Introduction to Forecasting Models

Exercise 1: Graphical Analysis and Descriptive Statistics

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Abstract: In this exercise a graphical analysis and descriptive statistics of selected time series is carried out. The two selected time series are daily closing stock prices of Google and Apple companies. The selected time frame is from January 2016 to December 2021.

Keywords: EDA, Descriptive Statistics, Time Series, Stock Prices

Introduction

Purpose of this paper is to provide a basic analysis of daily closing stock prices of two giant tech companies Apple and Google in years from 2016 to 2021. The first part concerns with graphical analysis of the original time series as well as with their transformed versions. In the latter part descriptive statistics of the time series are presented. The whole analysis is implemented in statistical software .

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1 Graphical Analysis

First the original time series will be inspected. The growth trend can be easily seen and it is obvious that none of the series is stationary, therefore we will need to transform them for further analysis. Both series also contain a fall in the period of the first COVID-19 outbreak.

Figure 1: Apple Closing Prices

Figure 2: Google Closing Prices

Next the time series are transformed to returns using following formula:

$$r_t = \frac{price_t - price_{t-1}}{price_{t-1}} \tag{1.1}$$

From the figures of returns we might assume that there was higher volatility in 2020 compared to other observed years, we will inspect this assumption later from the values of variance.

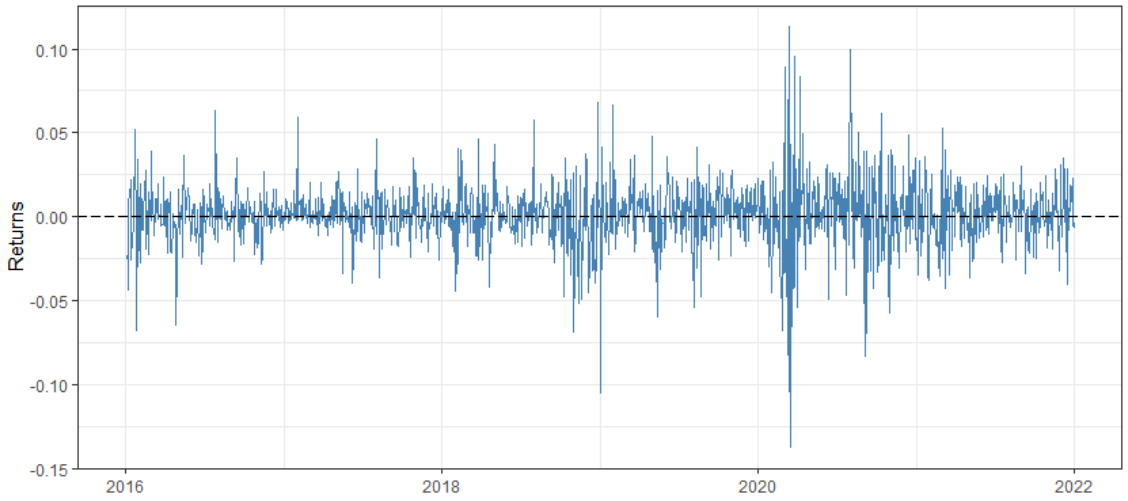

Figure 3: Apple Returns

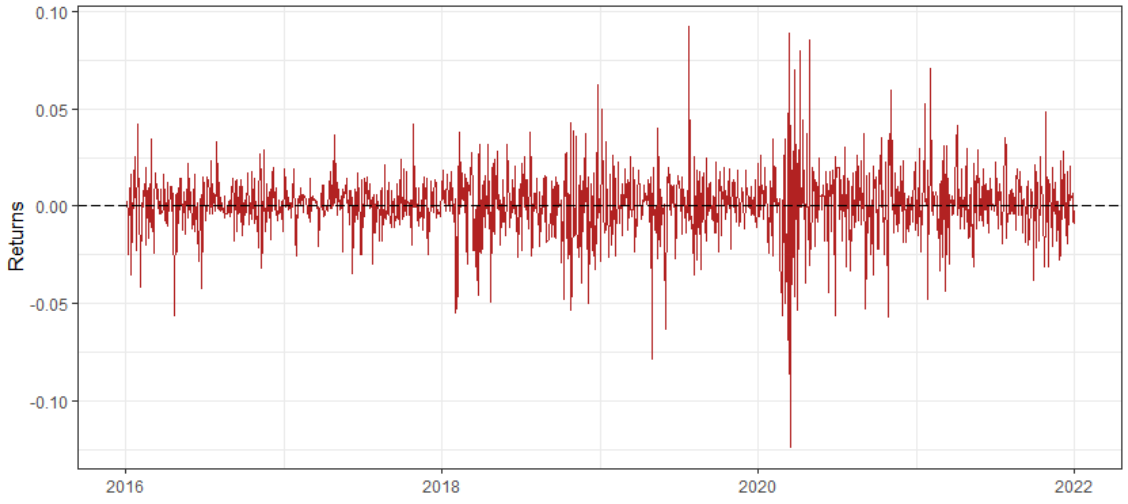

Figure 4: Google Returns

Next we will have a look on the distribution of returns of both series, from that we may see whether the returns can be normal distributed or not. The histogram bars show represent the observed data, the curve is an approximation by normal distribution. Even though the real values look visually quite close to the normal distribution approximation we have to take into consideration the count of observed values which is quite high and will contribute to rejecting the null hypothesis of normally distributed values. We will present the numerical results in the second part.

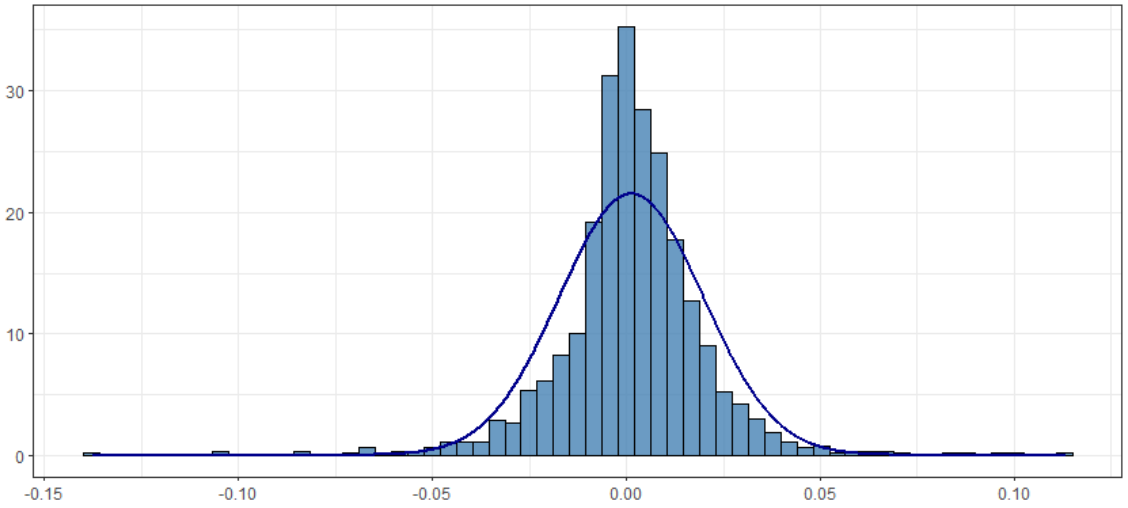

Figure 5: Apple Returns Distribution

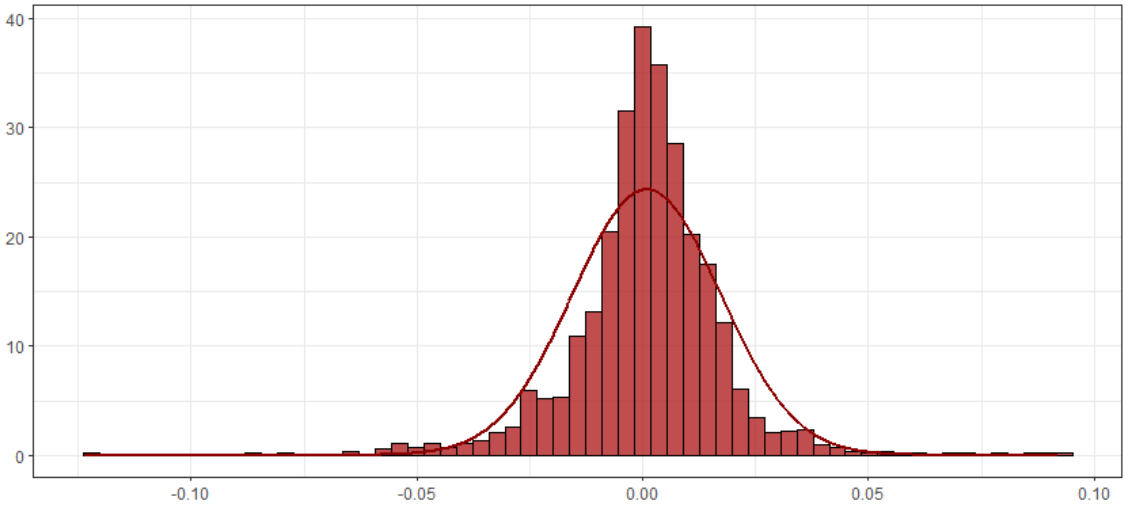

Figure 6: Google Returns Distribution

Ultimately, we will have a look on the relation between the two time series. The scatter plot implies a strong positive correlation which is in line with our expectations as both of the companies are operate on the same market.

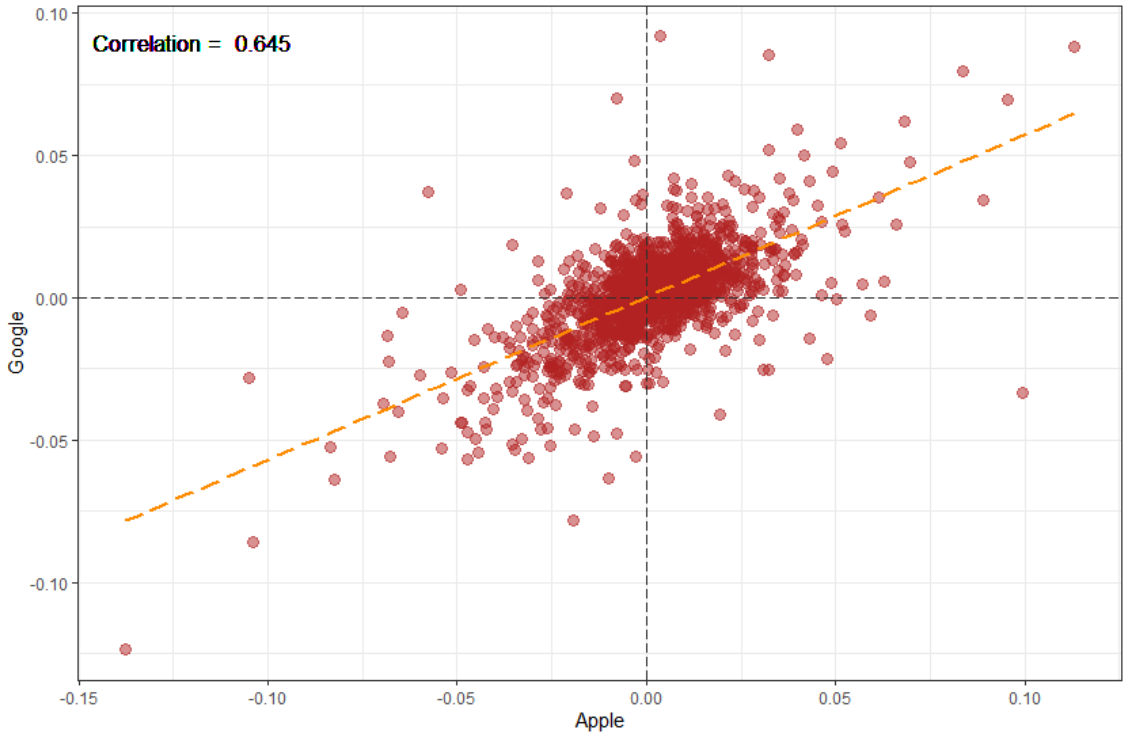

Figure 7: Scatter plot

2 Descriptive Statistics

In this section we will have a look at some descriptive statistics to complete and support the results from graphical analysis.

Firstly, we present analysis of the whole time period for both stocks separately. While Apple has bigger average growth (0.13 % vs 0.09 %), Google's stock prices ware more stable in the selected period which is in line with the Capital Asset Pricing Model. Both series are slightly skewed but we can observe high Excess Kurtosis that probably led to rejection of null hypothesis of normally distributed values in Jarque-Bera test.

The autocorrelation tests suggest that there is an autocorrelation present as we reject all of the null hypothesis of no autocorrelation for all selected lags.

Regarding Value at Risk statistics we again observe higher absolute values for Apple company which speaks for higher volatility compared to Google.

Statistics	Apple	Google
Mean	0.0013	0.0009
Median	0.0011	0.0013
Std	0.019	0.016
Min	-0.138	-0.124
Max	0.113	0.092
Skewness	-0.336	-0.357
Excess Kurtosis	9.972	9.227
Obs	1,510	1,510
Jarque-Bera statistic	3,086.8	2,471.9
Jarque-Bera p-value	0	0
Q(1) statistic	17.4	21.2
Q(1) p-value	0.00003	< 0.00001
Q(5) statistic	21.9	23.3
Q(5) p-value	0.001	0.0003
Q(10) statistic	88.2	98.1
Q(10) p-value	< 0.00001	< 0.00001
1% VaR	-0.051	-0.050
1% CVaR	-0.075	-0.063
99% VaR	0.050	0.042
99% CVaR	0.071	0.062

Table 1: Overall Descriptive Statistics

The yearly statistics show the difference of year 2020 compared to the other years. For both companies we observe in this year the highest standard deviation of returns of all years and the biggest fall in one day. Apple recorded also the biggest rise of its stock price in one day in 2020. The only year when both companies were losing its value on average was 2018.

Year	Mean	Std	Min	Max	Skewness	Excess Kurtosis
2016	0.0004	0.015	−0.068	0.063	−0.307	7.260
2017	0.002	0.011	−0.040	0.059	0.433	7.641
2018	−0.0003	0.018	−0.069	0.068	−0.138	4.841
2019	0.002	0.017	−0.105	0.066	−1.118	11.000
2020	0.002	0.029	−0.138	0.113	−0.306	6.818
2021	0.001	0.016	−0.043	0.052	−0.122	3.332

Table 2: Yearly Descriptive Statistics - Apple

Year	Mean	Std	Min	Max	Skewness	Excess Kurtosis
2016	0.0002	0.013	−0.056	0.042	−0.631	5.482
2017	0.001	0.010	−0.035	0.042	−0.095	5.611
2018	−0.00003	0.018	−0.054	0.062	−0.441	4.266
2019	0.001	0.015	−0.078	0.092	0.067	11.945
2020	0.001	0.024	−0.124	0.088	−0.480	7.202
2021	0.002	0.015	−0.048	0.070	0.301	5.303

Table 3: Yearly Descriptive Statistics - Google

If we compare the correlation between the two series over years, we can see that the highest one was recorder in 2020 and the second in 2018. These years were also the most volatile, so we may assume that in the times of uncertainty on the market the stock prices tend to follow the same trends more than in the times when the market is stable.

Year	Correlation
Overall	0.645
2016	0.502
2017	0.478
2018	0.670
2019	0.559
2020	0.759
2021	0.556

Table 4: Correlation between series

Conclusion

In this exercise we had a closer look on two stock price time series. The two considered companies were Google and Apple, the selected time period was from January 2016 to December 2021.

We found a positive correlation between the two time series, which tends to be stronger in times of greater volatility than in times of stable conditions on the stock market.

Apple recorded a bigger average growth in the observed period but also higher volatility which is in line with Capital Asset Pricing Model.