# Indian Institute of Technology Jodhpur


## Course Name: Time Series Analysis

## Assignment 1

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*Submitted by*

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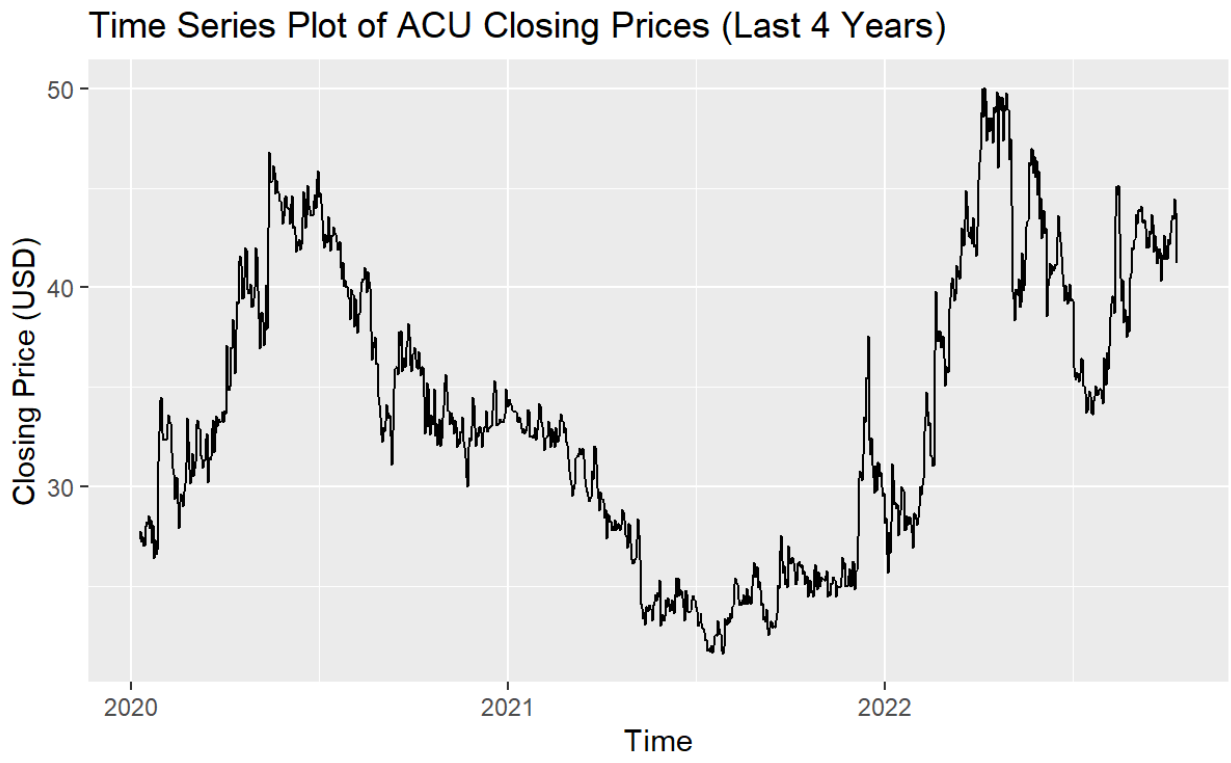
For this assignment, I have considered Acme United Corporation stock (ACU) data from yahoo.com using the quantmod package. The closing price is considered for analysis. The dataset is for 4 years, from 21-10-2020 to 20 - 10 -2024.

1. Here is the plot of the last 4 years

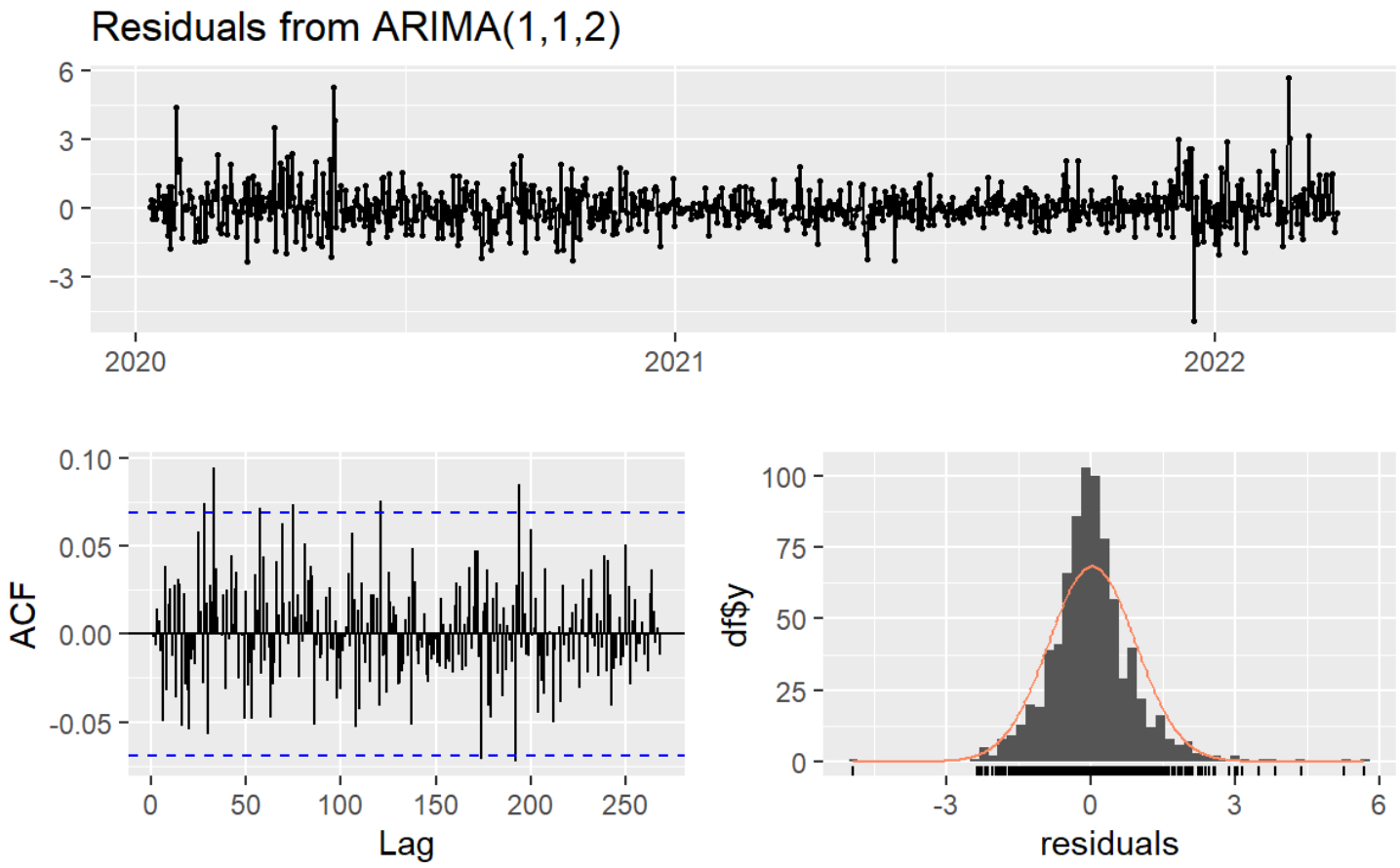



2. Total datapoints are 1005. I have considered 80 % of the total data as training and the rest 20 % as testing.

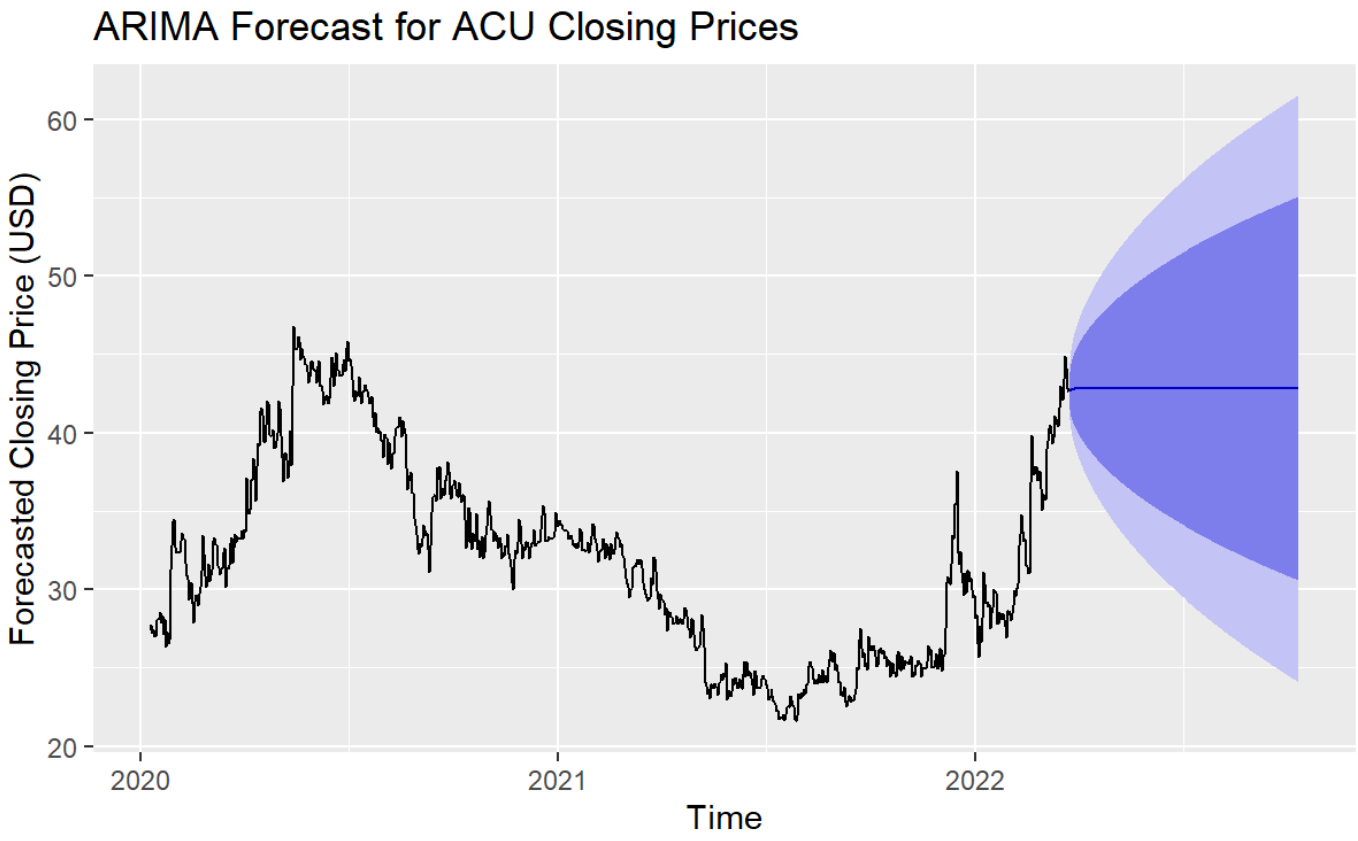
3. The `auto.arima()` function identified the ARIMA(1,1,2) model as the most suitable for the train set. The coefficients for AR1, MA1, and MA2 terms are significant, and the AIC (2134.05) and BIC (2152.81) indicate the goodness of fit.

**4.** Residual diagnostic checking of the above ARIMA(1, 1, 2) model.

The Ljung-Box test produced a high p-value (0.9868), indicating that the residuals are white noise, meaning they are random and not correlated. This is a positive indication that the ARIMA model fits the data well.



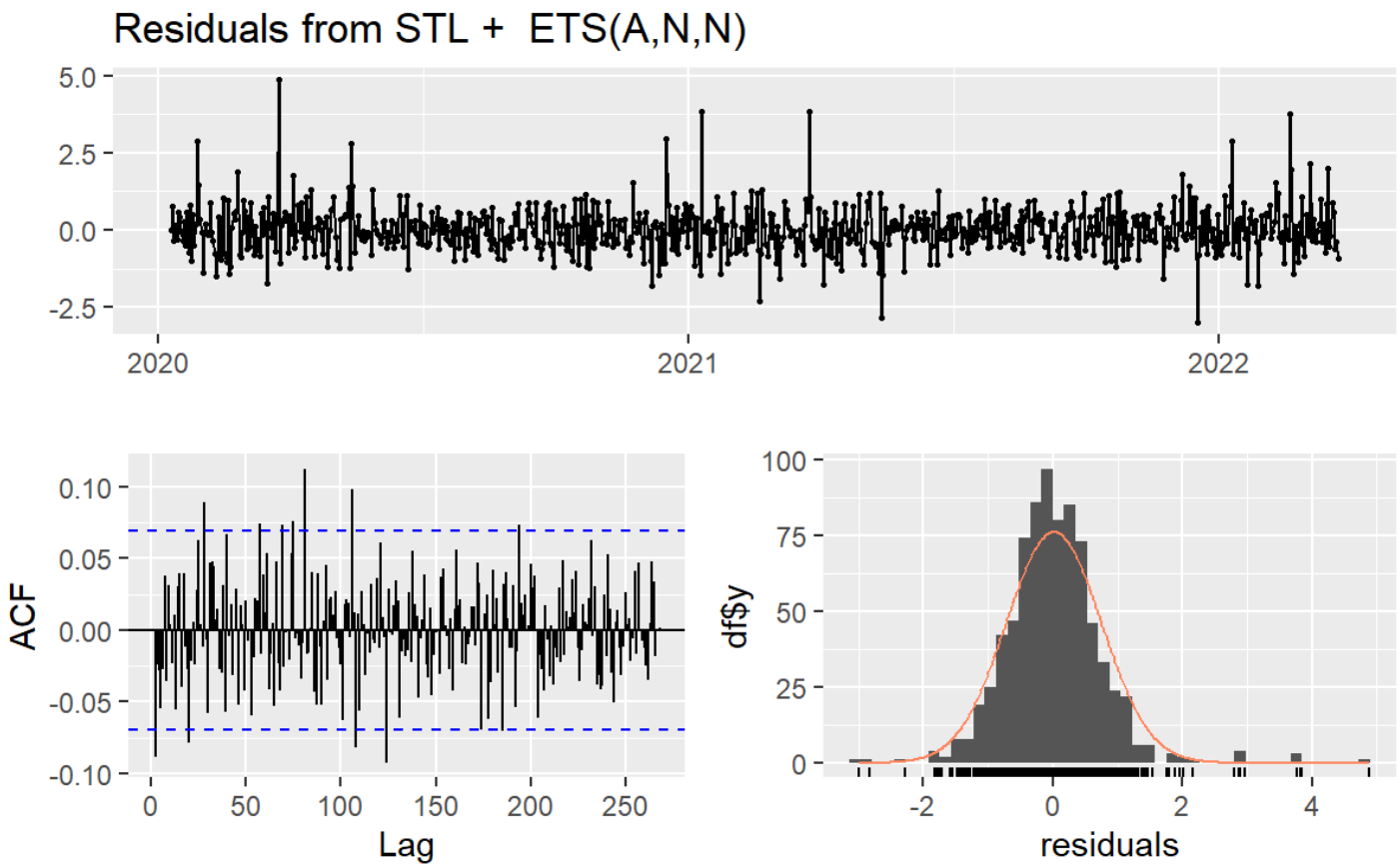
**5.** Forecast using ARIMA(1, 1, 2)



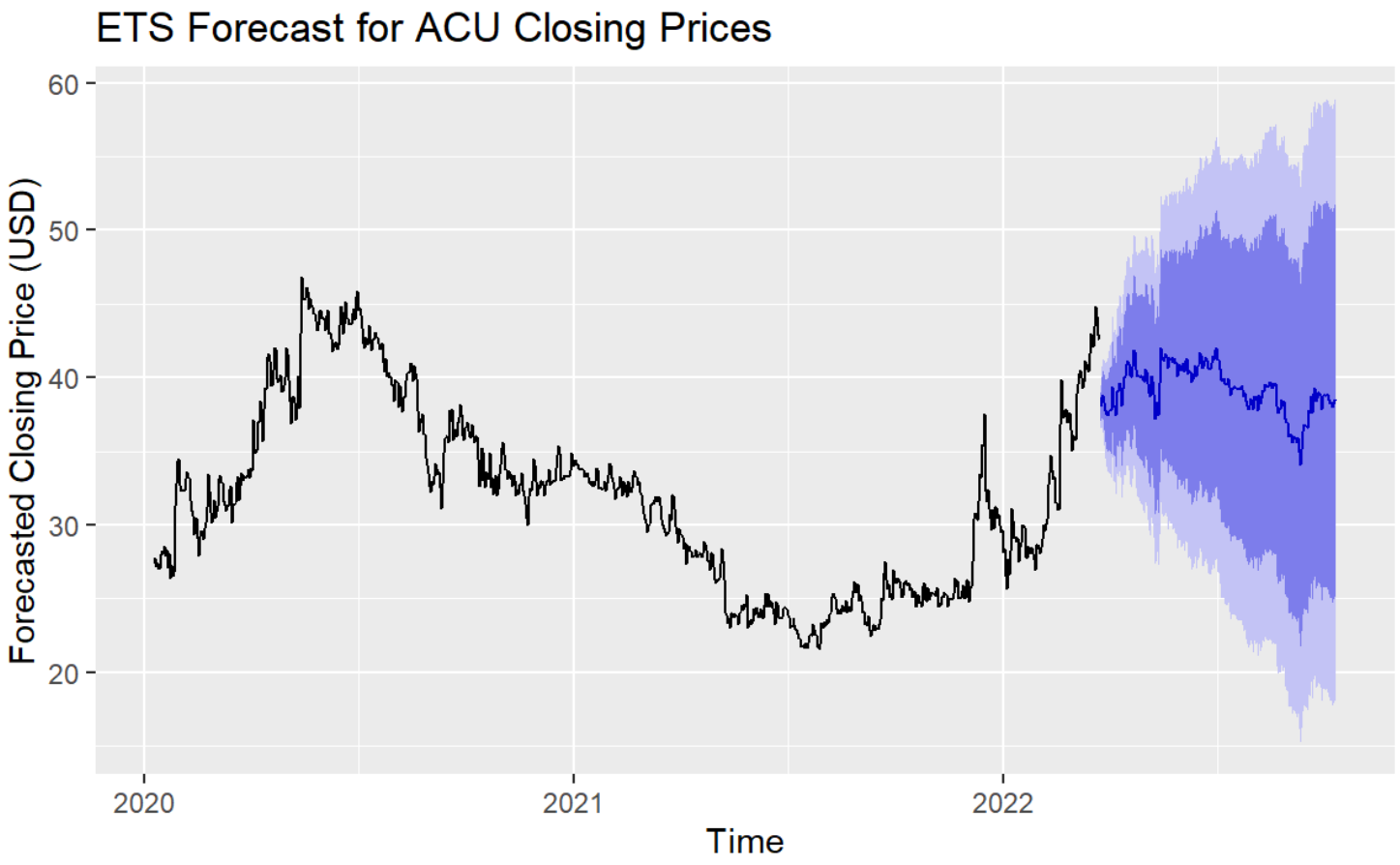

**6.** The ETS model identified was an ETS(A, N, N) (additive error, no trend, no seasonality). The AIC (4893.22) and BIC (4907.29) indicate a reasonable fit, though slightly higher compared to the ARIMA model.

**7.** Residual diagnostic checking of the above ETS(A, N, N) model.

The Ljung-Box test shows significant autocorrelation in the residuals (p-value = 0.0418), indicating the STL + ETS(A, N, N) model may not fully capture all patterns in the data and could need adjustments. The residuals is not White noise.



**8.** Forecast using ETS(A, N, N)



**9.** To compare the ARIMA and ETS models based on the accuracy metrics provided, let's focus on the test set Key metrics:

- **ME (Mean Error)**: Ideally close to 0, indicating little bias.
  - ARIMA: -1.07
  - ETS: 2.53
  - ARIMA shows less bias, as it is closer to 0.
- **RMSE (Root Mean Square Error)** and **MAE (Mean Absolute Error)**: Lower values are better, indicating smaller prediction errors.
  - ARIMA RMSE: 4.40, MAE: 3.48
  - ETS RMSE: 5.08, MAE: 4.23
  - ARIMA has lower RMSE and MAE, indicating better accuracy.
- **MPE (Mean Percentage Error)** and **MAPE (Mean Absolute Percentage Error)**: Lower values indicate more accurate percentage-based predictions.
  - ARIMA MPE: -3.66, MAPE: 8.72%
  - ETS MPE: 5.09, MAPE: 9.88%
  - ARIMA has a better MAPE (lower percentage error).
- **ACF1 (Autocorrelation of residuals at lag 1)**: Ideally close to 0, indicating uncorrelated residuals (i.e., less model misspecification).
  - ARIMA: 0.96
  - ETS: 0.95
  - Both models have similar autocorrelation in residuals, indicating comparable performance in this area.
- **Theil's U**: Values closer to 1 suggest better predictive accuracy. Higher values indicate worse performance.
  - ARIMA: 3.90
  - ETS: 3.94
  - ARIMA has a slightly better Theil's U score.

**Conclusion:**

The ARIMA model generally outperforms the ETS model on the test set based on RMSE, MAE, MAPE, and Theil's U, indicating that ARIMA provides better predictive accuracy.

## **10.** Using cross-validation

ARIMA Cross-Validation MSE: 0.8754185
ETS Cross-Validation MSE: 0.8737757

Both values are comparable. Although the ETS MSE is lower than ARIMA
So Based on cross-validation, ETS performs better.