Time series analysis on the stock price of Tesla Inc.

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4 Exploratory Data Analysis

To obtain a comprehensive understanding of the data, we conduct explanatory data analysis (EDA) first. Figure 1(a) is the time series plot of all the given time points. We observe that the average price of Tesla before 2020 is considerably lower than that after 2020. Also, the stock price before 2020 seems to have a constant trend and no seasonality. Moreover, due to the excessive number of time points, it is difficult to visually examine the trend and seasonality pattern for data after 2020. Therefore, for the sake of interest and convenience, we decide to only analyze the last 300 time points, which cover the period from 2020-08-26 to 2021-11-02 excluding weekends.
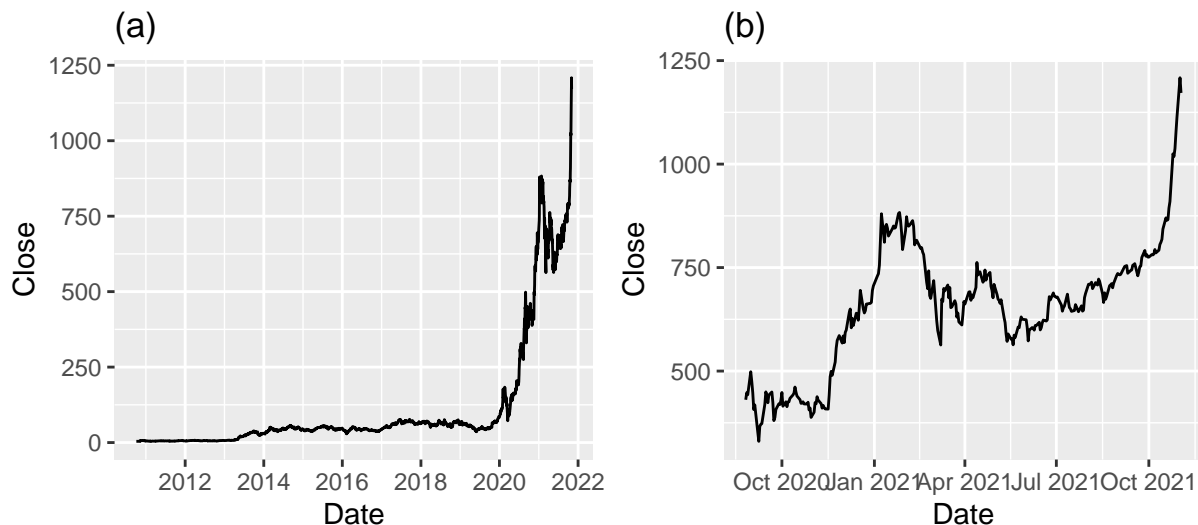

Figure 1: (a) Time series plot of all available trading days. (b) Time series plot of last 300 trading days

Figure 1(b) is the time series plot of the close prices of Tesla in last three hundred trading days before and including 2021-11-02. We first observe slight heteroskedasticity in Figure 1(b), so we experiment with square root and natural log transformation.

Intuitively, the (transformed) data is not stationary since there exists a nonlinear trend and possible seasonality. To be more concrete, we plot the sample ACF and PACF of the (transformed) data.

COMMENT TODO. (Decaying ACF -> trend) Next, to verify our superposition that the data does not have a strong seasonality pattern, we use the periodogram.
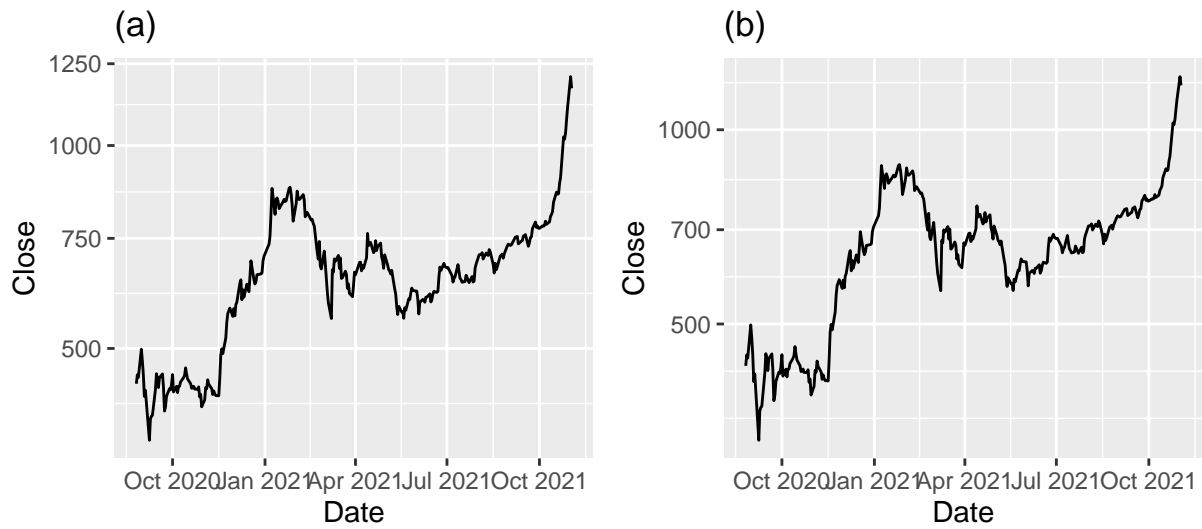
2

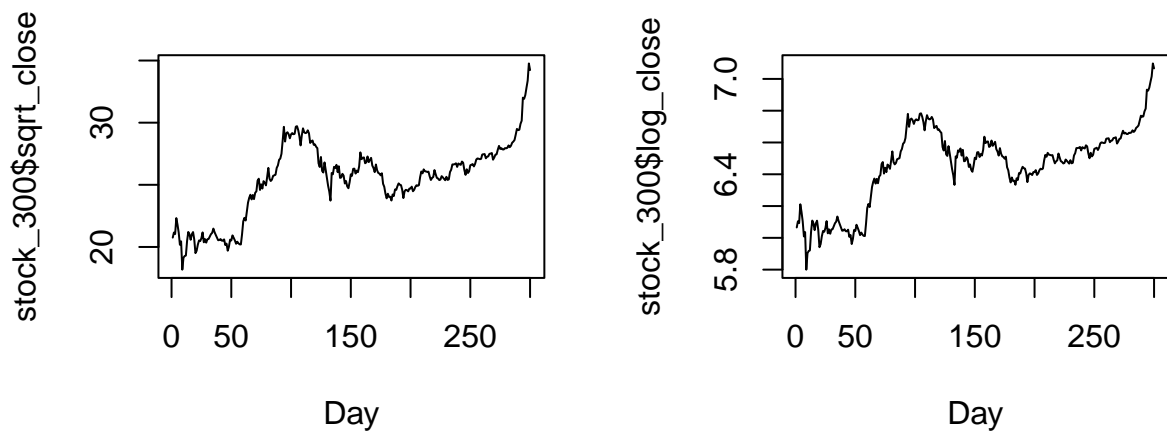Figure 2: (a) Time series plot of all available trading days. (b) Time series plot of last 300 trading days

Figure 3: (a) Time series plot of all available trading days. (b) Time series plot of last 300 trading days
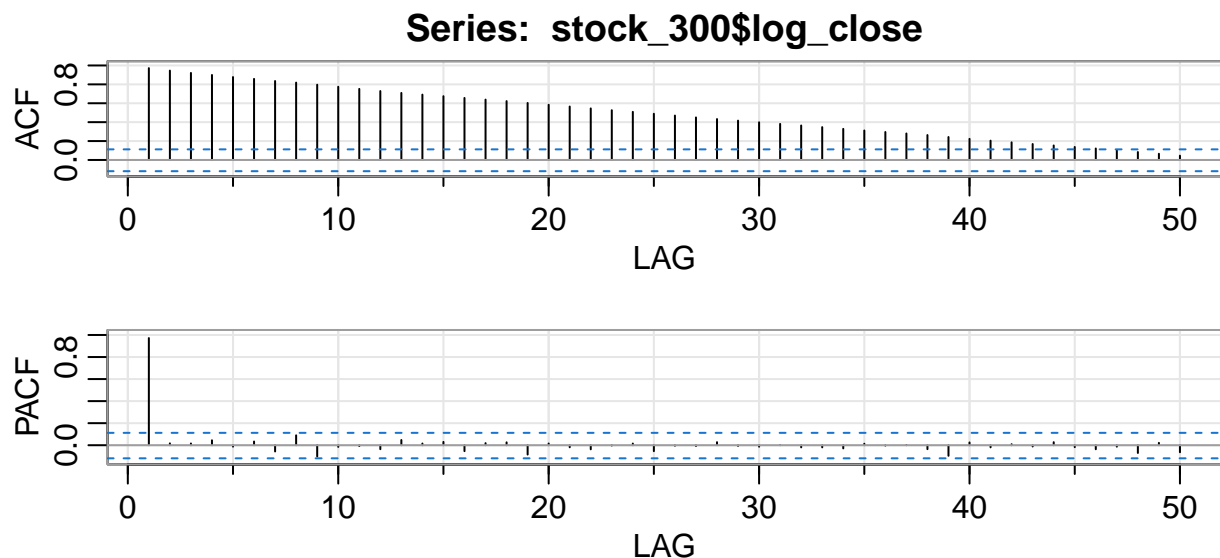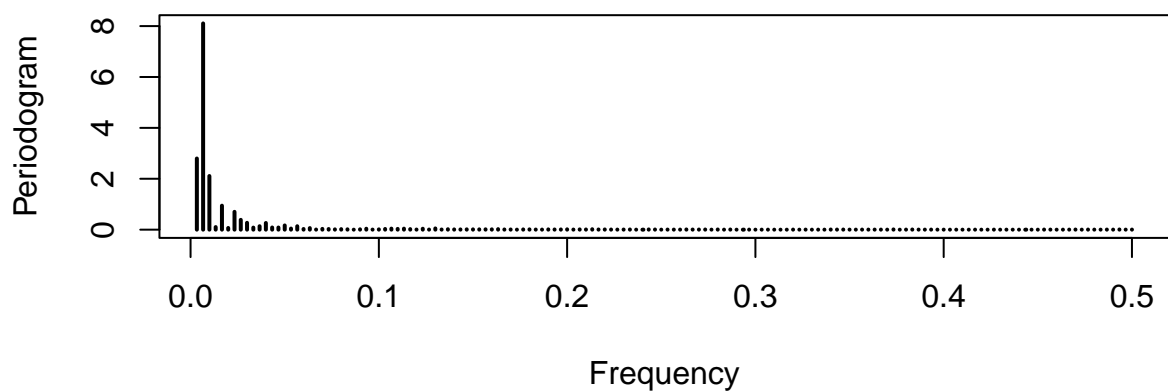
Series: stock_300$log_close


Figure 4: TODO

As we see multiple consecutive spikes, which is called "leakage", we confirm that there is not a dominant seasonality pattern in our data.

5   Model Construction

With a comprehensive understanding of our data, we start to experiment and construct different time series model. We first stabilize the variance of our data. Then, we choose and build two non-parametric signal models to remove any trend or seasonality from the data so that the residuals are approximately weekly stationary. We do not consider any parametric method for modeling trend because we think the trend of the stock price data is too complicated to be modeled by a parametric model, such as a high-order polynomial. We could use a 15 or 20 order polynomial, but it will overfit the training data and give inprecise predictions.

Finally, based on each signal model, we provide two ARMA models or its extension, such as SARMA or ARIMA, to whiten the residuals of the signal model. Thus, we have four candidate models, and we will explain how we select a final model in the next section.

5.1   Non-parametric Model: exponential smoothing with seasonal differencing

Series: res
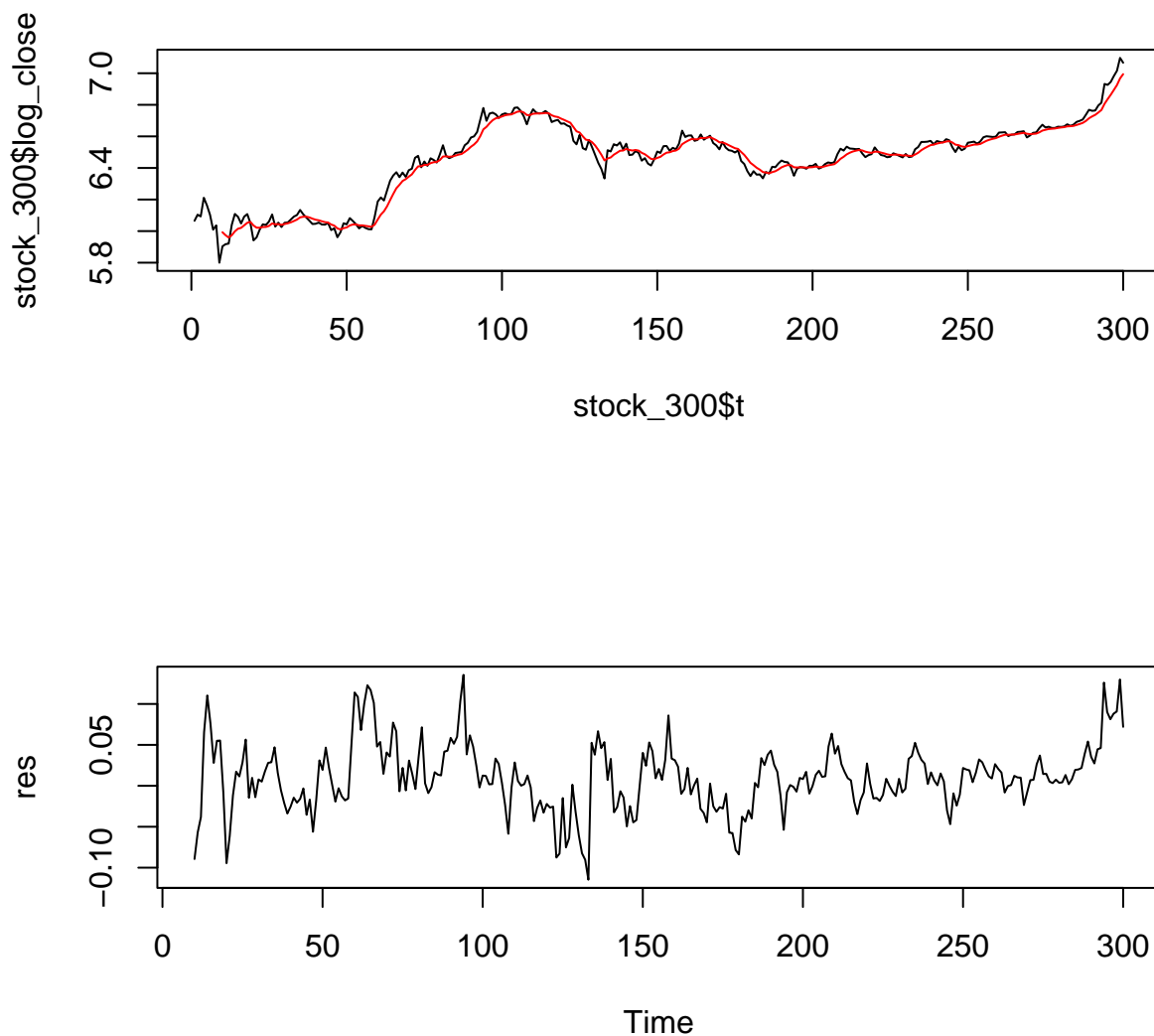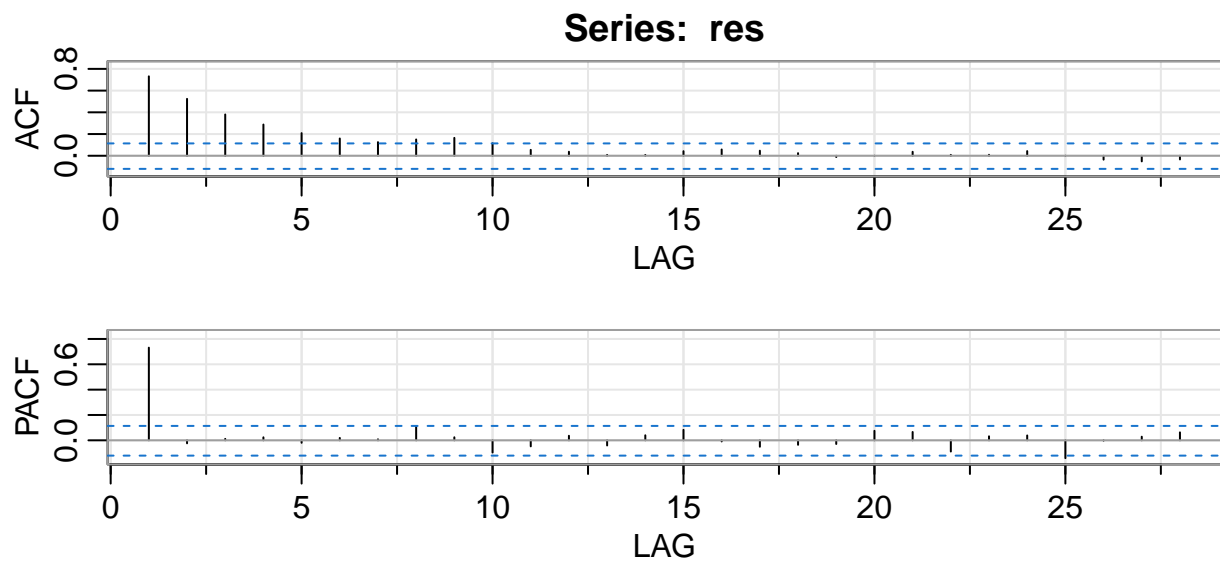
```
##         [,1]  [,2] [,3] [,4]  [,5] [,6] [,7] [,8] [,9] [,10] [,11] [,12] [,13]
## ACF   0.73  0.52 0.38 0.29  0.21 0.16 0.13 0.15 0.16  0.12  0.05  0.04  0.01
## PACF  0.73 -0.02 0.01 0.02 -0.02 0.02 0.01 0.11 0.02 -0.10 -0.05  0.04 -0.04
##        [,14] [,15] [,16] [,17] [,18] [,19] [,20] [,21] [,22] [,23] [,24] [,25]
## ACF    0.01  0.04  0.06  0.05  0.02 -0.01  0.00  0.04  0.01  0.01  0.04  0.00
## PACF   0.04  0.08 -0.01 -0.05 -0.04 -0.03  0.08  0.07 -0.09  0.03  0.04 -0.14
##        [,26] [,27] [,28]
## ACF   -0.04 -0.05 -0.03
## PACF   0.00  0.03  0.06
```

Series: diff_res
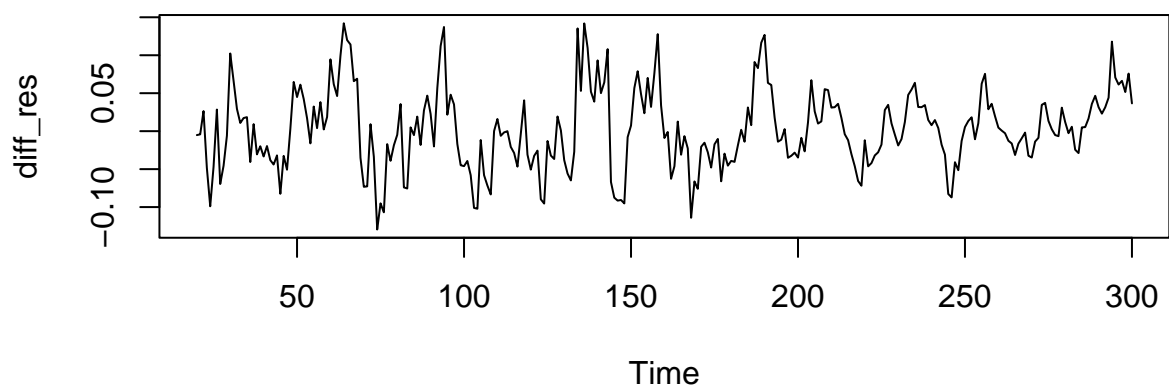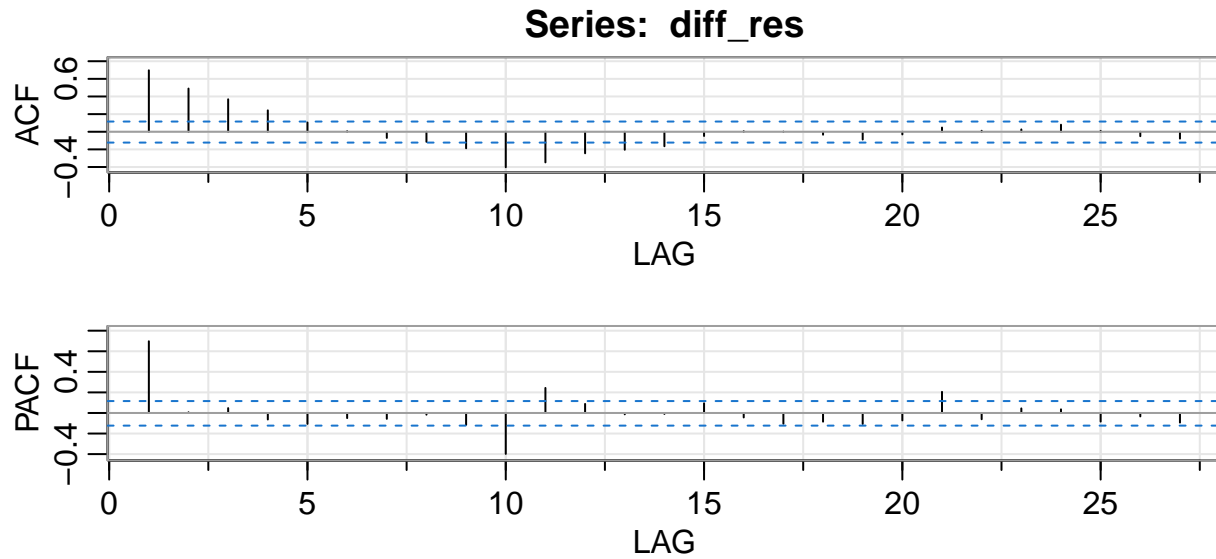

```
##      [,1] [,2] [,3]  [,4]  [,5]  [,6]  [,7]  [,8]  [,9] [,10] [,11] [,12] [,13]
## ACF   0.7 0.49 0.37  0.24  0.10  0.01 -0.07 -0.11 -0.19  -0.4 -0.35 -0.24 -0.20
## PACF  0.7 0.01 0.05 -0.06 -0.11 -0.05 -0.06 -0.02 -0.12  -0.4  0.24  0.09 -0.01
##      [,14] [,15] [,16] [,17] [,18] [,19] [,20] [,21] [,22] [,23] [,24] [,25]
## ACF  -0.16 -0.05  0.01   0.0 -0.03 -0.09 -0.03  0.05  0.01  0.03  0.08  0.01
## PACF -0.01  0.09 -0.04  -0.1 -0.08 -0.11 -0.07  0.21 -0.06  0.04  0.04 -0.08
##      [,26] [,27]
## ACF  -0.05 -0.08
## PACF -0.03 -0.09
```

5.2   Non-parametric Model: second order differencing with seasonal differencing

6   Model Comparision and Selection

7   Final Model

7.1   Model interpretation

7.2   Prediction

8   Conclusion