Final Project: Milestone 3

Mourad Askar

[1] DSC 425 - Time Series Analysis and Forecasting

[2] DePaul University

Final Project: Milestone 3

Crypto-Currency and Stock Data

S&P 500 and Bitcoin

S&P 500 Summary Statistics

```
## [1] "xts" "zoo"
```

```
##      Index              stock.SPY
##  Min.   :2016-10-03   Min.   :190.4
##  1st Qu.:2018-01-02   1st Qu.:242.5
##  Median :2019-04-03   Median :271.6
##  Mean   :2019-04-02   Mean   :287.8
##  3rd Qu.:2020-07-01   3rd Qu.:319.1
##  Max.   :2021-09-29   Max.   :451.7
```

```
##      Index            stock.SPY.log.returns
##  Min.   :2016-10-04   Min.   :-0.1158865
##  1st Qu.:2018-01-02   1st Qu.:-0.0029387
##  Median :2019-04-03   Median : 0.0007856
##  Mean   :2019-04-02   Mean   : 0.0006296
##  3rd Qu.:2020-07-01   3rd Qu.: 0.0055351
##  Max.   :2021-09-29   Max.   : 0.0867310
```

Bitcoin Summary Statistics

```
## [1] "xts" "zoo"
```

```
##      Index              stock.BTC
##  Min.   :2016-10-01   Min.   :  610.2
##  1st Qu.:2017-12-31   1st Qu.: 4110.7
##  Median :2019-04-01   Median : 8040.3
##  Mean   :2019-04-01   Mean   :12728.8
##  3rd Qu.:2020-06-30   3rd Qu.:11346.4
##  Max.   :2021-09-30   Max.   :63503.5
##                       NA's   :4
```

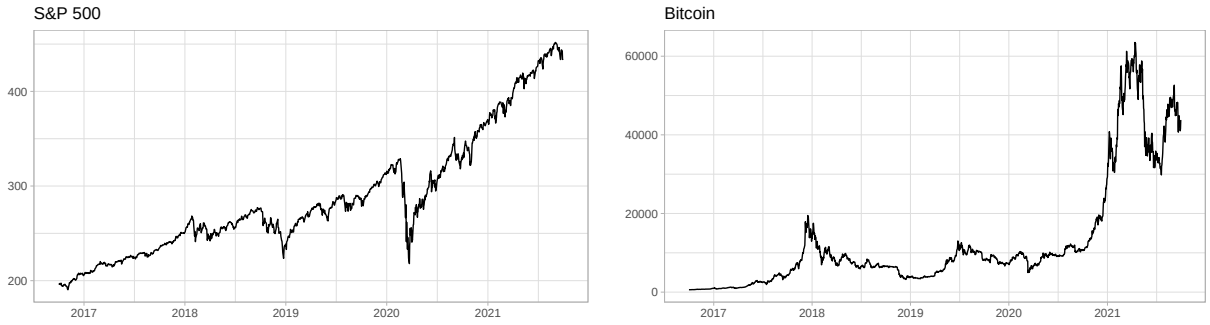
```
## [1] "Missing days:"
```

```
##            [,1]
## 2020-04-17   NA
## 2020-10-09   NA
## 2020-10-12   NA
## 2020-10-13   NA
```

- It seems that Bitcoin has 4 missing days, I will use na.approx function to interpolate the missing value.

```
##       Index              stock.BTC      
##  Min.   :2016-10-01   Min.   :  610.2  
##  1st Qu.:2017-12-31   1st Qu.: 4124.9  
##  Median :2019-04-01   Median : 8042.9  
##  Mean   :2019-04-01   Mean   :12723.4  
##  3rd Qu.:2020-06-30   3rd Qu.:11357.1  
##  Max.   :2021-09-30   Max.   :63503.5
```

Graphing the Time Series



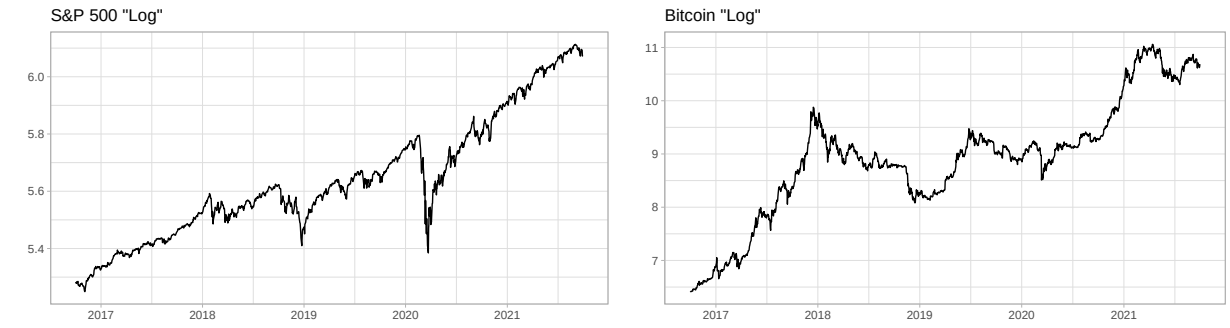
(a) SPY (b) BTC

Figure 1. Time Series

Figure (1) shows the time series for S&P 500 (SPY) and Bitcoin (BTC) starting October 2016 up to 2021. While Bitcoin appears to be a multiplicative, non-stationary time series, S&P 500 seem to be an additive non-stationary time series.

In Figure (2) we can see both time series with log transformation. The log transformation did not affect S&P 500 much, confirming the additive nature. On the other hand, it has transformed Bitcoin's into a more stable form.

In Figure (3), we can see the log returns. The plot shows general white noise in both tickers with a few outliers. SPY showed better uniform form using log.



(a) SPY (b) BTC

Figure 2. Time Series, Log

Auto-correlation for the series

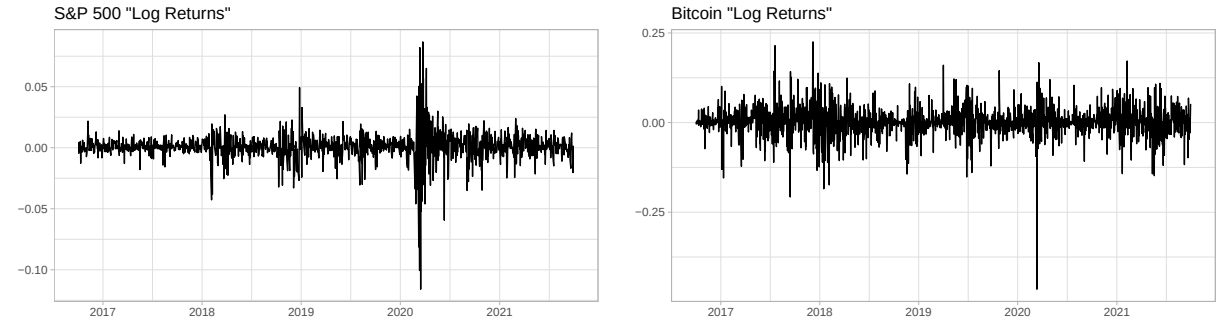
The ACF plots in Figure (4) shows that both have a strong Auto-correlation in this time series. The ACF gradually decreases indicating a non-stationary series.

Auto-correlation for the log returns

The Log Returns ACF plots in Figure (5) shows a more stationary form of the series.

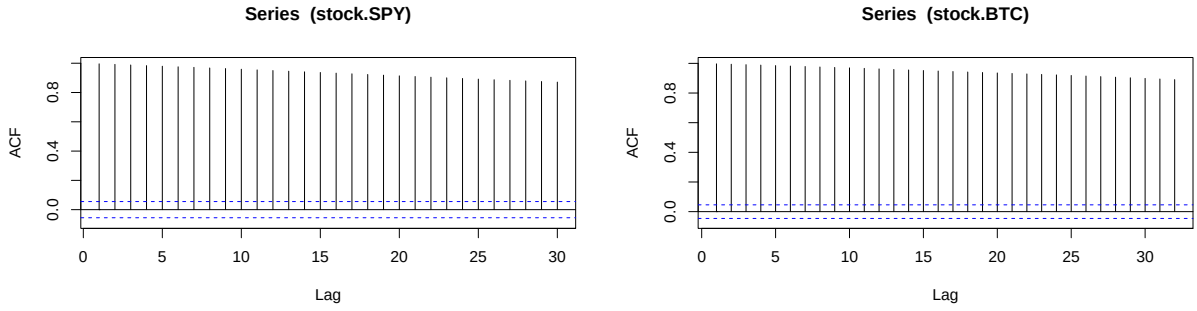
Partial Auto-correlation for the log returns

The Log Returns PACF plots in Figure (6) shows a more stationary form of the series.



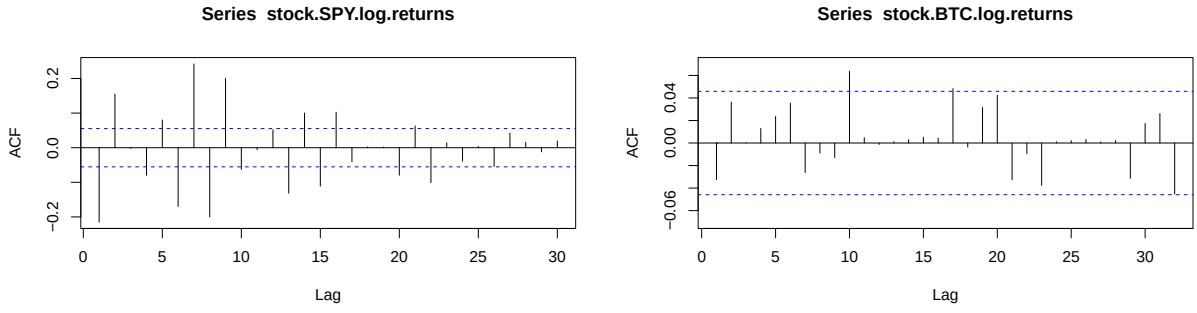
(a) SPY (b) BTC

Figure 3. Log Returns



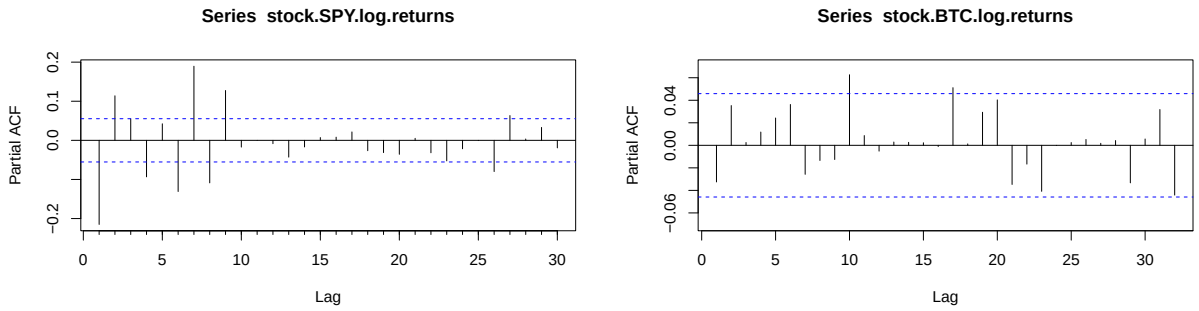
(a) SPY (b) BTC

Figure 4. ACF



(a) SPY (b) BTC

Figure 5. ACF Log Returns



(a) SPY (b) BTC

Figure 6. PACF Log Returns

Ljung Box Test

```
Box.test(stock.SPY.log.returns, lag = 300, type = "Ljung-Box")
```

```
##
##  Box-Ljung test
##
## data:  stock.SPY.log.returns
## X-squared = 783.87, df = 300, p-value < 2.2e-16
```

```
Box.test(stock.BTC.log.returns, lag = 1, type = "Ljung-Box")
```

```
##
##  Box-Ljung test
##
## data:  stock.BTC.log.returns
## X-squared = 1.9326, df = 1, p-value = 0.1645
```

Up to Lag 300, the SPY Ljung-Box p-value is close to zero so we can reject the null hypothesis and accept the alternative, while the BTC fails to reject the null hypothesis at the first lag. This indicates that SPY log returns has auto-correlations, while BTC is uncorrelated and similar to white noise and cannot be modeled.

Dickey-Fuller Test

```
adf.test(stock.SPY.log.returns)
```

```
##
##  Augmented Dickey-Fuller Test
##
## data:  stock.SPY.log.returns
## Dickey-Fuller = -9.8841, Lag order = 10, p-value = 0.01
## alternative hypothesis: stationary
```

```
adf.test(stock.BTC.log.returns)
```

```
##
##  Augmented Dickey-Fuller Test
##
## data:  stock.BTC.log.returns
## Dickey-Fuller = -11.111, Lag order = 12, p-value = 0.01
## alternative hypothesis: stationary
```

The Dicker-Fuller test supports rejecting the null-hypothesis of non-stationarity for both tickers. We can accept the alternative hypothesis both tickers are stationary using their log returns.

ARIMA

```
auto.arima(stock.SPY.log.returns)
```

```
## Series: stock.SPY.log.returns
## ARIMA(0,0,2) with non-zero mean
##
## Coefficients:
##           ma1     ma2   mean
##       -0.1881  0.1760  6e-04
## s.e.   0.0275  0.0291  3e-04
##
## sigma^2 estimated as 0.0001318:  log likelihood=3829.99
## AIC=-7651.99   AICc=-7651.95   BIC=-7631.44
```

```
auto.arima(stock.BTC.log.returns)
```

```
## Series: stock.BTC.log.returns
## ARIMA(0,0,0) with non-zero mean
##
## Coefficients:
##         mean
##       0.0023
## s.e.  0.0010
##
## sigma^2 estimated as 0.001748:  log likelihood=3204.73
## AIC=-6405.46   AICc=-6405.45   BIC=-6394.44
```