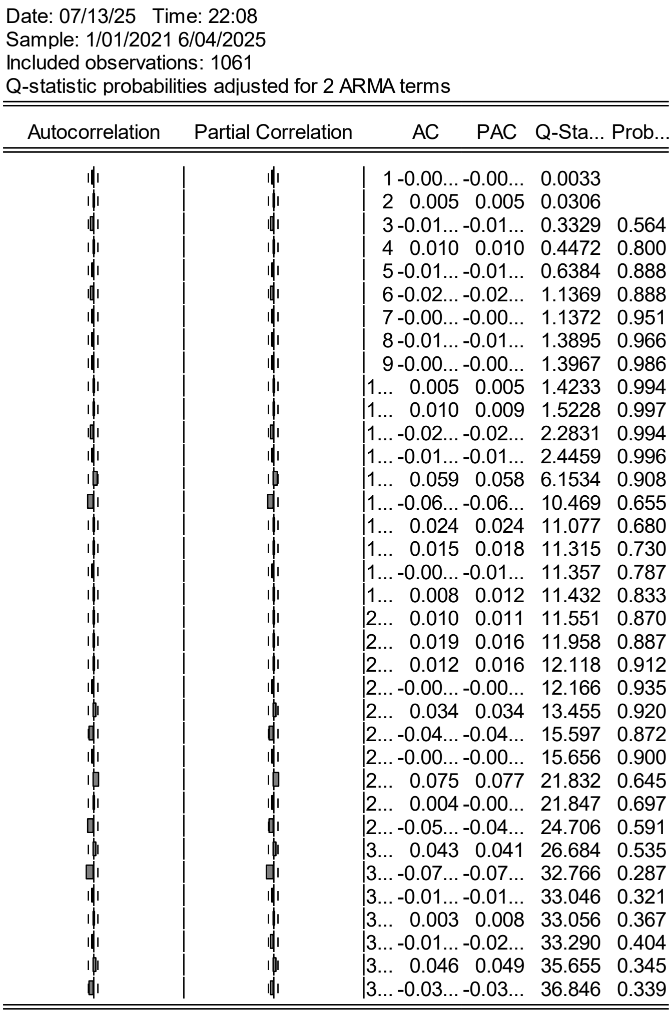
According to Figure 3, the p values of the residuals are greater than 0.05. Hence, it can be concluded with the 95% confidence that errors are identically and independently distributed. The constant variance of the residuals was confirmed since there was no systematic pattern shown in scatter plot between residuals and predicted values.

The Heteroskedasticity test for best fitted model resulted in p value of 0.9787(Table 4), which is greater than significance level(0.05). Hence, it can be concluded with 95% confidence that there is no ARCH effect present. Therefore, ARIMA(1,1,1).ARCH(2) is suitable for predicting the exchange rate.

Table 4: *Heteroskedasticity test for ARCH effect*

Heteroskedasticity Test: ARCH

F-statistic	0.000715	Prob. F(1,1058)	0.9787
Obs*R-squared	0.000716	Prob. Chi-Square(1)	0.9786



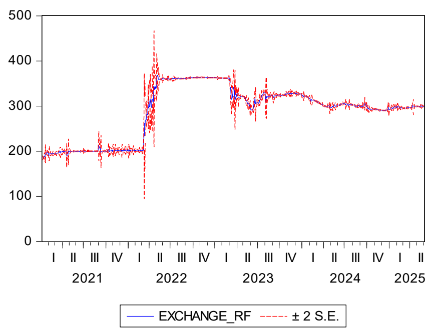
Date: 07/13/25 Time: 22:08
Sample: 1/01/2021 6/04/2025
Included observations: 1061
Q-statistic probabilities adjusted for 2 ARMA terms

Autocorrelation	Partial Correlation		AC	PAC	Q-Sta...	Prob...
		1	-0.00...	-0.00...	0.0033	
		2	0.005	0.005	0.0306	
		3	-0.01...	-0.01...	0.3329	0.564
		4	0.010	0.010	0.4472	0.800
		5	-0.01...	-0.01...	0.6384	0.888
		6	-0.02...	-0.02...	1.1369	0.888
		7	-0.00...	-0.00...	1.1372	0.951
		8	-0.01...	-0.01...	1.3895	0.966
		9	-0.00...	-0.00...	1.3967	0.986
		1...	0.005	0.005	1.4233	0.994
		1...	0.010	0.009	1.5228	0.997
		1...	-0.02...	-0.02...	2.2831	0.994
		1...	-0.01...	-0.01...	2.4459	0.996
		1...	0.059	0.058	6.1534	0.908
		1...	-0.06...	-0.06...	10.469	0.655
		1...	0.024	0.024	11.077	0.680
		1...	0.015	0.018	11.315	0.730
		1...	-0.00...	-0.01...	11.357	0.787
		1...	0.008	0.012	11.432	0.833
		2...	0.010	0.011	11.551	0.870
		2...	0.019	0.016	11.958	0.887
		2...	0.012	0.016	12.118	0.912
		2...	-0.00...	-0.00...	12.166	0.935
		2...	0.034	0.034	13.455	0.920
		2...	-0.04...	-0.04...	15.597	0.872
		2...	-0.00...	-0.00...	15.656	0.900
		2...	0.075	0.077	21.832	0.645
		2...	0.004	-0.00...	21.847	0.697
		2...	-0.05...	-0.04...	24.706	0.591
		3...	0.043	0.041	26.684	0.535
		3...	-0.07...	-0.07...	32.766	0.287
		3...	-0.01...	-0.01...	33.046	0.321
		3...	0.003	0.008	33.056	0.367
		3...	-0.01...	-0.02...	33.290	0.404
		3...	0.046	0.049	35.655	0.345
		3...	-0.03...	-0.03...	36.846	0.339

*Probabilities may not be valid for this equation specification.

Figure 3: *ACF and PACF of the Residuals of the Best-Fitted Model*

The Forecast Values for the Training Data Set with The Confidence Interval



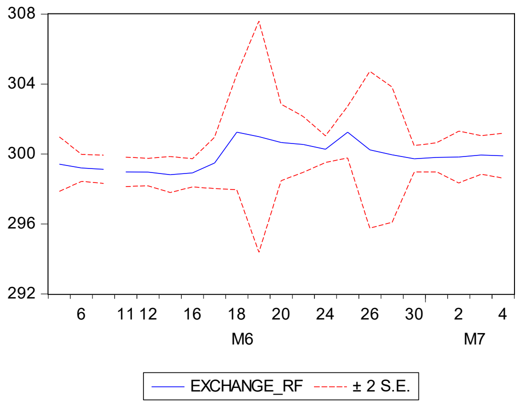
Forecast: EXCHANGE_RF
Actual: EXCHANGE_RATE
Forecast sample: 1/01/2021 6/04/2025
Adjusted sample: 1/05/2021 6/04/2025
Included observations: 1061

Root Mean Squared Error	2.137874
Mean Absolute Error	0.866874
Mean Abs. Percent Error	0.316239
Theil Inequality Coefficient	0.003621
Bias Proportion	0.004539
Variance Proportion	0.001064
Covariance Proportion	0.994397

Figure 4: *The forecast and its 95% Confidence Limits for the training data set*

As per the Figure 4, ARIMA+ARCH model produced highly accurate in-sample forecasts with a Mean Absolute Percentage Error (MAPE) of just 0.32%, a Theil U statistic of 0.0036, and over 99% of the forecast error attributable to unsystematic variation. The percentage error also varied from -4.5% to 12%. This suggests that the model is well-specified, has minimal structural bias, and is suitable for forecasting.

The best fitted model ARIMA(1,1,1)+ARCH(2) was tested for an independent data set from 2021/06/05 to 2021/07/04 (Table 5). According to Figure 5, the forecast is stable for the independent data set. The MAPE is only 0.087% and the Theil inequality coefficient is closer to zero with the small bias proportion (0.07), indicating more accurate prediction. The percentage error varied from -0.25% to 0.43%.



Forecast: EXCHANGE_RF	
Actual: EXCHANGE_RATE	
Forecast sample: 6/05/2025 7/04/2025	
Included observations: 21	
Root Mean Squared Error	0.421076
Mean Absolute Error	0.263990
Mean Abs. Percent Error	0.087883
Theil Inequality Coefficient	0.000702
Bias Proportion	0.069906
Variance Proportion	0.047985
Covariance Proportion	0.882109

Figure 5: *The forecast and its 95% Confidence Limits for the test data set*

Study Limitations

This study is univariately based on past values of the USD/LKR SPOT exchange rate and does not consider macroeconomic factors such as interest rates, foreign reserves, remittances, political events, or trade policies. Therefore, the model may not fully capture all drivers of exchange rate fluctuations, potentially limiting its forecasting effectiveness under unusual economic conditions or shocks.

Conclusion and Recommendation

This study provides an accurate model to forecast the indicative rate of the USD/LKR spot exchange rate using ARIMA and ARCH models. The result confirmed that the best model is ARIMA(1,1,1)+ARCH(2) due to its significant coefficients, the lowest AIC, the lowest SIC, the lowest H-QC and the maximum likelihood. The model diagnostics confirmed that the errors are identically and independently distributed with no ARCH effect present.
Hence, the best fitted model is,

$$(1 - 0.7672B)(1 - B)Y_t = -0.2674 + (1 + 0.3937)\varepsilon_t$$

$$\sigma_t^2 = 0.14 + 0.4767\varepsilon_{t-1}^2 + 6.3326\varepsilon_{t-2}^2$$

The forecasting power of the model was validated using a test dataset, showing a minimal Mean Absolute Percentage Error (MAPE) of 0.087% and a Theil Inequality Coefficient (U) of 0.0007. These results underscore the model's robustness in accurately predicting the exchange rate.

Hence, financial institutions, policy makers, and investors are encouraged to use the ARIMA(1,1,1)+ ARCH(2) model for short-term forecasting. It is a reliable tool for predicting future exchange rates because of its accuracy and low error rates.

We recommend incorporating key external variables into the forecasting framework to capture broader economic drivers.

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