Portfolio Investment Assignment

FE8828 AY21/22 Group Assignment

TBD: NEE, TSLA, APPL, NVDA, AMD

```
## -- Attaching packages --------------------------------------- tidyverse 1.3.1 --
```

```
## v ggplot2 3.3.5     v purrr   0.3.4
## v tibble  3.1.4     v dplyr   1.0.7
## v tidyr   1.1.3     v stringr 1.4.0
## v readr   2.0.1     v forcats 0.5.1
```

```
## [conflicted] Will prefer dplyr::last over any other package
```

```
## [conflicted] Will prefer dplyr::lag over any other package
```

```
## [conflicted] Will prefer dplyr::filter over any other package
```

1. Overview

- SPDR sector ETFs: `c('XLB','XLE','XLF','XLI','XLK','XLP','XLU','XLV','XLY')` and `'SPY'`
- History from 1999-11-01 to now.
- Strategy:
    - Equal-weighted with 1) no re-balance, 2) monthly re-balance, 3) annual re-balance
    - Momentum strategy with 1) long top 4, 2) long top 2 and short bottom 2
- Note:
    - All equity position, no cash.
    - Do not load other library, use only the listed packages here.
    - Submit Rmd and Rda/RDs data files together
- Disclaimer: this is no an investment advise.

1.1 Download

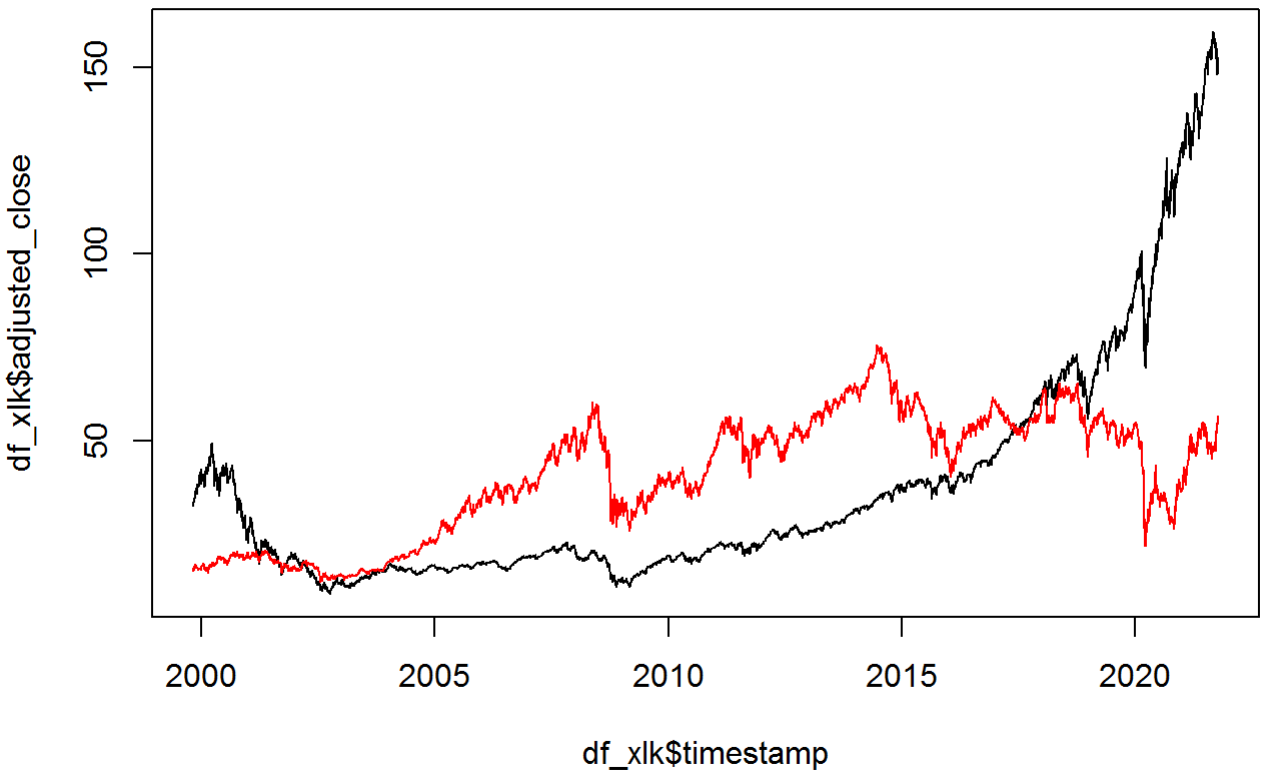
1.2 Load and check

```
## [1] "XLB 1999-11-01 2021-10-08 5521"
## [1] "XLE 1999-11-01 2021-10-08 5521"
## [1] "XLF 1999-11-01 2021-10-08 5521"
## [1] "XLI 1999-11-01 2021-10-08 5521"
## [1] "XLK 1999-11-01 2021-10-08 5521"
## [1] "XLP 1999-11-01 2021-10-08 5521"
## [1] "XLU 1999-11-01 2021-10-08 5521"
## [1] "XLV 1999-11-01 2021-10-08 5521"
## [1] "XLY 1999-11-01 2021-10-08 5521"
## [1] "SPY 1999-11-01 2021-10-08 5521"
```

1.4 Background of last 20 years: Energy vs. Technology

- Energy was the rock star during 90s and 00s, abruptly stopped during GFC on the journey towards $200/bbl (never there).
- Technology was a prodigy from late 70s, stumbled in early 00s, but now a rock star.

```
plot(df_xlk$timestamp, df_xlk$adjusted_close,type='l')
points(df_xle$timestamp, df_xle$adjusted_close,col='red',type='l')
```



2. Equal-weighted Strategy (No re-balance)

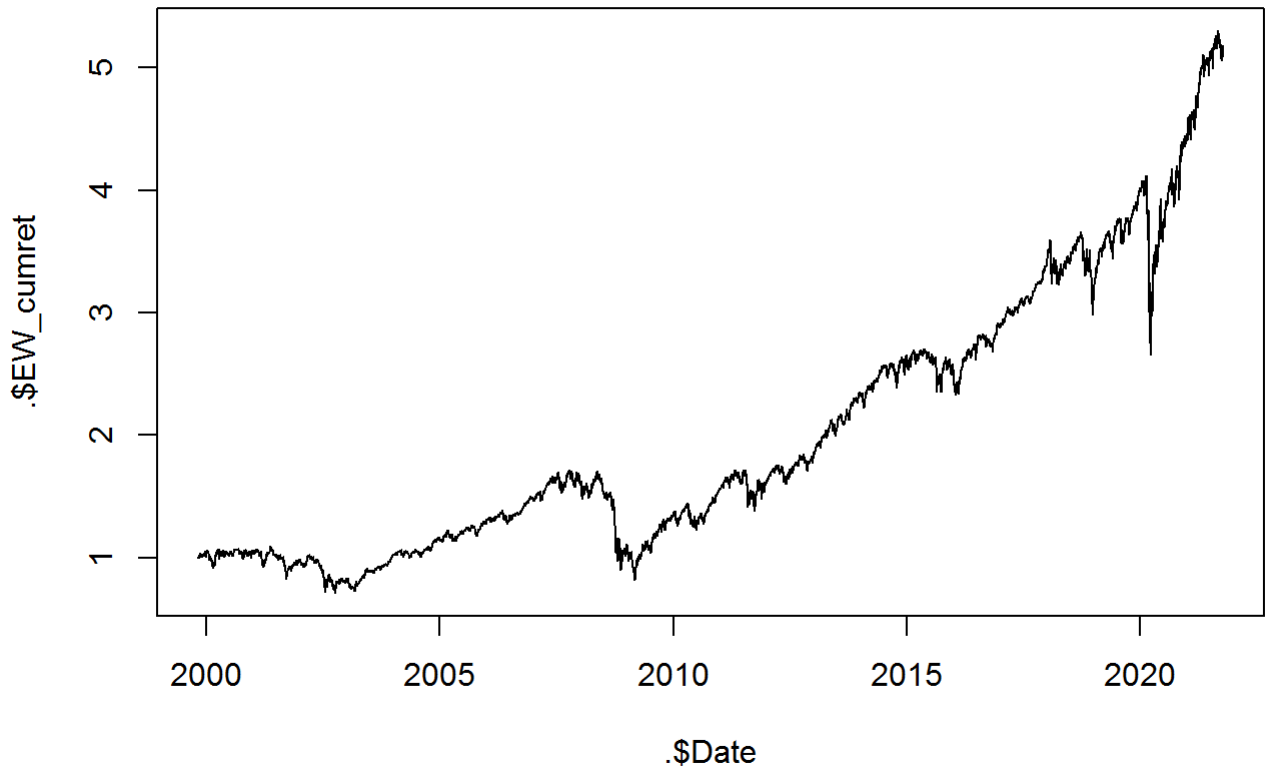
2.1 Compute daily return series

```
len_tickers <- length(all_tickers)
ii <- 1
daily_ret <- tail(tibble(Date = dd[[1]]$timestamp), -1)
for (ii in 1:len_tickers) {
  daily_ret[all_tickers[ii]] <- tail(dd[[ii]]$adjusted_close / lag(dd[[ii]]$adjusted_close, 1)-1
,-1) #自动路过了第一天的收益
}
for (ii in 1:len_tickers) {
  daily_ret[paste0(all_tickers[ii],"_cumret")] <- cumprod(1 + daily_ret[all_tickers[ii]])
}
```

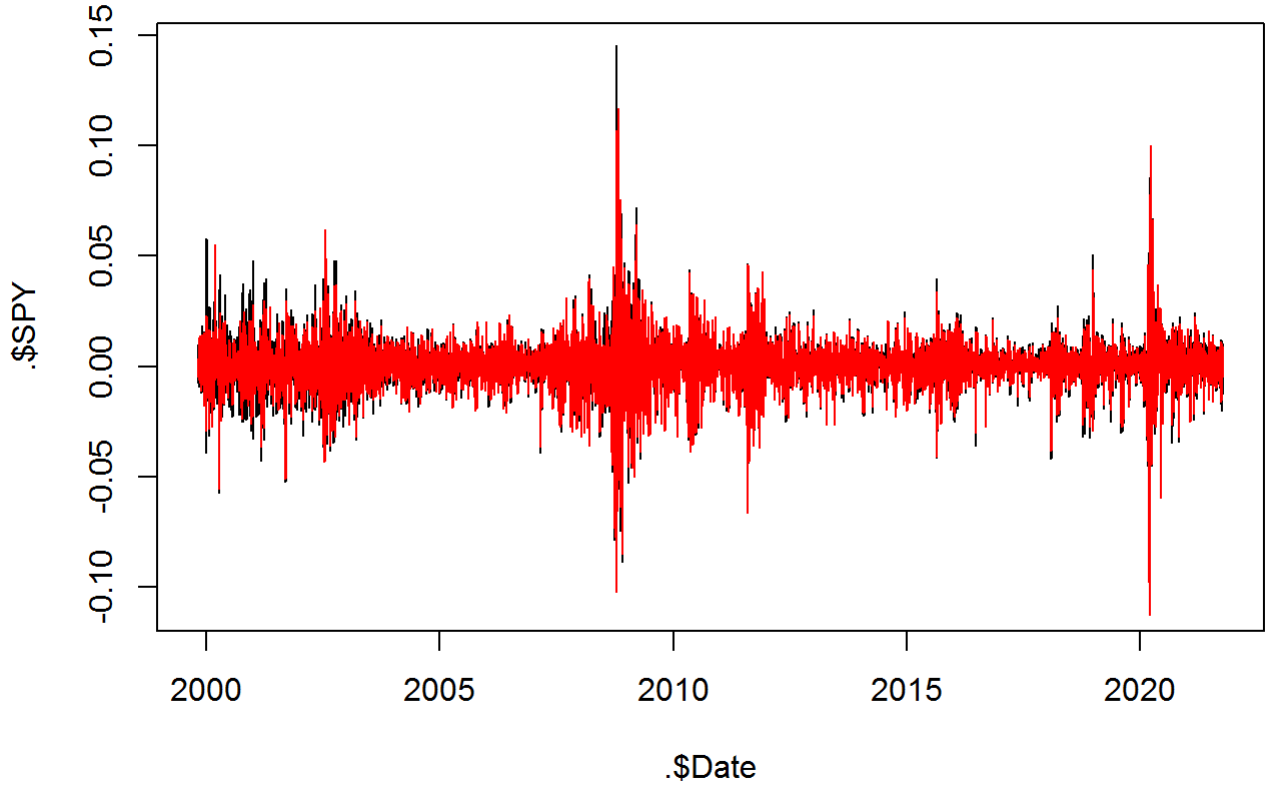
2.2 Performance

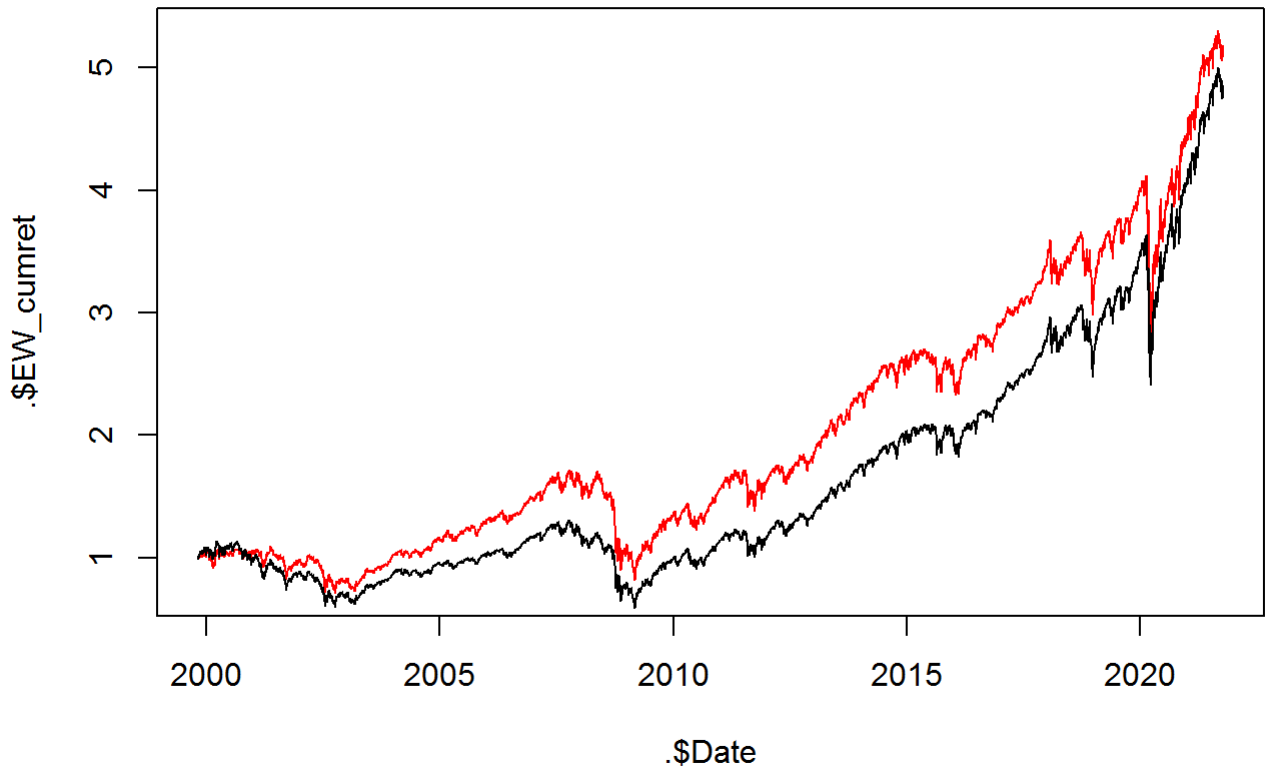
2.2.1 Calculate Strategy Return

```
## [1] 0.1111111 0.1111111 0.1111111 0.1111111 0.1111111 0.1111111 0.1111111
## [8] 0.1111111 0.1111111
```



2.2.2 Relative Performance between EW and SPY


.$SPY
0.15
0.10
0.05
0.00
-0.05
-0.10
2000
2005
2010
2015
2020
.$Date


.$EW_cumret
5
4
3
2
1
2000
2005
2010
2015
2020
.$Date

2.2.3 Metric

```
# annualized return for EW
prod(daily_ret$EW_ret + 1) ** (250 / length(daily_ret$EW_ret))
```

```
## [1] 1.077284
```

```
# annualized return for SPY
prod(daily_ret$SPY + 1) ** (250 / length(daily_ret$SPY))
```

```
## [1] 1.07411
```

```
# simplified Sharp ratio
prod(daily_ret$EW_ret + 1) ** (250 / length(daily_ret$EW_ret)) / sd(daily_ret$EW_ret) / sqrt(250
)
```

```
## [1] 5.791503
```

```
prod(daily_ret$SPY + 1) ** (250 / length(daily_ret$SPY)) / sd(daily_ret$SPY) / sqrt(250)
```

```
## [1] 5.491341
```

```
## Maximum Drawdown
```

```
## [1] 0.5232095
```

2.2.4 Analyze

```
## Under no-balance: rank all ETFs by its contribution to PnL over the entire period in decreasi
ng order:
##
```

```
## [1] "XLY" "XLV" "XLB" "XLI" "XLU" "XLP" "XLK" "XLE" "XLF"
```

```
## Under no-balance: rank all ETFs by its risk (max. draw down %) over the entire period in decr
easing order:
##
```

```
## [1] "XLF" "XLK" "XLE" "XLI" "XLB" "XLY" "XLU" "XLV" "XLP"
```

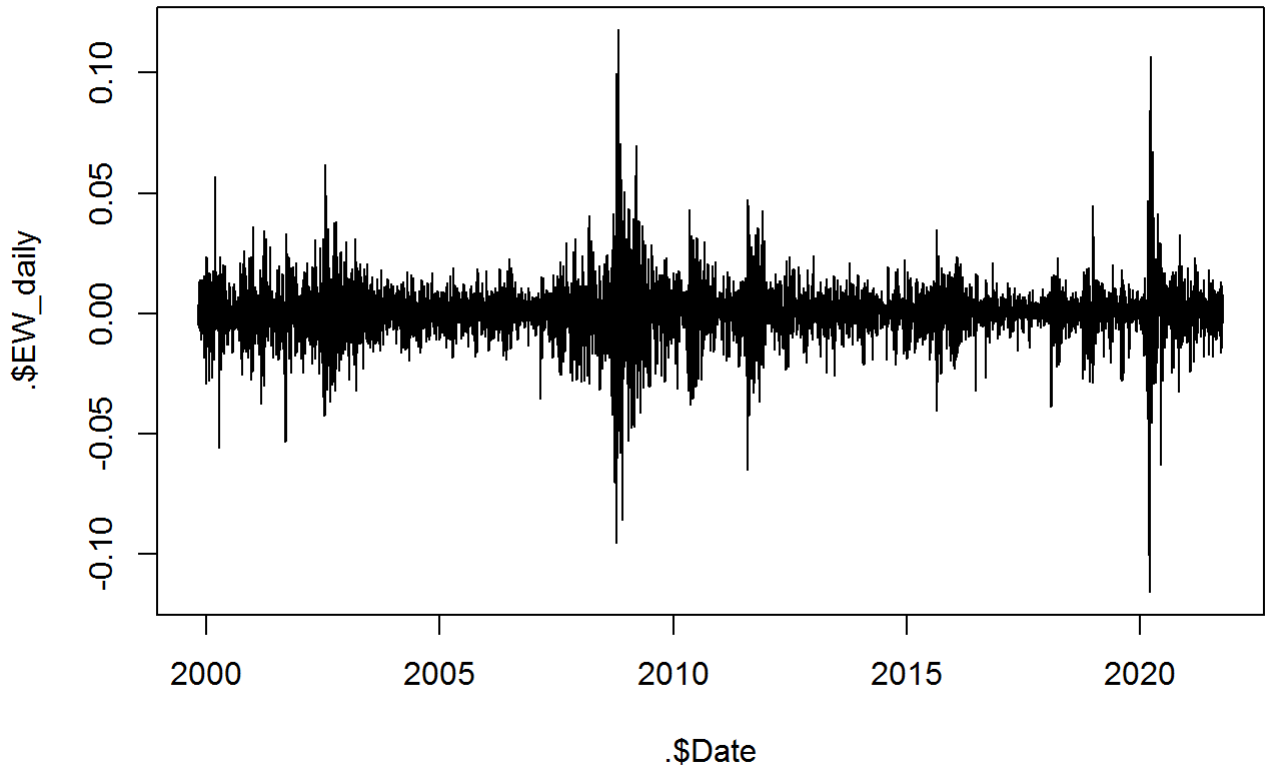
2.3 Let’s try improve

- Add Re-balance: reset the weights so each ETF has equal market value.

Re-balance is an action to adjust the weights of each stock so each ETF will have equal market value. Without re-balance, some stocks can grow their value to a certain extend that reduces the diversification of our investment portfolio.

- The starting allocation for each ETF is 1/9.
- On the next re-balance day, calculate the value of the portfolio. For example, it has grown to 1.3 based on each ETF's relative return during the previous period.
- The allocation for each ETF becomes 1.3/9.

If we re-balance every day, multiply weights to return everyday



EW_daily_cumret
<dbl>
6.149864

1 row

```
## [1] 1.085744
```

- If we re-balance less frequently.

Step 1: to calculate re-balance dates so the last re-balance happens on the last day.

rebal_days is the vector of numbers. They are the n-th days on which re-balance is applied. I have written the custom function calc_rebal_days() to help you to obtain the rebal_days vector which always ends at the last day of the downloaded data.

```
calc_rebal_days <- function(nn, period) {
  rev(nn - (0:(round(nn / period,0) - 1)) * period)
}

# Monthly re-balance
# every 21 days
rebal_days_monthly <- calc_rebal_days(length(dd[[1]]$timestamp), 21)
head(rebal_days_monthly)
```

```
## [1]  19  40  61  82 103 124
```

```
# Annual re-balance
# every 252 days
rebal_days_annually <- calc_rebal_days(length(dd[[1]]$timestamp), 252)
head(rebal_days_annually)
```

```
## [1]  229  481  733  985 1237 1489
```

Step 2: generalized code to do re-balance

```
# 12:20 is where we have stored cumret for each ETF  We will re-write these columns' content.

row_daily_ret <- nrow(daily_ret) # 总的表格多少行

rebal_days <- 1:row_daily_ret
w0 <- w
for (ii in 1:row_daily_ret) {
  if (ii == 1) {
    prev_cumret <- matrix(w0,1,len_invest) # 第一行的话，w0是初始权重，len_invest是有多少只股,得到[0.11111,0.111111,0.11111,0.11111...]
  }
  daily_ret[ii,12:20] <- prev_cumret * as.matrix(1 + daily_ret[ii,2:10]) # 第2到最后一行，是之前每一个股票相对retrun去加1乘以初始权重

  if (ii %in% rebal_days_monthly) {
    # when re-balance, multiple weights with cumret
    port_sum <- sum(daily_ret[ii,12:20]) #比如ii等于要rebalance的第21天，第21行culret全部加起来（因为是乘以权重了的，所以加起来为组合的）
    daily_ret[ii,12:20] <- matrix(rep(port_sum, len_invest) / len_invest, 1, len_invest) # 第21行改为新权重（第21行所有股票的culret加起来
  }
  prev_cumret <- as.matrix(daily_ret[ii,12:20]) #新的初始分配
}

# sum(daily_ret[row_daily_ret,12:20])
# daily_ret['EM_Daily_cumret'] <- rowSums(as.matrix(daily_ret[12:20])) # 每一天的累计收益（每一行相加，即不同股票同一天的相加）
# daily_ret %>% { plot(.$Date, .$EM_Daily_cumret, type='l') } # 画出了每日累计收益和时间关系图
#
# daily_ret['EM_Daily_ret'] <- ret_from_cumret(daily_ret['EM_Daily_cumret']) # 之前写的函数算出每天的相对收益
# daily_ret %>% { plot(.$Date, .$EM_Daily_ret, type='l') }# 画出了每日相对收益和时间关系图
```

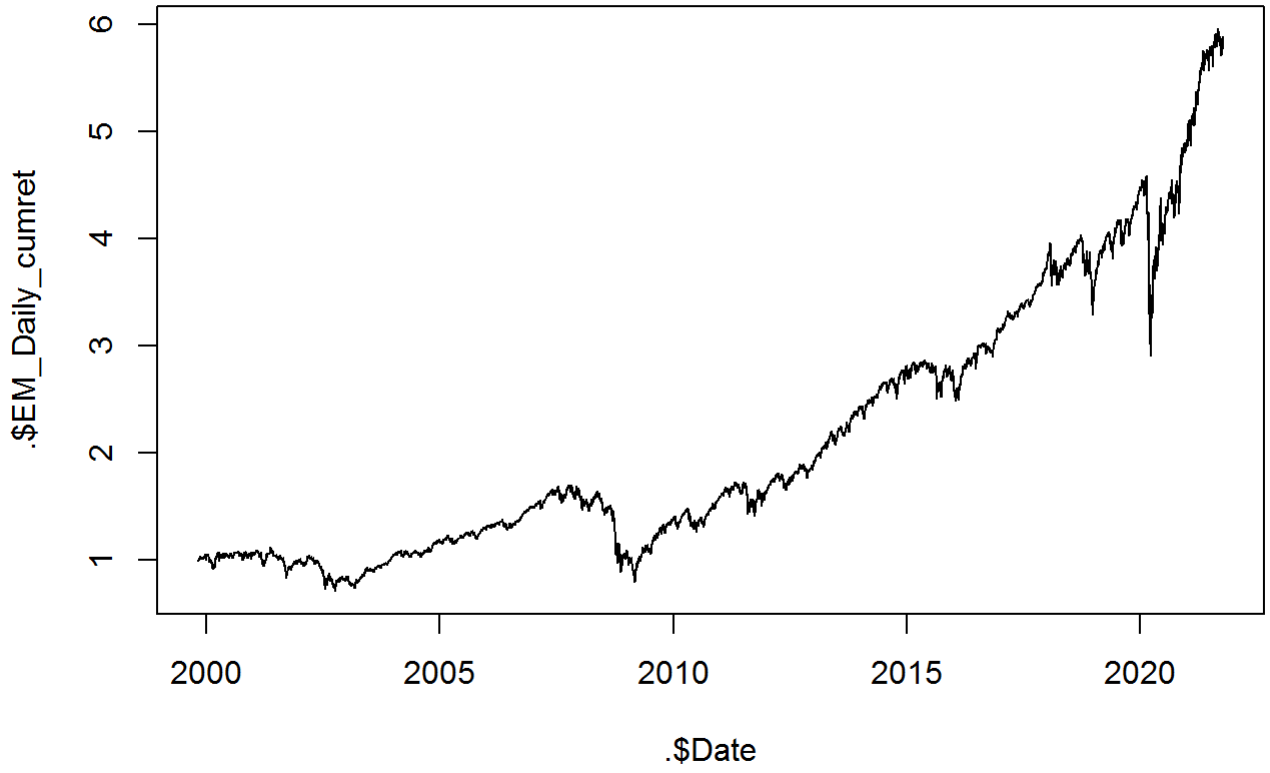
2.4 TODO

For each of 3 EW strategy: + no re-balance

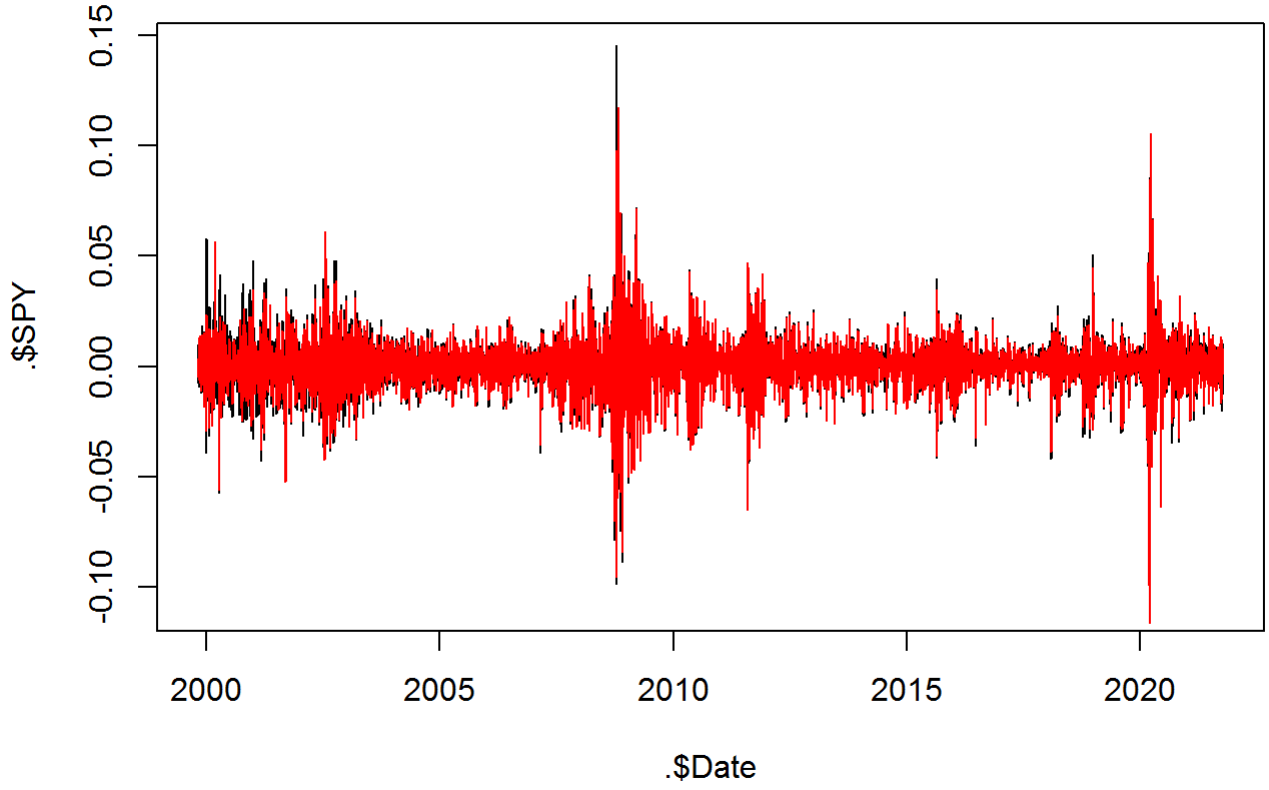
(A) Monthly Rebalance Strategy

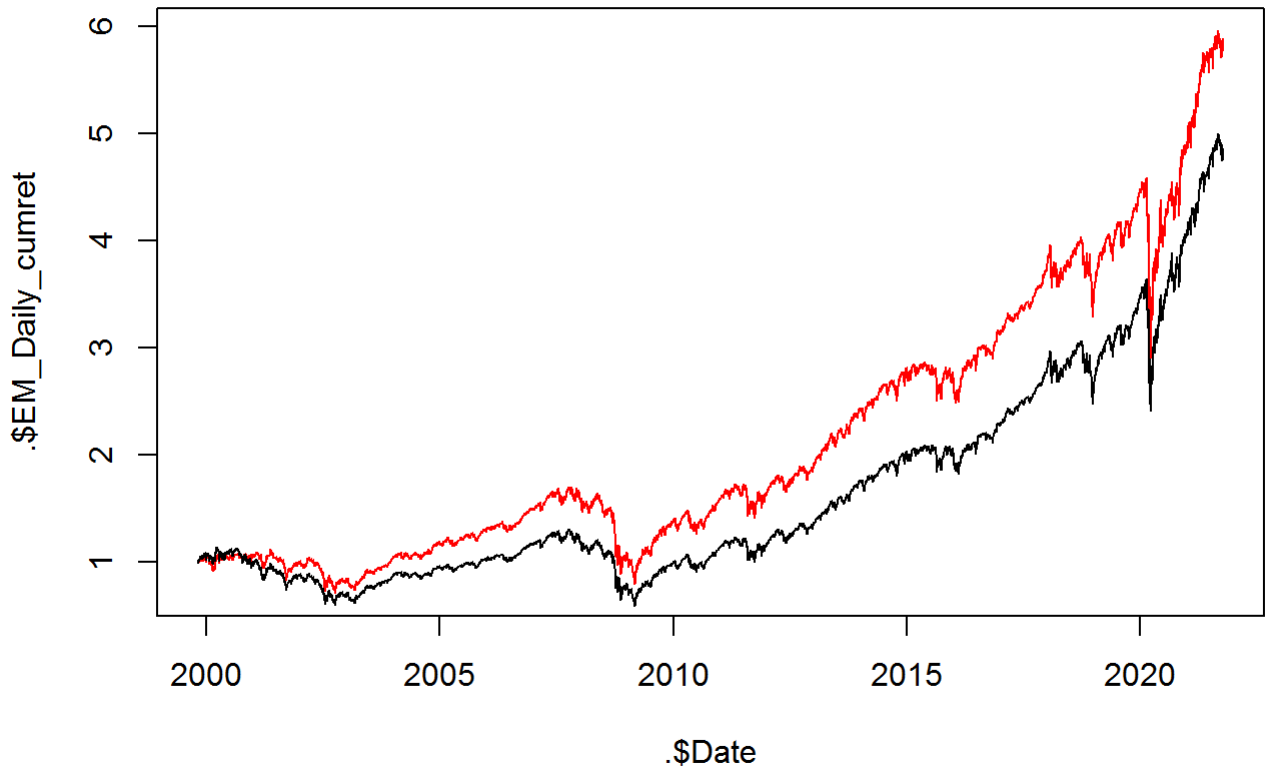
2.4.1 Strategy Return for Monthly Startegy

```
## [1] 5.885557
```



2.4.2 Relative Return for Monthly Startegy


.$SPY
0.15
0.10
0.05
0.00
-0.05
-0.10
2000
2005
2010
2015
2020
.$Date


.$EM_Daily_cumret
6
5
4
3
2
1
2000
2005
2010
2015
2020
.$Date

2.4.3 Matric for Monthly Startegy

```
## Annual Return:
```

```
## [1] 1.083586
```

```
## [1] 1.07411
```

```
## Sharp ratio:
```

```
## [1] 5.794553
```

```
## [1] 5.491341
```

2.4.4 Analyze for Monthly Startegy

```
## Max Drawdown:
```

```
## [1] 0.5344628
```

```
## Under monthly-balance:rank all ETFs by its contribution to PnL over the entire period in decr
easing order:
##
```

```
## [1] "XLY" "XLV" "XLB" "XLI" "XLU" "XLP" "XLK" "XLE" "XLF"
```

```
## Under monthly-balance:rank all ETFs by its risk (max. draw down %) over the entire period in
decreasing order:
##
```

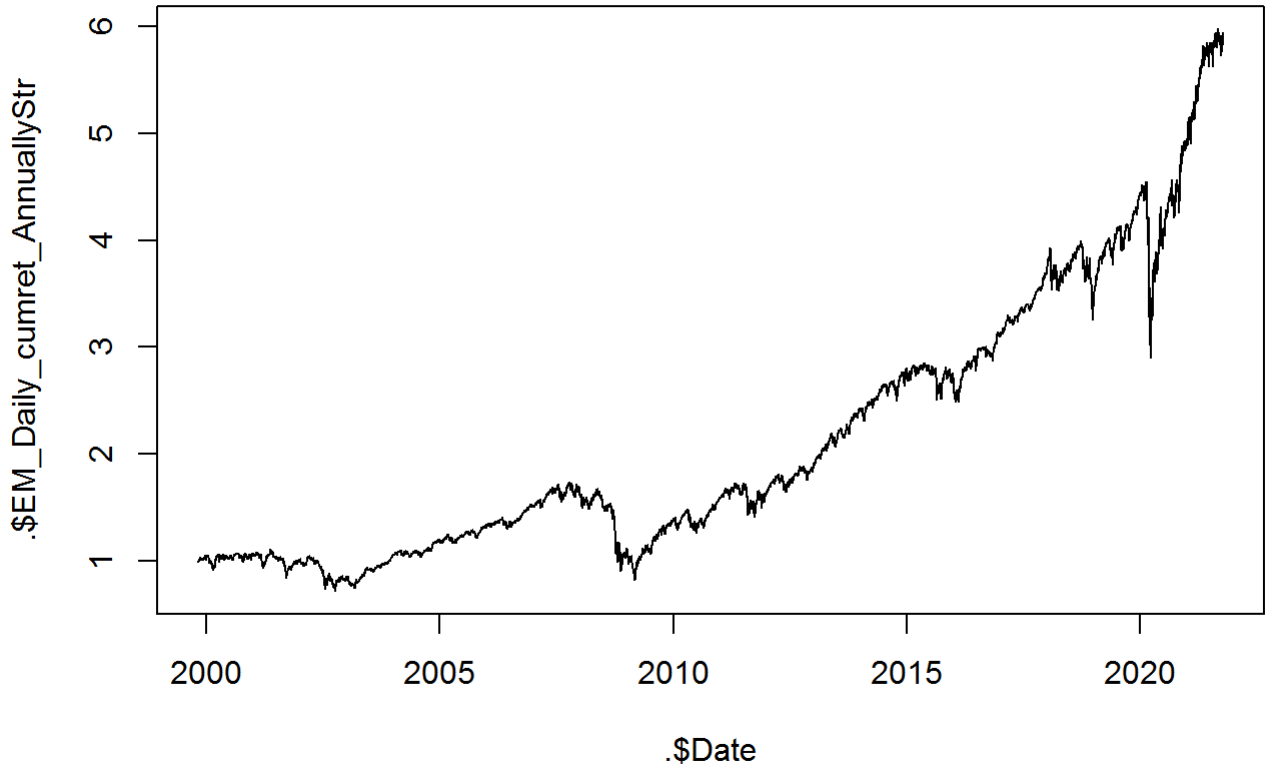
```
## [1] "XLF" "XLK" "XLE" "XLI" "XLB" "XLY" "XLU" "XLV" "XLP"
```

(B) Annual Strategy

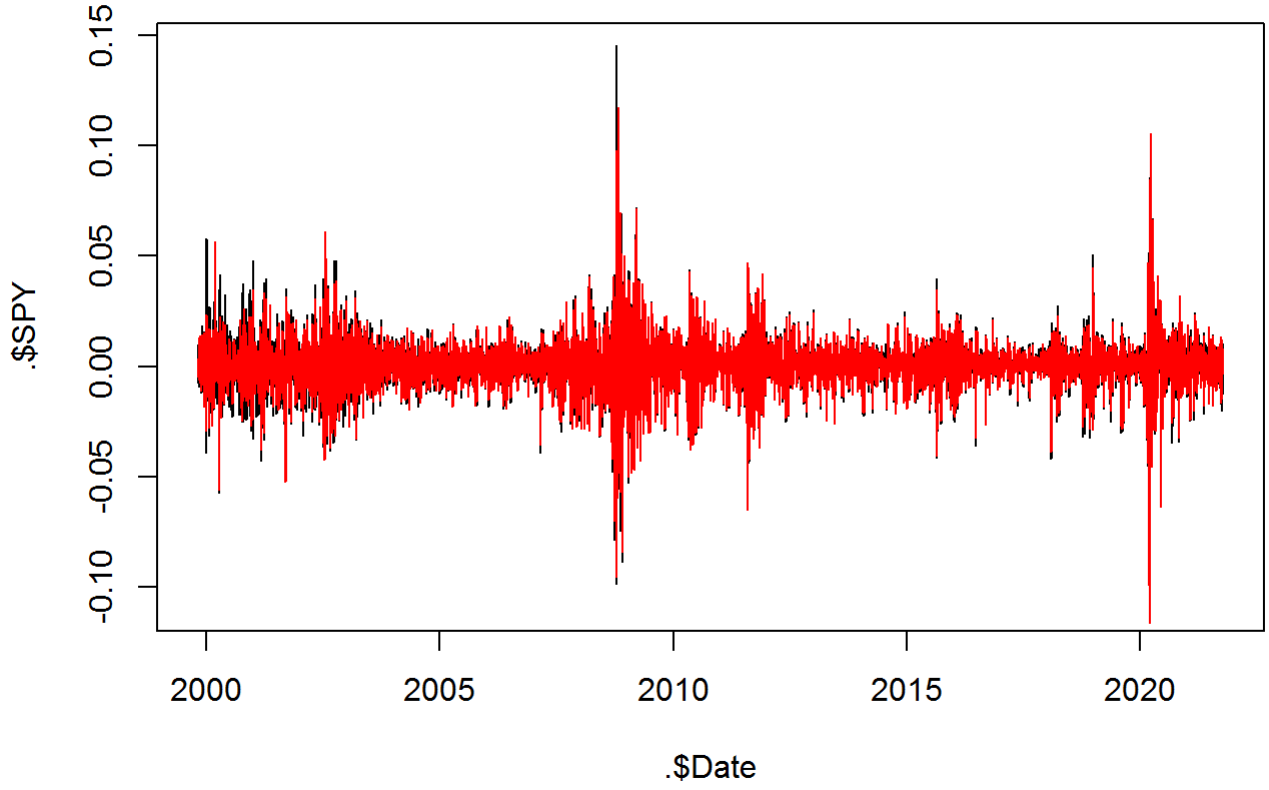
Rebalance for Annual Strategy

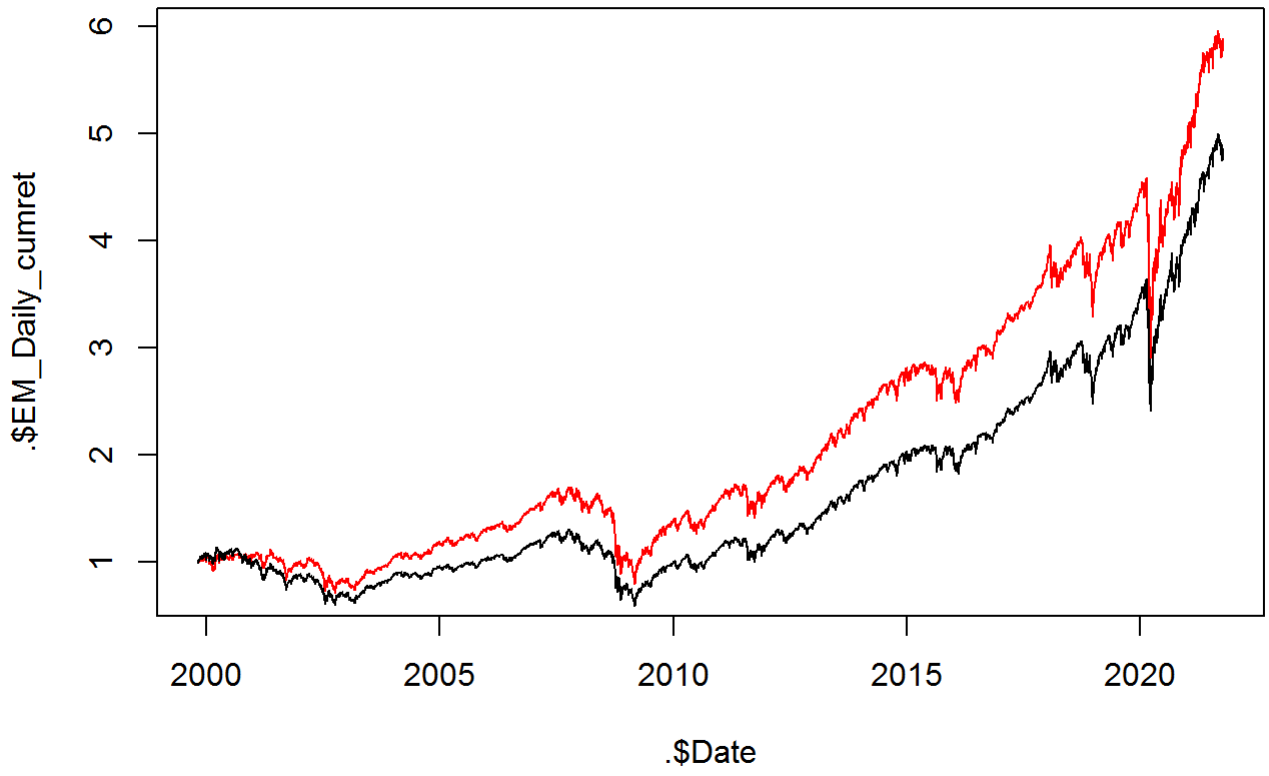
2.4.5 Strategy Return for Annually Startegy

```
## [1] 5.945465
```



2.4.6 Relative Return for Annually Startegy


.$SPY
0.15
0.10
0.05
0.00
-0.05
-0.10
2000
2005
2010
2015
2020
.$Date


.$EM_Daily_cumret
6
5
4
3
2
1
2000
2005
2010
2015
2020
.$Date

2.4.7 Matric for Annually Startegy

```
## Annual Return:
```

```
## [1] 1.084084
```

```
## [1] 1.07411
```

```
## Sharp ratio:
```

```
## [1] 5.85697
```

```
## [1] 5.491341
```

2.4.8 Analyze for Annual Startegy

```
## Max Drawdown:
```

```
## [1] 0.5280284
```

```
## Under annually-balance:rank all ETFs by its contribution to PnL over the entire period in dec
reasing order:
##
```

```
## [1] "XLY" "XLV" "XLB" "XLI" "XLU" "XLP" "XLK" "XLE" "XLF"
```

```
## Under annually-balance:rank all ETFs by its risk (max. draw down %) over the entire period in
decreasing order:
##
```

```
## [1] "XLF" "XLK" "XLE" "XLI" "XLB" "XLY" "XLU" "XLV" "XLP"
```

3. Momentum Strategy

- Empirically, there appears to be certain “inertia” in stock returns known as the momentum effect, whereby future returns are positively correlated with past returns.
- We use a price momentum here. At any point, we rank the ETFs according to following.
    - At row `i` , momentum is
      `( price[i-21] - price[i-252] ) / price[i-252] - ( price[i-1] - price[i-21] ) / price[i-21]`
- Set to re-balance every month
    1. Long the top 4 stocks with equal weights,

- Calculate the portfolio value of A, B, C, D on re-balance day. For example, 1.2
- Allocation is to replace B,D with E,F. Make A,C,E,F has equal weights of 1.2/4 for the next period, or

2. Long the top 2 stocks and Short bottom 2 stocks with equal weights.
    - Shorting means borrow the stock, sell it and later buy it back to return. You need to pay the full cost of the stock to borrow it and you won't not receive cash from selling. It will be held against your liability of returning the stock.
    - In simple terms, for either long or short, you pay the full cost of stock at the start.
    - It's still equal weights from the portfolio value, 1/4 each for the top 2 long, and -1/4 each for the bottom 2 shorts.

TODO

For each of 2 Momentum strategies (Both are monthly re-balanced): - Long the top 4 stocks with equal weights, or - Long the top 2 stocks and Short bottom 2 stocks with equal weights.

Do the analysis prescribed in the ## 2.2 Performance section.

- Note: there is lead-in period *exclude* the lead-in period when Momentum strategy still wait for more data.
    - For both momentum strategy portfolio and S&P in comparison, you need to exlcude the lead-in period so as to start from the first rebal_day day.

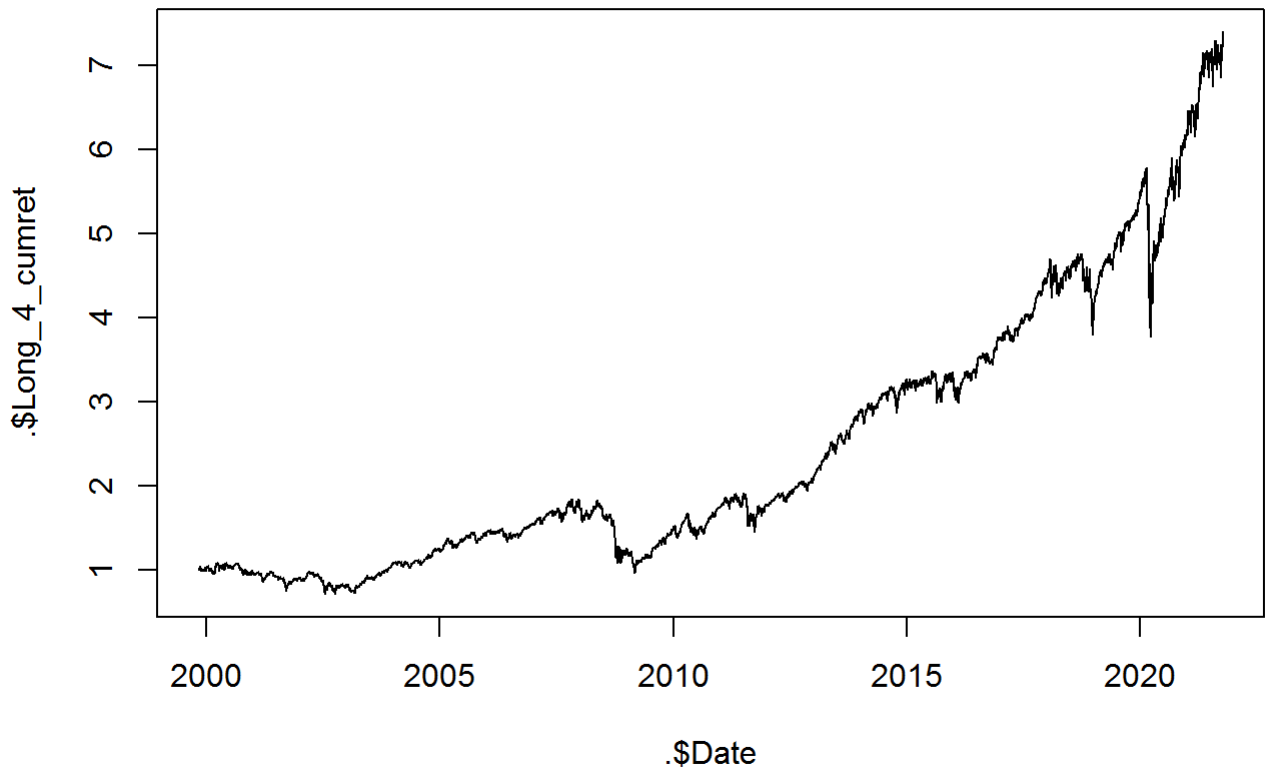
Analyze Momentum Monthly Rebalance Strats

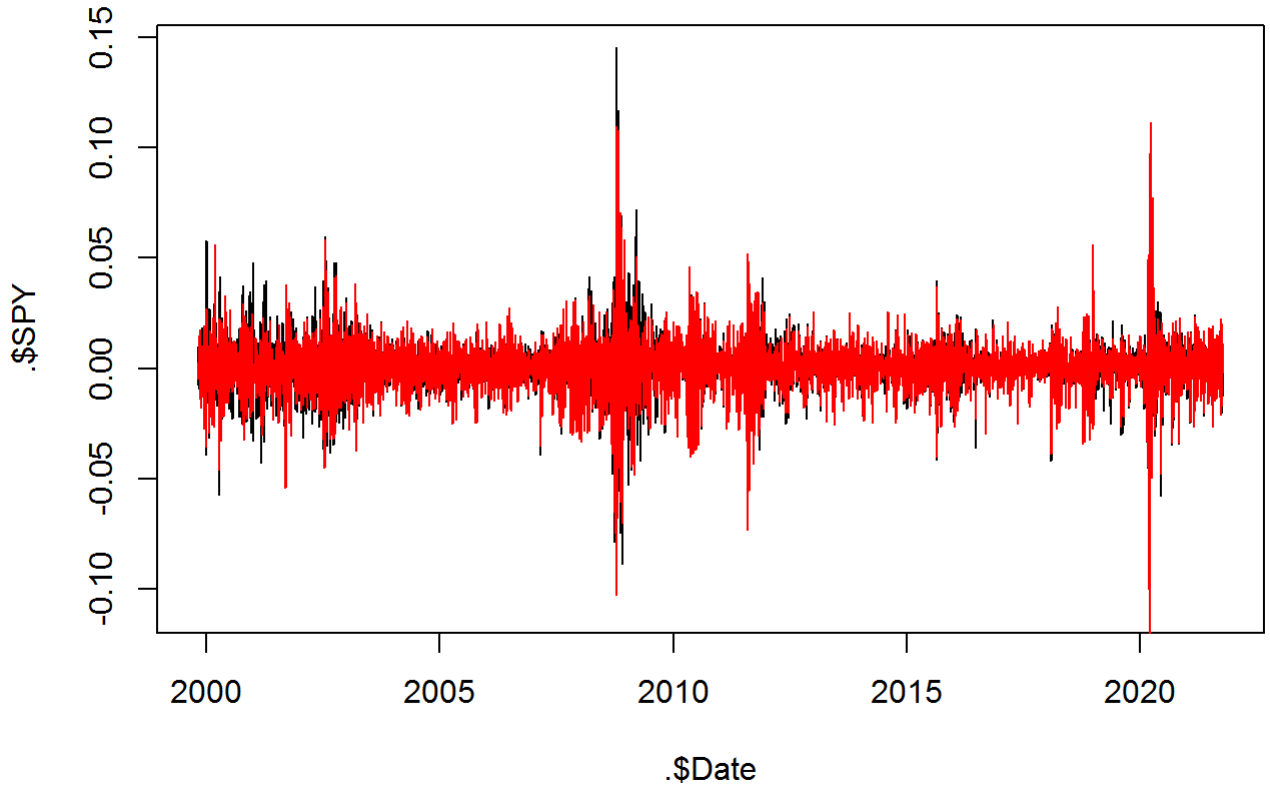
Calculation of Momentum

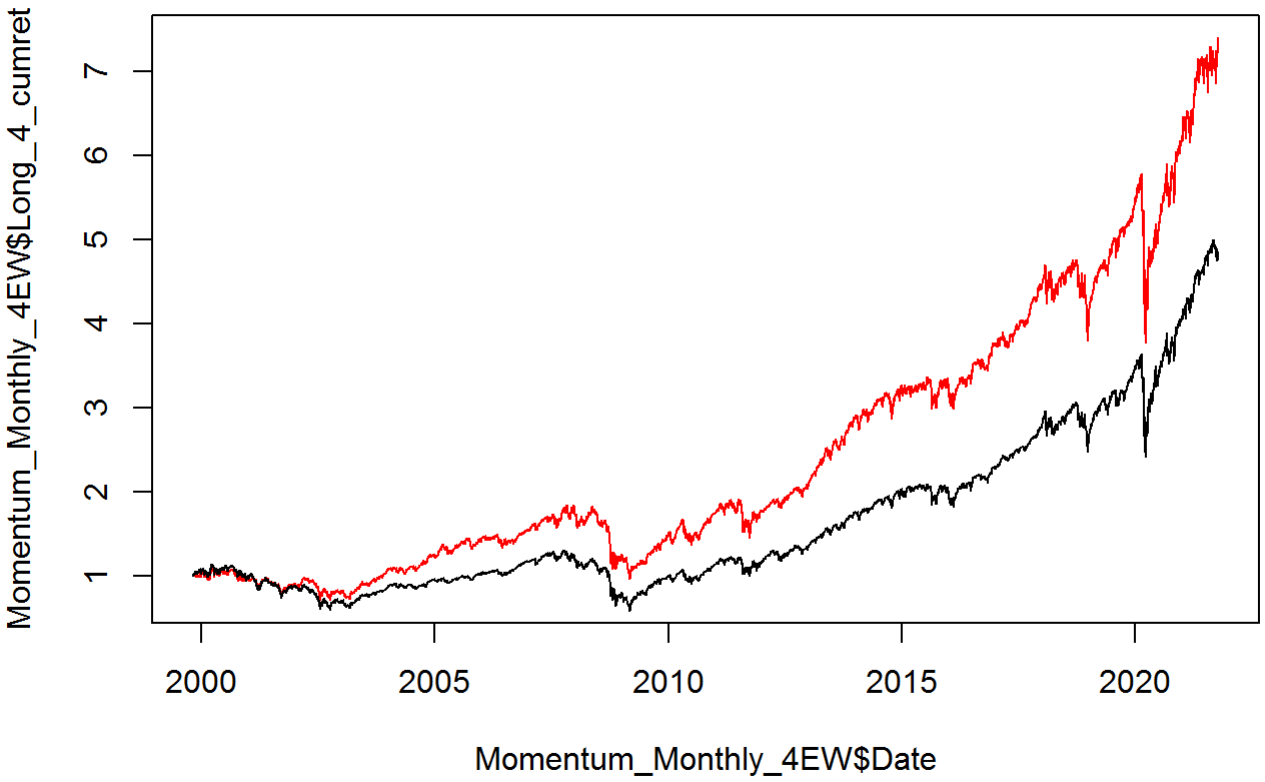
3.1 Long 4 Monthly Momentum Strategy

3.1.1 Strategy Return for Long 4 Monthly Momentum

```
## [1] 7.400994
```


.$Long_4_cumret
1
2
3
4
5
6
7
2000
2005
2010
2015
2020
.$Date


.$SPY
-0.10
-0.05
0.00
0.05
0.10
0.15
2000
2005
2010
2015
2020
.$Date




```
## integer(0)
```

Long 4 Momentum Strategy

```
## Annual Return:
```

```
## [1] 1.094889
```

```
## [1] 1.07411
```

```
## Sharp ratio:
```

```
## [1] 5.746648
```

```
## [1] 5.491341
```

3.1.2 Analysis of Long 4 Strategy: Maximum Drawdown

```
## Max Drawdown:
```

```
## [1] 0.4763122
```

3.1.3 Rank all ETFs by its contribution to PnL over the entire period.

```
## Warning in xtfrm.data.frame(x): cannot xtfrm data frames
```

```
## Ranking of all ETFs by Contributions from Highest to Lowest:
```

```
## [1] "XLE" "XLY" "XLK" "XLF" "XLI" "XLB" "XLV" "XLP" "XLU"
```

3.1.4 Rank all ETFs by its Risks (Maximun Drawdown) over the entire period.

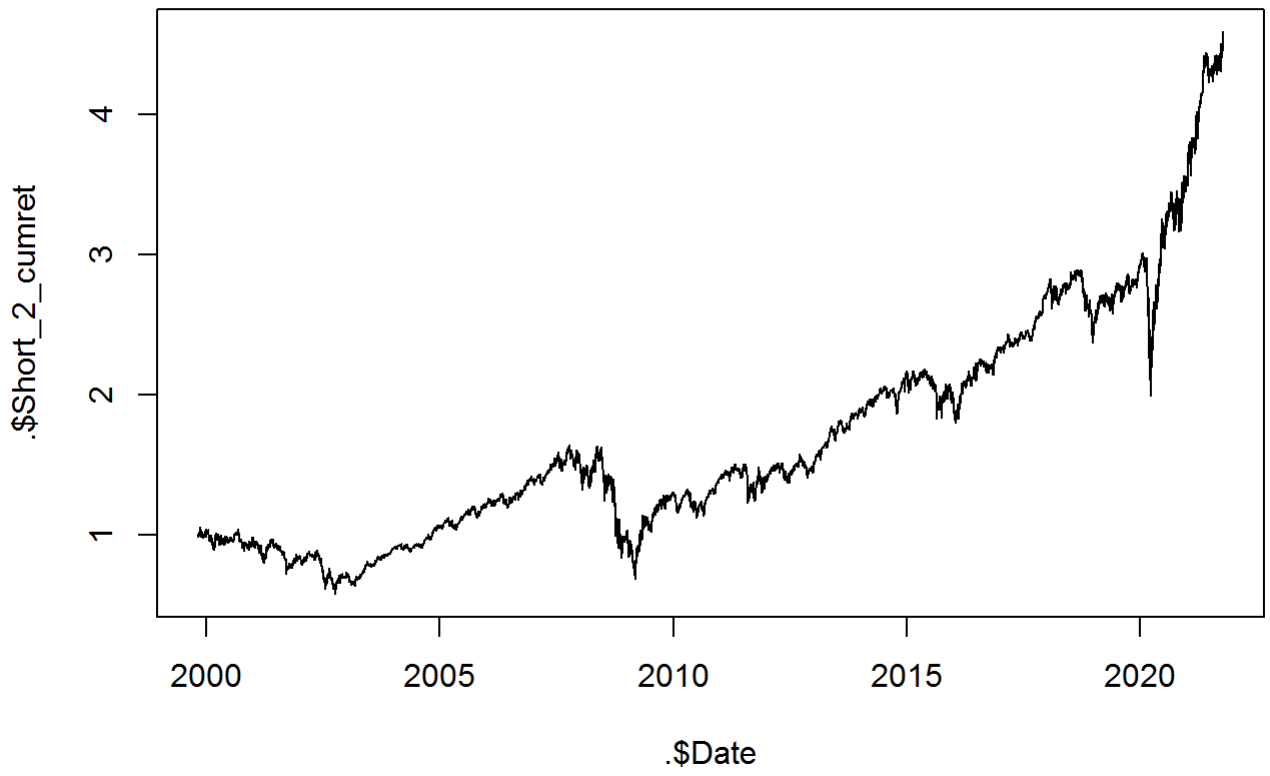
```
## Under monthly-balance:rank all ETFs by its risk (max. draw down %) over the entire period in
decreasing order:
##
```

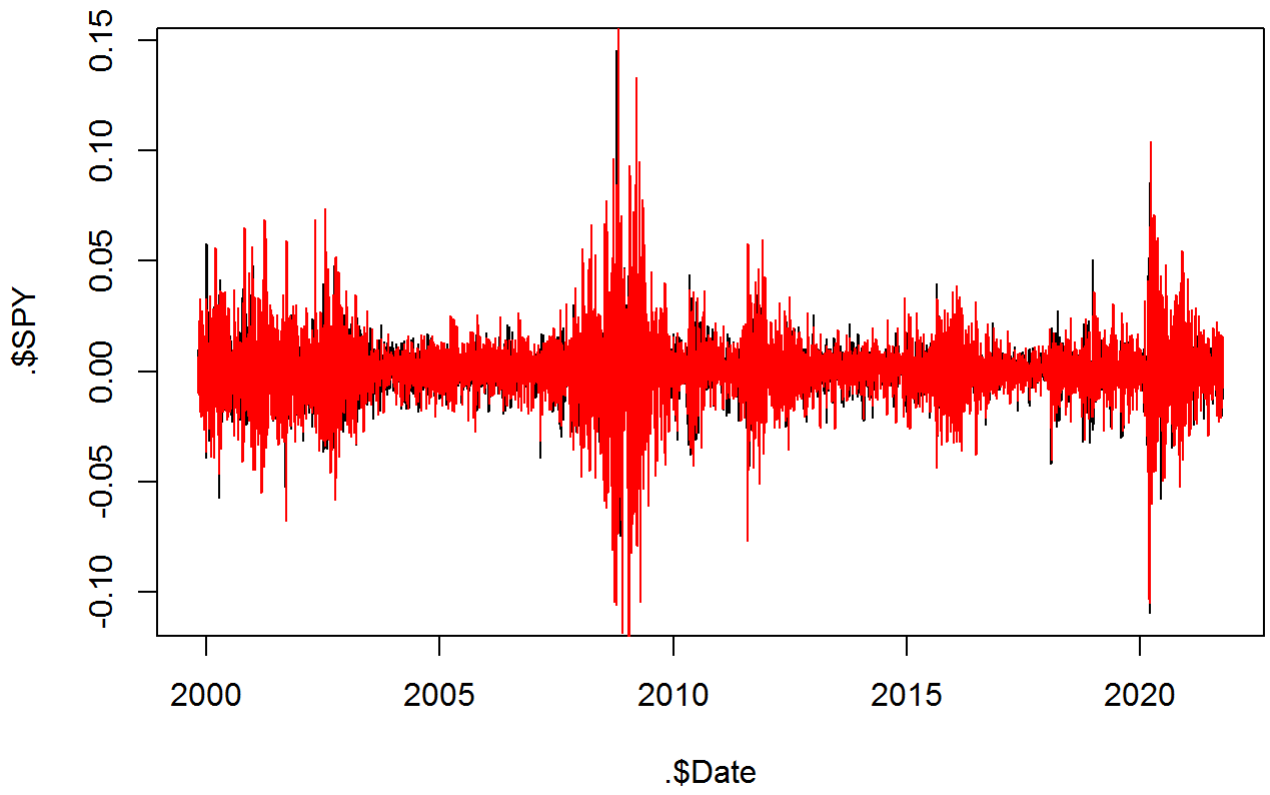
```
## [1] "XLE" "XLP" "XLB" "XLF" "XLY" "XLK" "XLI" "XLV" "XLU"
```

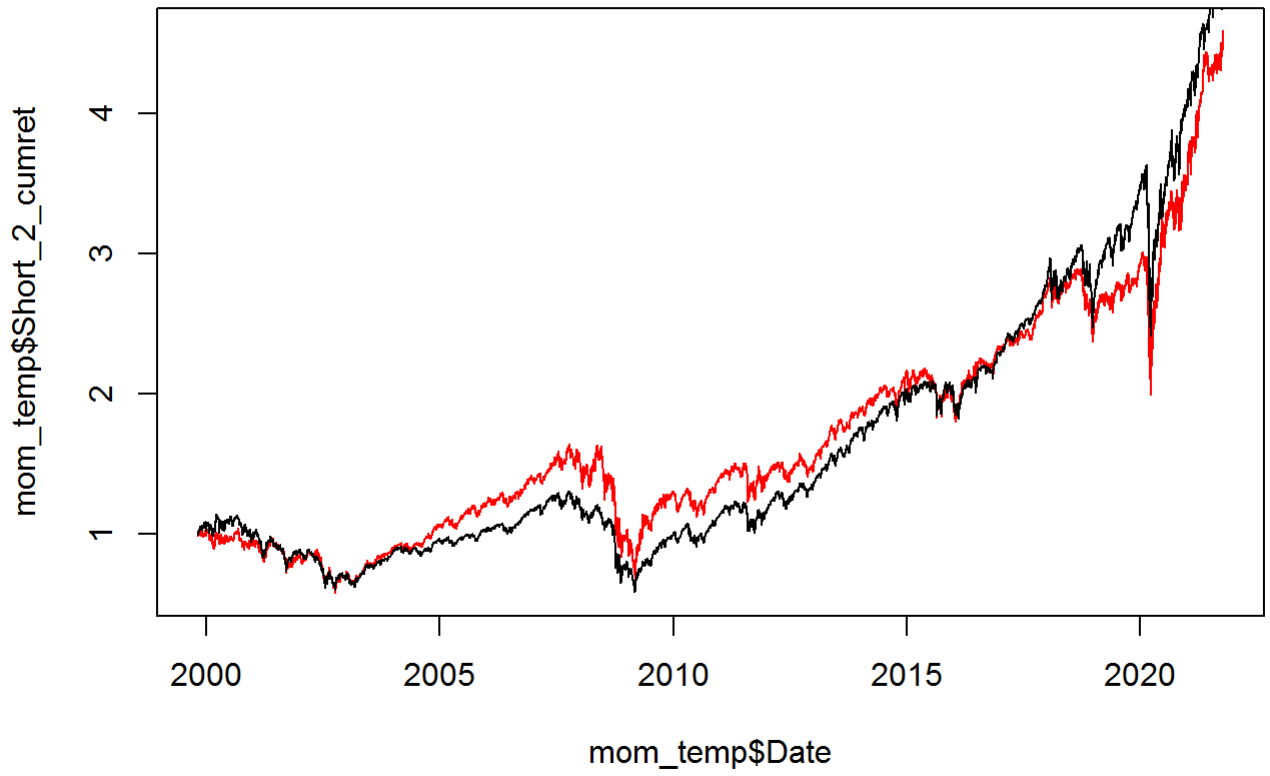
3.2 Long 2 Short 2 Monthly Momentum Strategy

3.2.1 Strategy Return for Long 2 Short 2 Monthly Momentum

```
## [1] 4.593139
```


.$Short_2_cumret
1
2
3
4
2000
2005
2010
2015
2020
.$Date


.$SPY
0.15
0.10
0.05
0.00
-0.05
-0.10
2000
2005
2010
2015
2020
.$Date


mom_temp$Short_2_cumret
4
3
2
1
2000
2005
2010
2015
2020
mom_temp$Date

```
## integer(0)
```

3.2.2 Long 2 Short 2 Momentum Strategy

```
## Annual Return:
```

```
## [1] 1.071487
```

```
## [1] 1.07411
```

```
## Sharp ratio:
```

```
## [1] 4.177496
```

```
## [1] 5.491341
```

3.2.3 Analyze for Long 2 Short 2 Strategy: Maximum Drawdown

```
## Max Drawdown:
```

```
## [1] 0.5817556
```

3.2.4 Rank all ETFs by its contribution to PnL over the entire period.

```
## Warning in xtfrm.data.frame(x): cannot xtfrm data frames
```

```
## Ranking of all ETFs by Contributions from Highest to Lowest:
```

```
## [1] "XLE" "XLF" "XLI" "XLV" "XLU" "XLP" "XLB" "XLK" "XLY"
```

3.2.5 Rank all ETFs by its risk (max. draw down %) over the entire period

```
## Under monthly-balance:rank all ETFs by its risk (max. draw down %) over the entire period in
decreasing order:
##
```

```
## [1] "XLF" "XLE" "XLK" "XLB" "XLY" "XLV" "XLU" "XLI" "XLP"
```