Assignment 04, Question 1&2

Jeff Nguyen

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University of Southern California
Marshall School of Business
FBE 543 Forecasting and Risk Analysis

Student Name: Ngoc Son (Jeff) Nguyen

Question 1

Downloading data:

```
library(quantmod)
```

```
## Loading required package: xts
```

```
## Loading required package: zoo
```

```
##
## Attaching package: 'zoo'
```

```
## The following objects are masked from 'package:base':
##
##     as.Date, as.Date.numeric
```

```
## Loading required package: TTR
```

```
## Registered S3 method overwritten by 'quantmod':
##   method            from
##   as.zoo.data.frame zoo
```

```
## Version 0.4-0 included new data defaults. See ?getSymbols.
```

```
# Set start date and end date of data
start_date <- "2018-01-01"
end_date <- "2021-03-17"

# Get data
getSymbols("AAPL", src = "yahoo", from = start_date, to = end_date)
```

```
## 'getSymbols' currently uses auto.assign=TRUE by default, but will
## use auto.assign=FALSE in 0.5-0. You will still be able to use
## 'loadSymbols' to automatically load data. getOption("getSymbols.env")
## and getOption("getSymbols.auto.assign") will still be checked for
## alternate defaults.
##
## This message is shown once per session and may be disabled by setting
## options("getSymbols.warning4.0"=FALSE). See ?getSymbols for details.

## [1] "AAPL"
```

```
getSymbols("^GSPC", src = "yahoo", , from = start_date, to = end_date) # S&P 500
```

```
## [1] "^GSPC"
```

```
# Adjusted Prices
adjAAPL <- AAPL$AAPL.Adjusted
adjGSPC <- GSPC$GSPC.Adjusted
```

a. Graph your AAPL against time (scatter diagram). Comment on the existence of time trend, seasonal trend, cyclical trend, autocorrelation, randomness, structural breaks, and outliers.

```
plot(adjAAPL, main="AAPL", col="Blue")
```

Time Trend: AAPL displays time trend, as price increases over time.
Seasonal Trend: AAPL displays seasonal trend with up and down spikes in price daily.
Cyclical Trend: AAPL is affected by business cycle of peaks and troughs.
Autocorrelation: AAPL rises for some times and they rise and vice versa.
Randomness: Price of AAPL is unpredictable via inspection.
Structural Breaks: AAPL does not experience any structural break during this time frame as price always recover quickly.
Outliers: AAPL price has several outliers during this period (Jan 2019, March 2020) where price fell more than 30% and recovered.

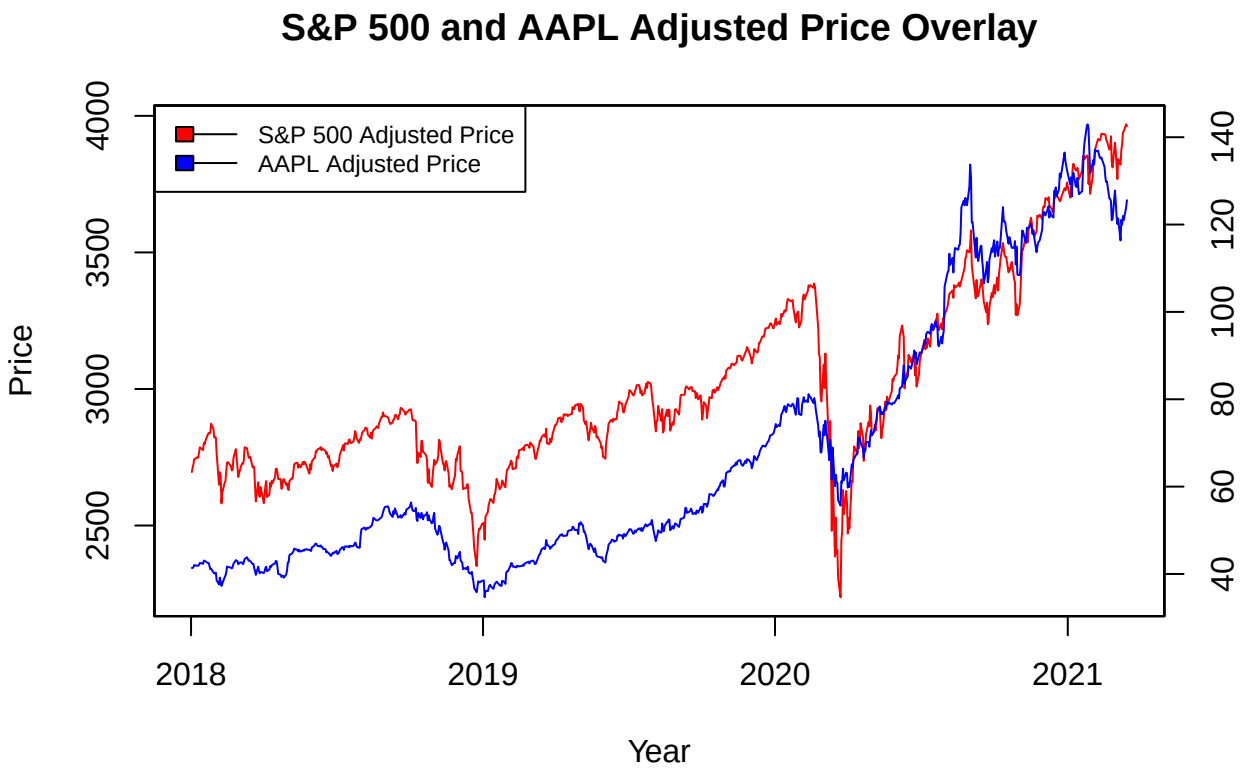
b. Graph S&P 500. Comment on the existence of time trend, seasonal trend, cyclical trend, autocorrelation, randomness, structural breaks, and outliers.

```
plot(adjGSPC, main="S&P500", col="Red")
```

Time Trend: S&P 500 displays time trend, as price increases over time.
Seasonal Trend: S&P 500 displays seasonal trend with up and down spikes in price daily.
Cyclical Trend: S&P 500 is affected by business cycle of peaks and troughs.
Autocorrelation: S&P 500 rises for some times and they rise and vice versa.
Randomness: Price of S&P 500 is unpredictable via inspection.
Structural Breaks: S&P 500 does not experience any structural break during this time frame as price always recover quickly.
Outliers: S&P 500 price has several outliers during this period (Jan 2019, March 2020) where price fell more than 30% and recovered.

c. Graph your variable against the market index S&P 500 on x-y axis. Comment on the behavior and the relationship between the two variables.

```
# Initialize xts objects contain adjusted price for S&P 500 and AAPL and merge
gspc_xts <- as.xts(GSPC["GSPC.Adjusted"])
aapl_xts <- as.xts(AAPL["AAPL.Adjusted"])
price_compare <- merge.xts(gspc_xts, aapl_xts)

# Graph monthly AAPL and monthly S&P500 on one coordinate system
# Plot S&P 500
plot(as.zoo(price_compare[, "GSPC.Adjusted"]), screens = 1,
     main = "S&P 500 and AAPL Adjusted Price Overlay",
     xlab = "Year", ylab = "Price", col = "Red")

# Keep working on the same plot
par(new = TRUE)

# Plot AAPL and suppress axis value
plot(as.zoo(price_compare[, "AAPL.Adjusted"]),
     screens = 1,
     xaxt = "n", yaxt = "n",
     xlab = "", ylab = "",
     col = "Blue")

# Add right-handed axis to display AAPL price
axis(4)

# Add legend
legend("topleft",
       c("S&P 500 Adjusted Price", "AAPL Adjusted Price"),
       lty = 1:1,
       cex = 0.75,
       fill = c("red", "blue"))
```



Remarks

1. Seasonal Trend: Both display similar seasonal trend with up and down spikes in price days after days.

2. Cyclical Trend:

Both is affected by business cycle with similar peaks and troughs. The S&P 500 has more prominent troughs compared to that of AAPL. Especially during the period of March 2020 with the COVID-19 lockdowns started rolling across the countries.

3. Auto-correlation:

Both behave similar in this regard where both rises for some times when they rise and vice versa.

4. Randomness:

Price of both is unpredictable via inspection.

5. Time:

Both follows similar time trend.

6. Structural Break:

Both does not experience any structural break during this time frame. During the COVID-19 March sell-off, price recovered quickly in a V-shaped fashion.

7. Outliers:

SPY looks to have several outliers corresponded to the March 2020 sell-off when the indicies retreated 30% in a short period of a few weeks before quickly recovered.

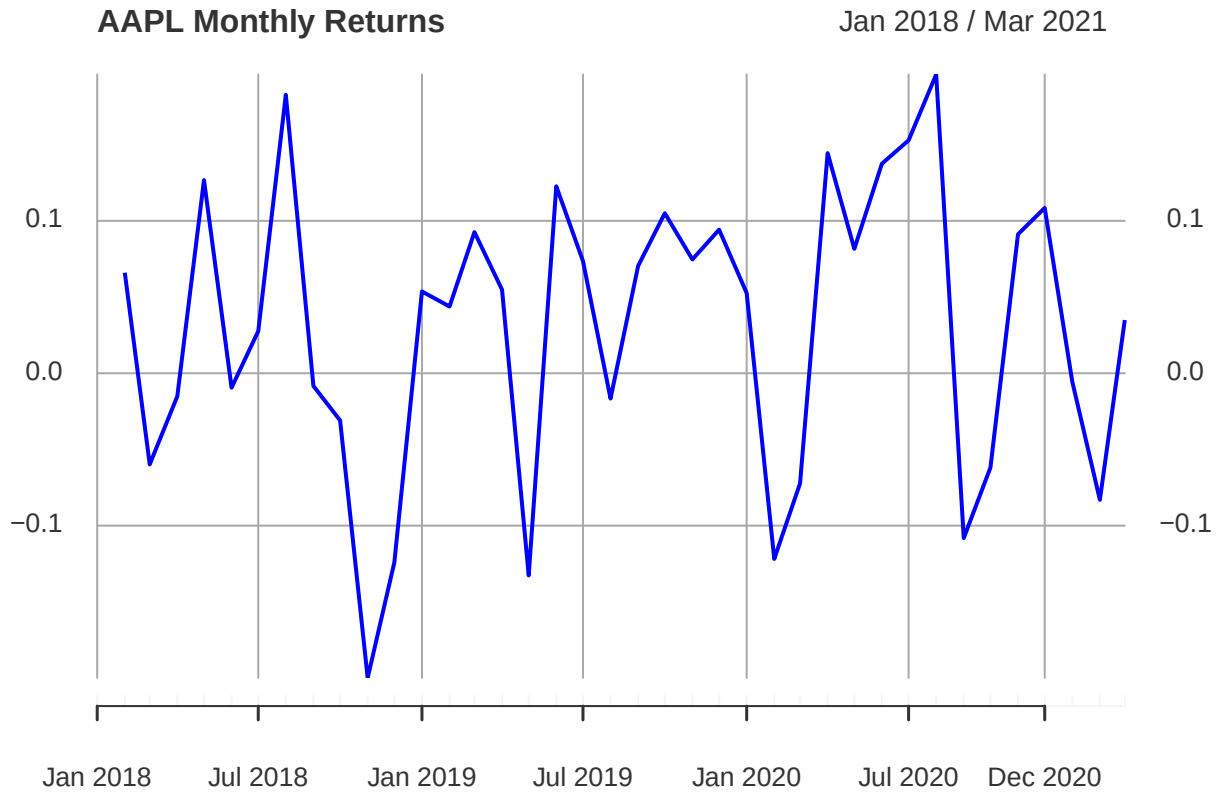
d. Repeat a to c for the monthly returns to AAPL and S&P 500.

Adjusting data to monthly:

```
# Get adjusted returns data
rAAPL <- diff(log(to.monthly(AAPL)$AAPL.Adjusted))
rGSPC <- diff(log(to.monthly(GSPC)$GSPC.Adjusted))
```

d.a. Graph your AAPL monthly returns against time (scatter diagram). Comment on the existence of time trend, seasonal trend, cyclical trend, autocorrelation, randomness, structural breaks, and outliers.

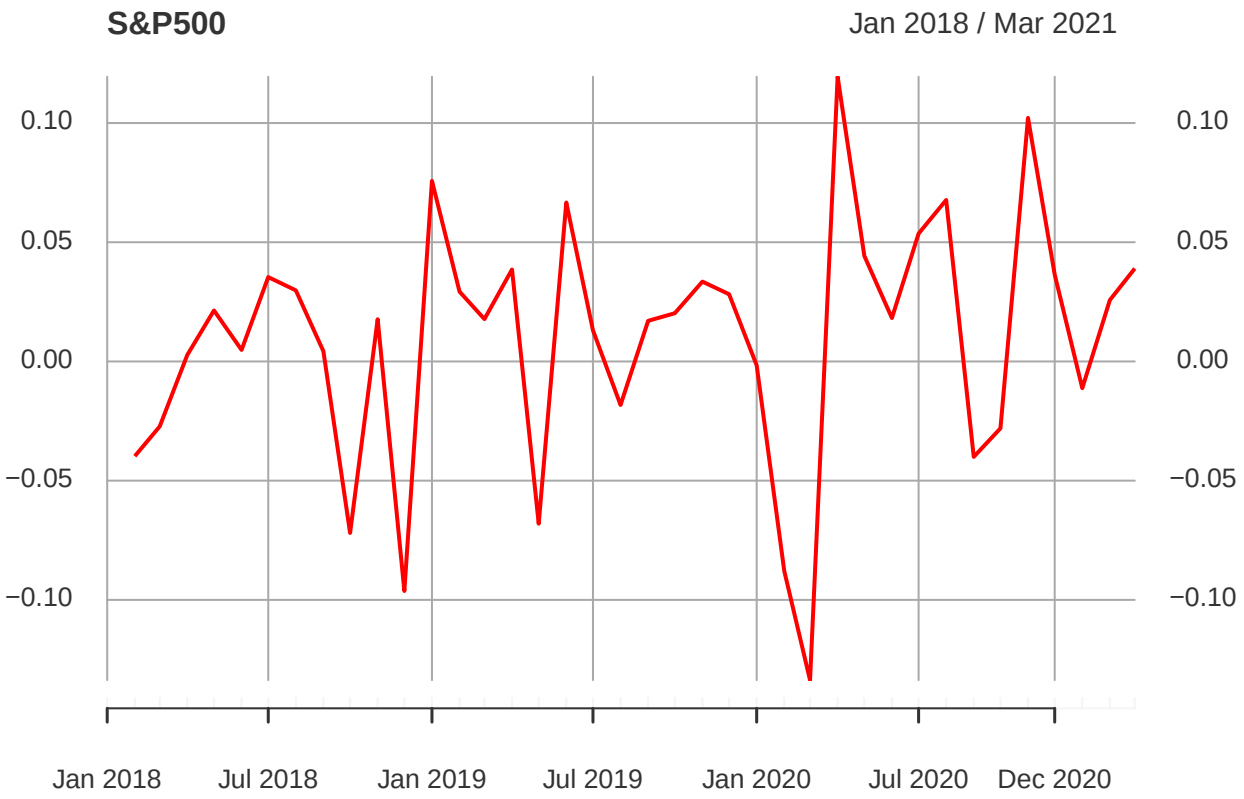
```
plot(rAAPL, main="AAPL Monthly Returns", col="Blue")
```



Time Trend: We can not observe a clear time trend here. **Seasonal Trend:** AAPL monthly returns displays seasonal trend with up and down spikes.
Cyclical Trend: We cannot observe a clear cyclical trend that coincides with business cycles here even though there are peaks and troughs.
Autocorrelation: We cannot observe autocorrelation characteristics.
Randomness: AAPL monthly returns can be observed to be unpredictable.
Structural Breaks: We cannot observe any structural break here.
Outliers: AAPl monthly returns have several clear outliers during this period.

d.b. Graph S&P 500. Comment on the existence of time trend, seasonal trend, cyclical trend, autocorrelation, randomness, structural breaks, and outliers.

```
plot(rGSPC, main="S&P500", col="Red")
```

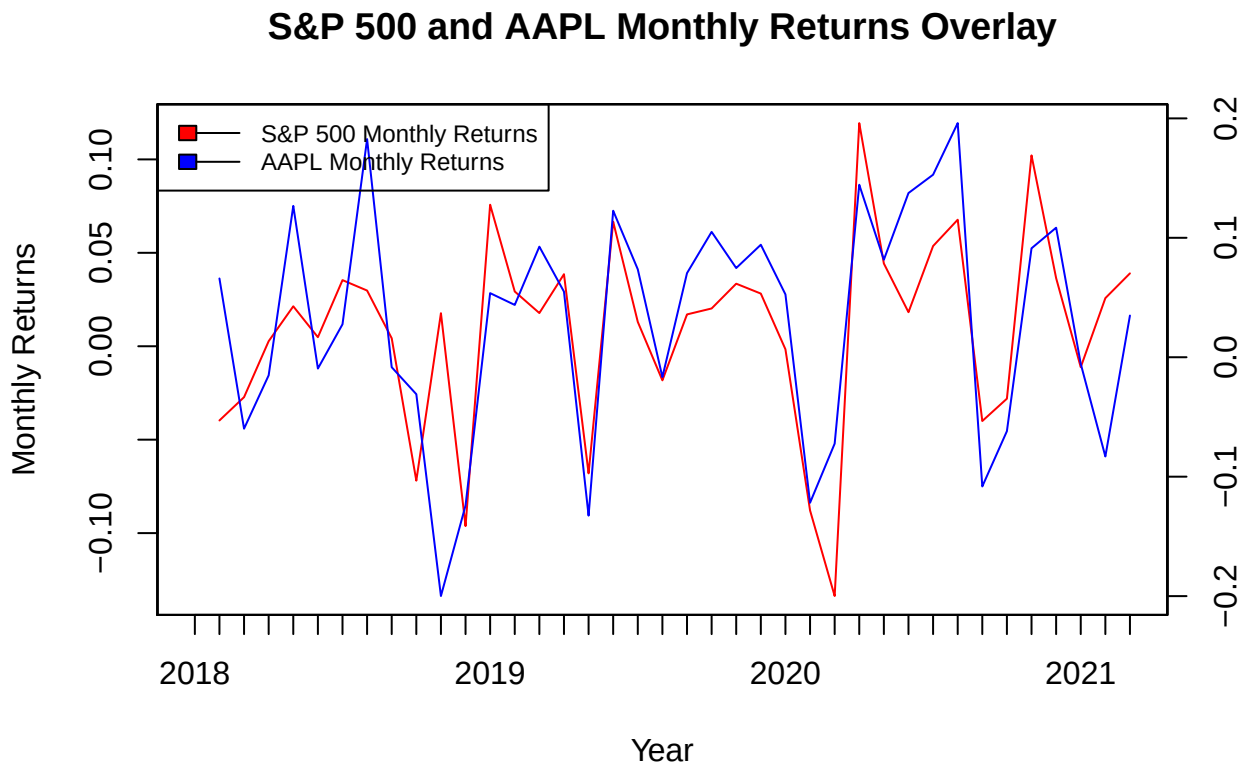


Time Trend: We can not observe a clear time trend here. **Seasonal Trend:** S&P 500 monthly returns displays seasonal trend with up and down spikes.
Cyclical Trend: We cannot observe a clear cyclical trend that coincides with business cycles here even though there are peaks and troughs.
Autocorrelation: We cannot observe autocorrelation characteristics.
Randomness: S&P 500 monthly returns can be observed to be unpredictable.
Structural Breaks: We cannot observe any structural break here.
Outliers: S&P 500 monthly returns have several clear outliers during this period.

d.c. Graph your variable against the market index S&P 500 on x-y axis. Comment on the behavior and the relationship between the two variables.

```
# Initialize xts objects contain adjusted price for S&P 500 and AAPL and merge
rgspc_xts <- as.xts(rGSPC[,"GSPC.Adjusted"])
raapl_xts <- as.xts(rAAPL[,"AAPL.Adjusted"])
monthlyR_compare <- merge.xts(rgspc_xts, raapl_xts)

# Graph monthly AAPL and monthly S&P500 on one coordinate system
# Plot S&P 500
plot(as.zoo(monthlyR_compare[, "GSPC.Adjusted"]), screens = 1,
     main = "S&P 500 and AAPL Monthly Returns Overlay",
     xlab = "Year", ylab = "Monthly Returns", col = "Red")

# Keep working on the same plot
par(new = TRUE)
```

```r
# Plot AAPL and suppress axis value
plot(as.zoo(monthlyR_compare[, "AAPL.Adjusted"]),
     screens = 1,
     xaxt = "n", yaxt = "n",
     xlab = "", ylab = "",
     col = "Blue")

# Add right-handed axis to display AAPL price
axis(4)

# Add legend
legend("topleft",
       c("S&P 500 Monthly Returns", "AAPL Monthly Returns"),
       lty = 1:1,
       cex = 0.75,
       fill = c("red", "blue"))
```



Remarks
For the most part, both monthly returns of AAPL and S&P 500 follow each other in lock-step saved for a few periods where AAPL monthly returns become more volatile. S&P 500 experienced larger draw down in returns compared to AAPL in the March 2020 "pandemic sell-off".

e. Compare the risk and return of AAPL with the risk and return to S&P 500.

Calculations:

```
# Calculate statistics
AAPL_meanR <- mean(rAAPL, na.rm=TRUE)
GSPC_meanR <- mean(rGSPC, na.rm=TRUE)

AAPL_riskR <- sqrt(var(rAAPL, na.rm=TRUE))
GSPC_riskR <- sqrt(var(rGSPC, na.rm=TRUE))
```

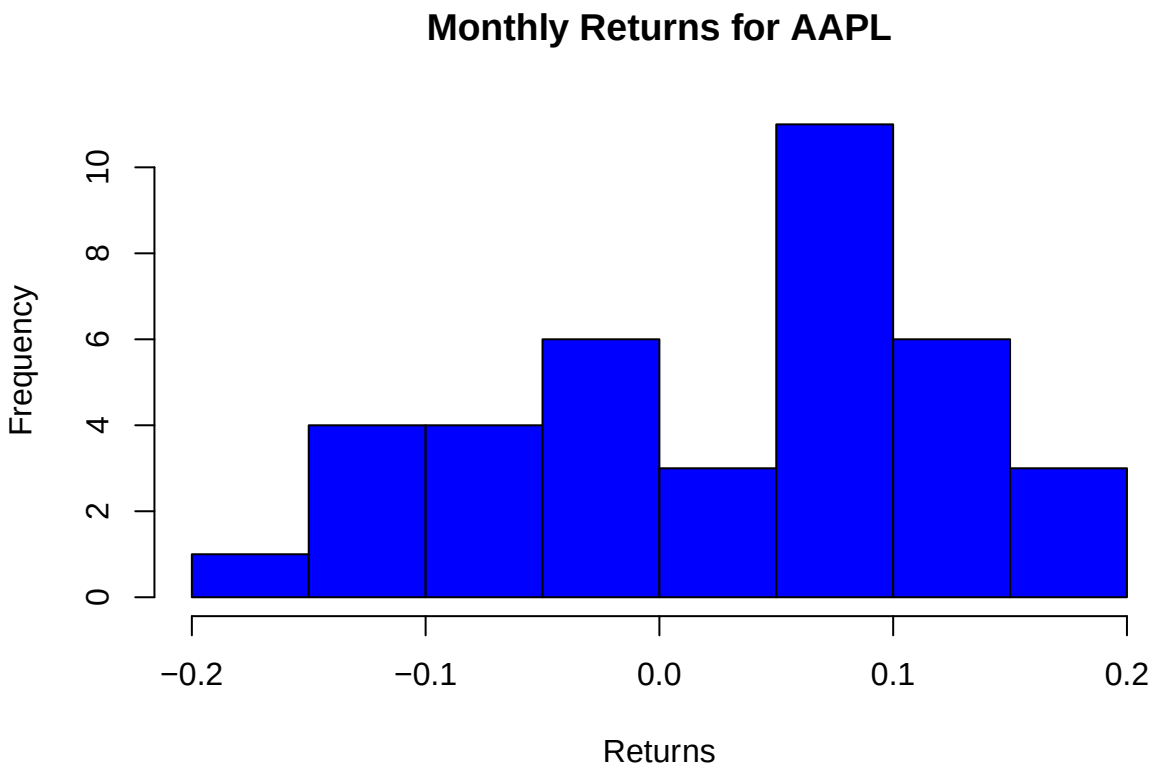
Comparison:

Underlying	Expected Monthly Returns	Risk
S&P 500	0.0089169	0.0528529
AAPL	0.0299605	0.0959594

We can observe AAPL has higher expected monthly returns but also higher risk than the S&P 500.

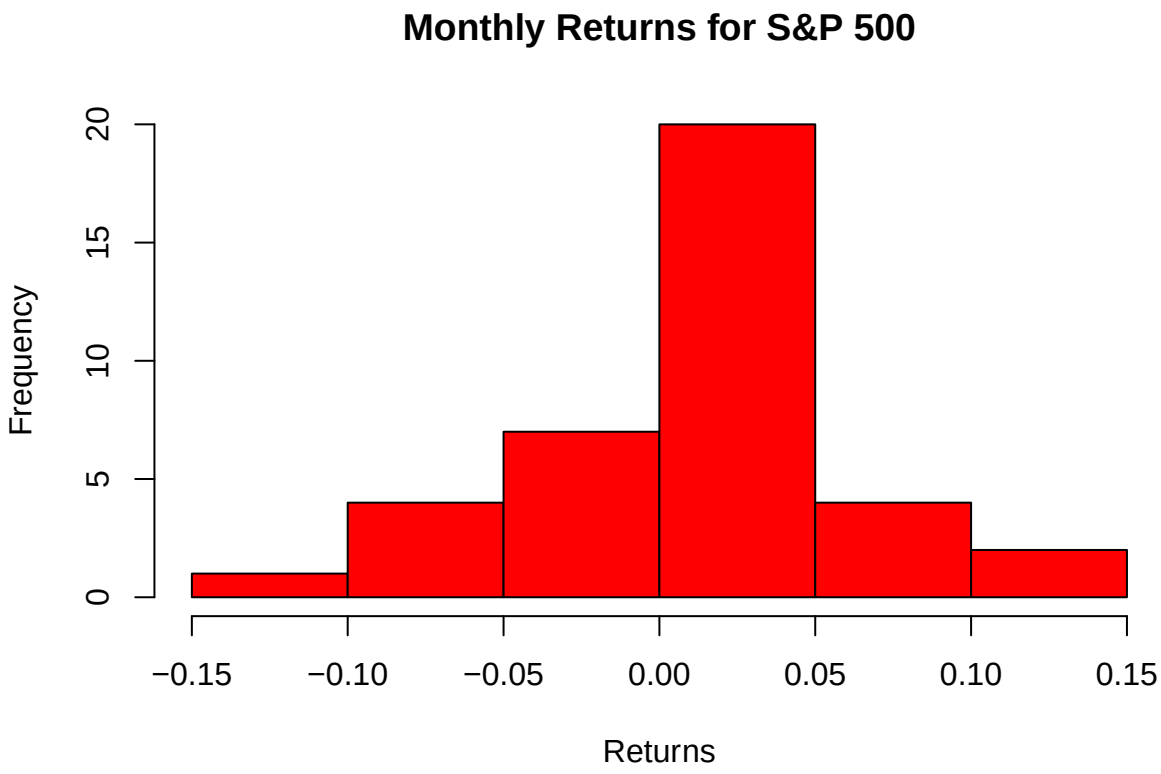
f. Plot histograms of returns to AAPL and returns to S&P 500. Comment on the distribution of the returns.

```
hist(rAAPL,
     main='Monthly Returns for AAPL',
     xlab='Returns',
     col='blue',
    )
```



We can observe that AAPL has a fat left tail (to the downside).

```
hist(rGSPC,
     main='Monthly Returns for S&P 500',
     xlab='Returns',
     col='red',
    )
```



We can observe that compared to AAPL, S&P 500 resembles, but not necessary is, a normal distribution with fairly even tails.

g. Test whether the distributions of returns to AAP and returns to S&P 500 are normal or not.

We run Shapiro-Wilk normality test on AAPL monthly returns:

```
shapiro.test(as.vector(rAAPL))
```

```
##
##  Shapiro-Wilk normality test
##
## data:  as.vector(rAAPL)
## W = 0.96862, p-value = 0.3559
```

We can see that p-value $> .05$ implying that the distribution of AAPL monthly returns is not significantly different from a normal distribution, and thus, we can assume normality.

Similar with S&P 500:

```
shapiro.test(as.vector(rGSPC))
```

```
##
```

```
##  Shapiro-Wilk normality test
##
## data:  as.vector(rGSPC)
## W = 0.95624, p-value = 0.143
```

Similarly, we can see that the distribution of S&P 500 monthly returns is not significantly different from a normal distribution, and thus, we can assume normality.

h. Fit $MA(5)$ and $MA(9)$ on AAPL data and compare the accuracy criterion of the fits.