Momentum Assignment

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```
library('dplyr')

##
## Attaching package: 'dplyr'

## The following objects are masked from 'package:stats':
##
##     filter, lag

## The following objects are masked from 'package:base':
##
##     intersect, setdiff, setequal, union

library('ggplot2')
library("lubridate")

##
## Attaching package: 'lubridate'

## The following objects are masked from 'package:base':
##
##     date, intersect, setdiff, union

library("readxl")
library("zoo")

##
## Attaching package: 'zoo'

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

*Table 1 and Table 2 can be found both in the middle and at the end of the document

0.1 Stock Price Data:\

```
setwd('C:/Users/Zhong/Desktop/')
crsp_monthly <- read.csv('crsp_monthly.csv')

df <- subset(crsp_monthly, (SHRCD==10 | SHRCD==11))
#df$RET[df$RET!="C"] <- df$RET[df$RET!="C"] %>% as.character() %>% as.numeric()
df$RET <- ifelse(df$RET=="", as.numeric(as.character(df$DLRET)),
as.numeric(as.character(df$RET)))
```

```
## Warning in ifelse(df$RET == "", as.numeric(as.character(df$DLRET)),
## as.numeric(as.character(df$RET))): NAs introduced by coercion

## Warning in ifelse(df$RET == "", as.numeric(as.character(df$DLRET)),
## as.numeric(as.character(df$RET))): NAs introduced by coercion

df$PRC <- abs(df$PRC)
df$ym <- df$date %>% ymd %>% as.yearmon()
df$Date <- df$ym %>% as.Date() %>% ymd()
```

0.2. Initial Strategy:
(1)

```
#To calculate the past returns for each stock-month observation
months <- df$ym %>% unique() %>% sort

past_year <- NA

for (m in months[1]) {
  t <- m %>% as.Date.yearmon()
  t12 <- t %m-% months(12)
  t1 <- t %m-% months(1)
  output <- df %>% filter(Date >= t12 & Date <= t1) %>% group_by(PERMNO) %>%
    mutate(comp_return = cumprod(ifelse(is.na(RET), 1, (RET+1)))-1) %>% top_n(1,
Date) %>%
    select(PERMNO, comp_return)

  colnames(output)[2] <- m %>% as.yearmon %>% as.character()
  past_year <- output
}

for (m in months[-1]) {
  t <- m %>% as.Date.yearmon()
  t12 <- t %m-% months(12)
  t1 <- t %m-% months(1)
  output <- df %>% filter(Date >= t12 & Date <= t1) %>% group_by(PERMNO) %>%
    mutate(comp_return = cumprod(ifelse(is.na(RET), 1, (RET+1)))-1) %>% top_n(1,
Date) %>%
    select(PERMNO, comp_return)

  colnames(output)[2] <- m %>% as.yearmon %>% as.character()
  past_year <- full_join(past_year, output, by = "PERMNO")
}
```

(2)

```
#To build the function that calculates stock returns for the future x months
future_returns <- function(x) {
```

```r
  for (m in months[1]) {
  t <- m %>% as.Date.yearmon()
  t1 <- t %m+% months(x)
  output <- df %>% filter(Date > t & Date <= t1) %>% group_by(PERMNO) %>%
    mutate(comp_return = cumprod(ifelse(is.na(RET), 1, (RET+1)))-1) %>%
    top_n(1, Date) %>% select(PERMNO, comp_return)

  colnames(output)[2] <- m %>% as.yearmon %>% as.character()
  future <- output
  }

  for (m in months[-1]) {
  t <- m %>% as.Date.yearmon()
  t1 <- t %m+% months(x)
  output <- df %>% filter(Date > t & Date <= t1) %>% group_by(PERMNO) %>%
    mutate(comp_return = cumprod(ifelse(is.na(RET), 1, (RET+1)))-1) %>% top_n(1,
Date) %>%
    select(PERMNO, comp_return)

  colnames(output)[2] <- m %>% as.yearmon %>% as.character()
  future <- full_join(future, output, by = "PERMNO")
  }
  return(future)
}

future_1m <- future_returns(1)
future_3m <- future_returns(3)
future_6m <- future_returns(6)
future_12m <- future_returns(12)
future_60m <- future_returns(60)

library(reshape2)

#To change the format of above datasets and merge them into one combined dataset
#and then merge them with the above $5 stock-month observations
df_5 <- subset(df, PRC >= 5)

past_melted <- past_year %>% melt(id.vars = "PERMNO",
                                  value.name = "past_year_return")
melted_future_1m <- future_1m %>% melt(id.vars = "PERMNO",
                                  value.name = "future_1_m")
melted_future_3m <- future_3m %>% melt(id.vars = "PERMNO",
                                  value.name = "future_3_m")
melted_future_6m <- future_6m %>% melt(id.vars = "PERMNO",
                                  value.name = "future_6_m")
melted_future_12m <- future_12m %>% melt(id.vars = "PERMNO",
                                  value.name = "future_12_m")
melted_future_60m <- future_60m %>% melt(id.vars = "PERMNO",
                                  value.name = "future_60_m")
```

```r
combined <- past_melted %>% left_join(melted_future_1m, by = c("PERMNO",
"variable")) %>%
                                left_join(melted_future_3m) %>%
                                left_join(melted_future_6m) %>%
                                left_join(melted_future_12m) %>%
                                left_join(melted_future_60m)

names(combined)[2] <- "ym"
combined$ym <- combined$ym %>% as.character %>% as.yearmon

portfolio <- left_join(df_5, combined, by = c("PERMNO", "ym"))

portfolio$dt <- portfolio$ym %>% as.Date

#setwd('C:/Users/Zhong/Desktop/')
#write.csv(portfolio, "portfolio.csv")

# I reloaded the csv here to save memory and make the rmd file knittable
setwd('C:/Users/Zhong/Desktop/')
portfolio <- read.csv('portfolio.csv')
portfolio$ym <- portfolio$dt %>% as.yearmon

#To calculate the deciles based on past year return for each month and designate
the top decile and the bottom decile for each month
d_1_10 <- portfolio %>% group_by(ym) %>%
                summarize(monthly_d10 = quantile(past_year_return, probs = 0.90,
na.rm = T),
                        monthly_d1 = quantile(past_year_return, probs = 0.10,
na.rm = T))

## `summarise()` ungrouping output (override with `.groups` argument)

portfolio <- left_join(portfolio, d_1_10, by = "ym")
portfolio$up <- ifelse(portfolio$past_year_return > portfolio$monthly_d10, 1, 0)
portfolio$down <- ifelse(portfolio$past_year_return < portfolio$monthly_d1, 1, 0)
```

(5) Portfolio return of an equal-weighted portfolio of Ups:

```r
ups <- portfolio %>% filter(up == 1) %>% group_by(ym) %>%
                                summarize(portfl_return_1m = mean(future_1_m,
na.rm = T),
                                        portfl_return_3m = mean(future_3_m,
na.rm = T),
                                        portfl_return_6m = mean(future_6_m,
na.rm = T),
                                        portfl_return_12m = mean(future_12_m,
na.rm = T),
                                        portfl_return_60m = mean(future_60_m,
na.rm = T))

## `summarise()` ungrouping output (override with `.groups` argument)

print(ups, n = 200)
```

```
## # A tibble: 1,127 x 6
##     ym    portfl_return_1m portfl_return_3m portfl_return_6m portfl_return_1~
##     <yea>            <dbl>            <dbl>            <dbl>            <dbl>
##  1 Feb ~         -0.109          -0.0891           0.000139           0.0986
##  2 Mar ~          0.0318          0.133            0.145              0.243
##  3 Apr ~          0.0287          0.110            0.142              0.314
##  4 May ~          0.0480          0.141            0.169              0.338
##  5 Jun ~          0.0229          0.0732           0.117              0.288
##  6 Jul ~          0.0406          0.0104           0.0799             0.328
##  7 Aug ~          0.00489         0.0282           0.122              0.363
##  8 Sep ~         -0.0258          0.0409           0.120              0.410
##  9 Oct ~          0.0409          0.0828           0.188              0.432
## 10 Nov ~          0.0131          0.0824           0.194              0.462
## 11 Dec ~          0.0129          0.0807           0.171              0.474
## 12 Jan ~          0.0492          0.0825           0.224              0.463
## 13 Feb ~         -0.00709         0.128            0.193              0.285
## 14 Mar ~          0.0437          0.127            0.270              0.371
## 15 Apr ~          0.108           0.179            0.172              0.374
## 16 May ~         -0.0313          0.0531           0.111              0.211
## 17 Jun ~          0.0928          0.132            0.202              0.209
## 18 Jul ~         -0.00547        -0.0138           0.104              0.100
## 19 Aug ~          0.0454          0.0547           0.0328             0.161
## 20 Sep ~         -0.0426          0.0666           0.0872             0.237
## 21 Oct ~          0.0779          0.148            0.253              0.341
## 22 Nov ~          0.0526          0.0424           0.246              0.541
## 23 Dec ~          0.0448          0.0736           0.0896             0.429
## 24 Jan ~         -0.0532          0.107            0.0477             0.417
## 25 Feb ~          0.129           0.246            0.245              0.609
## 26 Mar ~          0.0773          0.0281           0.190              0.433
## 27 Apr ~          0.0427         -0.0214           0.176              0.375
## 28 May ~         -0.0839          0.00776          0.307              0.122
## 29 Jun ~          0.0103          0.163            0.437              0.350
## 30 Jul ~          0.0825          0.214            0.448              0.439
## 31 Aug ~          0.0666          0.302            0.318              0.302
## 32 Sep ~          0.0529          0.253            0.251              0.182
## 33 Oct ~          0.196           0.224            0.246             -0.184
## 34 Nov ~         -0.00923         0.0352          -0.126             -0.449
## 35 Dec ~          0.0305          0.0548           0.00770           -0.407
## 36 Jan ~          0.0334          0.0378           0.0141            -0.362
## 37 Feb ~          0.0103         -0.117            0.0136            -0.369
## 38 Mar ~          0.0319         -0.0129          -0.0629            -0.303
## 39 Apr ~         -0.133          -0.0198          -0.325             -0.384
## 40 May ~          0.125           0.197           -0.334             -0.301
## 41 Jun ~          0.0307          0.0544          -0.335             -0.438
## 42 Jul ~          0.0647         -0.245           -0.323             -0.407
## 43 Aug ~         -0.00857        -0.394           -0.300             -0.428
## 44 Sep ~         -0.288          -0.373           -0.231             -0.503
## 45 Oct ~         -0.135          -0.0374           0.0779            -0.324
## 46 Nov ~          0.0430          0.162            0.181             -0.248
## 47 Dec ~          0.0511          0.194           -0.0286            -0.261
```

```
## 48 Jan ~       0.0683      0.133       -0.0200      -0.227
## 49 Feb ~       0.0761      0.0362      -0.0770      -0.240
## 50 Mar ~      -0.0337     -0.194       -0.255       -0.345
## 51 Apr ~      -0.0271     -0.169       -0.328       -0.418
## 52 May ~      -0.183      -0.140       -0.332       -0.457
## 53 Jun ~       0.0508     -0.0941      -0.257       -0.244
## 54 Jul ~       0.00287    -0.140       -0.165       -0.259
## 55 Aug ~      -0.104      -0.179       -0.0985      -0.295
## 56 Sep ~      -0.0658     -0.133       -0.00605     -0.402
## 57 Oct ~      -0.0103     -0.0163      -0.0585      -0.258
## 58 Nov ~      -0.0540      0.0847      -0.0995      -0.278
## 59 Dec ~       0.0575      0.141       -0.0121      -0.385
## 60 Jan ~       0.0962     -0.0228      -0.0782      -0.357
## 61 Feb ~       0.0104     -0.141       -0.109       -0.292
## 62 Mar ~      -0.104      -0.115       -0.345       -0.396
## 63 Apr ~      -0.0915     -0.0337      -0.178       -0.382
## 64 May ~       0.0863      0.0808      -0.132       -0.445
## 65 Jun ~      -0.0159     -0.224       -0.270       -0.486
## 66 Jul ~      -0.0000317  -0.193       -0.293       -0.408
## 67 Aug ~      -0.235      -0.204       -0.243       -0.246
## 68 Sep ~       0.0964     -0.0361      -0.0548      -0.00970
## 69 Oct ~      -0.0474     -0.129       -0.272       -0.203
## 70 Nov ~      -0.0839     -0.0842      -0.386       -0.145
## 71 Dec ~      -0.0127     -0.0370      -0.290       -0.106
## 72 Jan ~       0.0301     -0.140       -0.143       -0.0612
## 73 Feb ~      -0.0499     -0.319        0.0282      -0.183
## 74 Mar ~      -0.0824     -0.224        0.0597      -0.0641
## 75 Apr ~      -0.172      -0.0404       0.114        0.294
## 76 May ~       0.0111      0.464        0.364        1.15
## 77 Jun ~       0.166       0.409        0.324        1.12
## 78 Jul ~       0.298       0.154        0.113        0.731
## 79 Aug ~      -0.0208     -0.125       -0.145        0.705
## 80 Sep ~      -0.0946     -0.131       -0.128        0.864
## 81 Oct ~      -0.0693     -0.0203       0.258        0.738
## 82 Nov ~       0.00323    -0.0896       0.683        0.723
## 83 Dec ~      -0.0187     -0.0851       0.973        0.825
## 84 Jan ~      -0.129       0.239        0.727        1.24
## 85 Feb ~       0.0598      0.814        1.23         1.21
## 86 Mar ~       0.275       1.05         1.09         1.24
## 87 Apr ~       0.432       0.447        0.344        0.616
## 88 May ~       0.152       0.234        0.0346       0.0954
## 89 Jun ~      -0.107      -0.120       -0.143       -0.00862
## 90 Jul ~       0.178      -0.165        0.131       -0.313
## 91 Aug ~      -0.193      -0.219       -0.00437     -0.197
## 92 Sep ~      -0.111      -0.0334       0.114       -0.160
## 93 Oct ~       0.0663      0.223        0.257        0.0146
## 94 Nov ~       0.0233      0.199        0.112        0.103
## 95 Dec ~       0.177       0.237        0.0921       0.0964
## 96 Jan ~       0.0185      0.0307      -0.261       -0.134
## 97 Feb ~       0.0397     -0.120       -0.196       -0.192
```

```
##  98 Mar ~      -0.0427        -0.180        -0.304        -0.318
##  99 Apr ~      -0.140         -0.355        -0.302        -0.261
## 100 May ~      -0.00549       -0.149        -0.0329       -0.0674
## 101 Jun ~      -0.184         -0.120         0.0269        0.0508
## 102 Jul ~       0.120          0.123         0.286         0.506
## 103 Aug ~      -0.00841        0.154         0.153         0.349
## 104 Sep ~       0.0157         0.162         0.0983        0.379
## 105 Oct ~       0.134          0.159         0.196         0.600
## 106 Nov ~       0.0751         0.0468        0.0902        0.568
## 107 Dec ~      -0.0420        -0.0947        0.0486        0.531
## 108 Jan ~       0.0101         0.00540       0.203         0.693
## 109 Feb ~      -0.0553        -0.00263       0.189         0.522
## 110 Mar ~       0.0669         0.191         0.414         0.784
## 111 Apr ~       0.0323         0.164         0.342         0.453
## 112 May ~       0.0747         0.195         0.373         0.546
## 113 Jun ~       0.0994         0.211         0.421         0.542
## 114 Jul ~       0.0376         0.214         0.379         0.533
## 115 Aug ~       0.101          0.291         0.571         0.700
## 116 Sep ~       0.137          0.338         0.559         0.807
## 117 Oct ~       0.0997         0.282         0.228         0.651
## 118 Nov ~       0.131          0.283         0.233         0.610
## 119 Dec ~       0.0849         0.189         0.0927        0.459
## 120 Jan ~       0.0306        -0.0657        0.0960        0.427
## 121 Feb ~       0.0573        -0.0326        0.0568        0.418
## 122 Mar ~      -0.176         -0.131         0.000564      0.318
## 123 Apr ~       0.0833         0.179         0.284         0.413
## 124 May ~      -0.0260         0.0982        0.265         0.245
## 125 Jun ~       0.108          0.162         0.295         0.138
## 126 Jul ~       0.0184         0.0899        0.348         0.215
## 127 Aug ~       0.0365         0.163         0.400         0.131
## 128 Sep ~       0.0571         0.128         0.337        -0.201
## 129 Oct ~       0.0634         0.171         0.0720       -0.370
## 130 Nov ~       0.0213         0.146         0.0178       -0.493
## 131 Dec ~       0.0874         0.133        -0.102        -0.532
## 132 Jan ~       0.0174        -0.0667       -0.0795       -0.567
## 133 Feb ~       0.0180        -0.112        -0.144        -0.534
## 134 Mar ~      -0.125         -0.198        -0.368        -0.690
## 135 Apr ~      -0.0147        -0.000821     -0.403        -0.598
## 136 May ~      -0.0899        -0.0600       -0.474        -0.641
## 137 Jun ~       0.0984        -0.230        -0.486        -0.428
## 138 Jul ~      -0.0576        -0.391        -0.521        -0.400
## 139 Aug ~      -0.252         -0.445        -0.452        -0.418
## 140 Sep ~      -0.139         -0.338        -0.520        -0.222
## 141 Oct ~      -0.128         -0.189        -0.270         0.0445
## 142 Nov ~      -0.0916        -0.0243       -0.208         0.105
## 143 Dec ~       0.0198        -0.169         0.0879        0.251
## 144 Jan ~       0.0395        -0.0345        0.137         0.194
## 145 Feb ~      -0.182         -0.0913        0.0746        0.195
## 146 Mar ~       0.136          0.247         0.309         0.344
## 147 Apr ~      -0.00339        0.165         0.239         0.240
```

```
## 148 May ~          0.106            0.174            0.294            0.323
## 149 Jun ~          0.0644           0.0500           0.223            0.184
## 150 Jul ~         -0.00968          0.0910           0.133            0.187
## 151 Aug ~         -0.0117           0.0809           0.135            0.0535
## 152 Sep ~          0.0919           0.182            0.0539           0.160
## 153 Oct ~          0.0309           0.0536          -0.0439           0.115
## 154 Nov ~          0.105            0.0656          -0.0249           0.0541
## 155 Dec ~         -0.0857          -0.219           -0.185            0.0414
## 156 Jan ~          0.0809          -0.150            0.0178           0.0711
## 157 Feb ~         -0.217           -0.0970          -0.161            0.0494
## 158 Mar ~          0.0414           0.0779           0.304            0.482
## 159 Apr ~          0.126            0.229            0.354            0.457
## 160 May ~         -0.0742          -0.0492           0.113           -0.0846
## 161 Jun ~          0.203            0.259            0.293            0.0477
## 162 Jul ~         -0.101            0.0550           0.0745          -0.0568
## 163 Aug ~          0.139            0.155            0.264            0.106
## 164 Sep ~          0.0536           0.0987           0.188            0.0372
## 165 Oct ~         -0.0988          -0.0851           0.0618          -0.0485
## 166 Nov ~          0.0695           0.0967          -0.112            0.101
## 167 Dec ~         -0.00539          0.0939          -0.119            0.00871
## 168 Jan ~          0.0604           0.160           -0.0846          -0.0292
## 169 Feb ~          0.0513          -0.234           -0.126           -0.0894
## 170 Mar ~          0.0598          -0.213           -0.132           -0.102
## 171 Apr ~         -0.292           -0.204           -0.117           -0.215
## 172 May ~          0.0729           0.159            0.309            0.160
## 173 Jun ~          0.0551           0.103            0.242            0.190
## 174 Jul ~          0.0133           0.122            0.0687           0.196
## 175 Aug ~          0.0224           0.131            0.0520           0.171
## 176 Sep ~          0.0960           0.119            0.0248           0.120
## 177 Oct ~          0.00618         -0.0197          -0.0855           0.0206
## 178 Nov ~          0.0246          -0.0490          -0.0945          -0.0187
## 179 Dec ~         -0.0577          -0.0621          -0.0478          -0.0639
## 180 Jan ~         -0.0209          -0.0677           0.110            0.0267
## 181 Feb ~          0.0102          -0.0350           0.136            0.0779
## 182 Mar ~         -0.0429           0.0359           0.112            0.0362
## 183 Apr ~          0.0163           0.213            0.163            0.0341
## 184 May ~          0.0771           0.183            0.138            0.00126
## 185 Jun ~          0.119            0.0978          -0.0106          -0.0306
## 186 Jul ~         -0.00364         -0.0397          -0.0240          -0.0603
## 187 Aug ~         -0.0181          -0.0468          -0.0371          -0.0156
## 188 Sep ~         -0.0173          -0.0806          -0.0451           0.0759
## 189 Oct ~         -0.00297         -0.000906        -0.107            0.130
## 190 Nov ~         -0.0621          -0.0120          -0.0748           0.144
## 191 Dec ~          0.0811           0.0207           0.0154           0.345
## 192 Jan ~         -0.0137          -0.114           -0.0298           0.256
## 193 Feb ~         -0.0644          -0.0862           0.0198           0.411
## 194 Mar ~         -0.0518          -0.0311           0.137            0.695
## 195 Apr ~          0.0228           0.0843           0.298            0.851
## 196 May ~         -0.00175          0.0890           0.203            0.899
## 197 Jun ~          0.0611           0.159            0.312            1.01
```

```
## 198 Jul ~        0.0321         0.163              0.311                  0.677
## 199 Aug ~        0.0524         0.131              0.397                  0.667
## 200 Sep ~        0.0793         0.132              0.472                  0.600
## # ... with 927 more rows, and 1 more variable: portfl_return_60m <dbl>
```

Portfolio return of an equal-weighted portfolio of Downs

```
downs <- portfolio %>% filter(down == 1) %>% group_by(ym) %>%
                                summarize(portfl_return_1m = mean(future_1_m,
na.rm = T),
                                    portfl_return_3m = mean(future_3_m,
na.rm = T),
                                    portfl_return_6m = mean(future_6_m,
na.rm = T),
                                    portfl_return_12m = mean(future_12_m,
na.rm = T),
                                    portfl_return_60m = mean(future_60_m,
na.rm = T))

## `summarise()` ungrouping output (override with `.groups` argument)

print(downs, n = 200)

## # A tibble: 1,127 x 6
##      ym    portfl_return_1m portfl_return_3m portfl_return_6m portfl_return_1~
##      <yea>            <dbl>            <dbl>            <dbl>            <dbl>
##   1 Feb ~         -0.120          -0.0577           0.00807          -0.0143
##   2 Mar ~          0.0262          0.0895           0.114            0.129
##   3 Apr ~         -0.00653         0.0779          -0.0431           0.0839
##   4 May ~          0.0778          0.103           -0.0213           0.150
##   5 Jun ~          0.00779        -0.00341         -0.0550          -0.0365
##   6 Jul ~          0.0302         -0.110           -0.126            0.0128
##   7 Aug ~         -0.0468         -0.142           -0.0915          -0.0580
##   8 Sep ~         -0.0833         -0.0676          -0.124            0.0207
##   9 Oct ~          0.0000456      -0.00199         -0.00747          0.125
##  10 Nov ~          0.0571          0.0490           0.0929           0.243
##  11 Dec ~         -0.0408         -0.0228           0.0197           0.312
##  12 Jan ~          0.0632          0.0418           0.165            0.590
##  13 Feb ~         -0.0479         -0.00960          0.0770           0.311
##  14 Mar ~         -0.0116         -0.00375          0.158            0.471
##  15 Apr ~          0.0395          0.0685           0.0981           0.653
##  16 May ~         -0.0466          0.000764         0.112            0.645
##  17 Jun ~          0.0504          0.0735           0.218            0.409
##  18 Jul ~         -0.00651        -0.0545           0.147            0.304
##  19 Aug ~          0.00804         0.0608           0.113            0.349
##  20 Sep ~         -0.0568          0.110            0.223            0.510
##  21 Oct ~          0.135           0.242            0.529            0.795
##  22 Nov ~          0.0400          0.0592           0.472            0.817
##  23 Dec ~          0.0225          0.0462           0.128            0.342
##  24 Jan ~          0.00466         0.290            0.203            0.567
##  25 Feb ~          0.0722          0.346            0.191            0.576
```

```
## 26 Mar ~        0.0967      0.0581       0.160        0.317
## 27 Apr ~        0.0821     -0.0472       0.0453       0.221
## 28 May ~       -0.0968     -0.107        0.0591      -0.0766
## 29 Jun ~       -0.0148      0.0772       0.177        0.0311
## 30 Jul ~        0.0221      0.0677       0.165       -0.0576
## 31 Aug ~        0.0342      0.198        0.121       -0.0567
## 32 Sep ~        0.00314     0.0919      -0.00360     -0.152
## 33 Oct ~        0.113       0.0900      -0.0172      -0.312
## 34 Nov ~       -0.0479     -0.0473      -0.212       -0.462
## 35 Dec ~        0.0201     -0.0554      -0.153       -0.457
## 36 Jan ~       -0.0287     -0.103       -0.166       -0.426
## 37 Feb ~       -0.0340     -0.153       -0.132       -0.399
## 38 Mar ~       -0.0273     -0.103       -0.161       -0.302
## 39 Apr ~       -0.124      -0.0825      -0.348       -0.342
## 40 May ~        0.0418      0.0318      -0.374       -0.305
## 41 Jun ~        0.0127     -0.0757      -0.447       -0.485
## 42 Jul ~       -0.0241     -0.319       -0.373       -0.485
## 43 Aug ~       -0.0816     -0.418       -0.334       -0.489
## 44 Sep ~       -0.250      -0.432       -0.159       -0.545
## 45 Oct ~       -0.170      -0.0952       0.0131      -0.512
## 46 Nov ~       -0.107       0.138        0.203       -0.441
## 47 Dec ~        0.169       0.434       -0.0925      -0.593
## 48 Jan ~        0.0656      0.213       -0.150       -0.509
## 49 Feb ~        0.159       0.0344      -0.239       -0.449
## 50 Mar ~       -0.00347    -0.320       -0.492       -0.511
## 51 Apr ~       -0.0687     -0.294       -0.552       -0.560
## 52 May ~       -0.268      -0.275       -0.525       -0.599
## 53 Jun ~        0.0598     -0.220       -0.492       -0.374
## 54 Jul ~       -0.0510     -0.401       -0.413       -0.462
## 55 Aug ~       -0.233      -0.371       -0.175       -0.376
## 56 Sep ~       -0.162      -0.323        0.0291      -0.540
## 57 Oct ~        0.0130      0.00423     -0.0203      -0.393
## 58 Nov ~       -0.196       0.218       -0.244       -0.487
## 59 Dec ~        0.172       0.267        0.0433      -0.539
## 60 Jan ~        0.255      -0.118       -0.184       -0.601
## 61 Feb ~       -0.103      -0.421       -0.371       -0.674
## 62 Mar ~       -0.196      -0.195       -0.562       -0.673
## 63 Apr ~       -0.188      -0.0862      -0.377       -0.683
## 64 May ~        0.301       0.171       -0.310       -0.669
## 65 Jun ~       -0.127      -0.459       -0.608       -0.754
## 66 Jul ~       -0.00488    -0.313       -0.514       -0.555
## 67 Aug ~       -0.383      -0.398       -0.482       -0.314
## 68 Sep ~        0.115      -0.301       -0.345       -0.124
## 69 Oct ~       -0.132      -0.315       -0.515       -0.326
## 70 Nov ~       -0.257      -0.170       -0.613       -0.346
## 71 Dec ~        0.158      -0.0389      -0.452       -0.155
## 72 Jan ~        0.00203    -0.391       -0.326       -0.224
## 73 Feb ~       -0.174      -0.544        0.294       -0.360
## 74 Mar ~       -0.240      -0.469        0.380       -0.152
## 75 Apr ~       -0.312       0.171        0.483        0.809
```

```
##  76 May ~        0.0362           1.91            0.779          2.65
##  77 Jun ~        0.636            1.66            0.780          3.27
##  78 Jul ~        0.862            0.341           0.132          1.36
##  79 Aug ~       -0.106           -0.401          -0.552          0.475
##  80 Sep ~       -0.188           -0.353          -0.442          0.177
##  81 Oct ~       -0.0681          -0.154           0.0218         0.209
##  82 Nov ~       -0.0528          -0.202           0.845          0.615
##  83 Dec ~       -0.0109          -0.112           1.52           0.964
##  84 Jan ~       -0.151            0.350           0.990          1.34
##  85 Feb ~        0.0292           1.26            1.69           1.82
##  86 Mar ~        0.541            1.59            1.09           1.61
##  87 Apr ~        0.513            0.480           0.193          0.774
##  88 May ~        0.170            0.0832         -0.142          0.0850
##  89 Jun ~       -0.0886          -0.187          -0.229         -0.0572
##  90 Jul ~        0.0642          -0.119           0.0695        -0.0788
##  91 Aug ~       -0.123           -0.168          -0.00698       -0.160
##  92 Sep ~       -0.115           -0.112           0.145         -0.118
##  93 Oct ~        0.00700          0.321           0.266         -0.0894
##  94 Nov ~       -0.0187           0.261           0.127          0.00327
##  95 Dec ~        0.256            0.266           0.157          0.0451
##  96 Jan ~       -0.00101         -0.0277         -0.287         -0.244
##  97 Feb ~       -0.00312         -0.105          -0.236         -0.256
##  98 Mar ~        0.0251          -0.0540         -0.149         -0.139
##  99 Apr ~       -0.0653          -0.171          -0.163         -0.124
## 100 May ~        0.0151          -0.119          -0.0731        -0.107
## 101 Jun ~       -0.263           -0.198          -0.185         -0.223
## 102 Jul ~        0.0742           0.00971         0.0582         0.242
## 103 Aug ~        0.00157          0.0427         -0.148          0.267
## 104 Sep ~       -0.0735           0.0128         -0.273          0.161
## 105 Oct ~        0.125            0.0258         -0.0729         0.367
## 106 Nov ~       -0.0134          -0.191          -0.110          0.442
## 107 Dec ~       -0.0729          -0.234          -0.0532         0.475
## 108 Jan ~       -0.130           -0.0900          0.0879         0.868
## 109 Feb ~       -0.0977           0.0335          0.323          1.26
## 110 Mar ~        0.142            0.276           0.597          1.70
## 111 Apr ~        0.0196           0.238           0.444          0.932
## 112 May ~        0.0594           0.299           0.661          1.06
## 113 Jun ~        0.128            0.214           0.572          0.861
## 114 Jul ~        0.0721           0.127           0.782          0.986
## 115 Aug ~       -0.0294           0.199           0.567          0.659
## 116 Sep ~        0.0572           0.300           0.565          0.799
## 117 Oct ~        0.161            0.387           0.374          0.754
## 118 Nov ~        0.0252           0.234           0.172          0.466
## 119 Dec ~        0.107            0.122           0.0591         0.372
## 120 Jan ~        0.0451          -0.0645          0.0140         0.339
## 121 Feb ~        0.000575        -0.0716          0.0115         0.339
## 122 Mar ~       -0.0736          -0.0387          0.0419         0.188
## 123 Apr ~        0.0286           0.0642          0.175          0.185
## 124 May ~        0.00225          0.0476          0.234          0.166
## 125 Jun ~        0.0487           0.0699          0.217          0.0963
```

```
## 126 Jul ~      -0.00415        0.0981         0.210          0.126
## 127 Aug ~       0.0309         0.165          0.256          0.103
## 128 Sep ~       0.0657         0.141          0.185         -0.144
## 129 Oct ~       0.0645         0.0909         0.00343       -0.238
## 130 Nov ~       0.00337        0.0680        -0.0357        -0.340
## 131 Dec ~       0.0570         0.0625        -0.149         -0.440
## 132 Jan ~      -0.00150       -0.123         -0.149         -0.437
## 133 Feb ~      -0.0173        -0.155         -0.194         -0.420
## 134 Mar ~      -0.0984        -0.215         -0.330         -0.571
## 135 Apr ~      -0.0521        -0.0467        -0.335         -0.493
## 136 May ~      -0.0991        -0.0687        -0.362         -0.438
## 137 Jun ~       0.123         -0.157         -0.382         -0.279
## 138 Jul ~      -0.0738        -0.341         -0.451         -0.327
## 139 Aug ~      -0.219         -0.364         -0.368         -0.284
## 140 Sep ~      -0.103         -0.316         -0.466         -0.174
## 141 Oct ~      -0.122         -0.197         -0.311          0.0714
## 142 Nov ~      -0.138         -0.0308        -0.299          0.0801
## 143 Dec ~       0.0811        -0.270          0.153          0.364
## 144 Jan ~       0.0877        -0.150          0.298          0.176
## 145 Feb ~      -0.384         -0.284          0.118          0.188
## 146 Mar ~       0.243          0.623          0.705          0.391
## 147 Apr ~      -0.0873         0.580          0.711          0.152
## 148 May ~       0.467          0.653          0.749          0.407
## 149 Jun ~       0.190          0.0931         0.316         -0.157
## 150 Jul ~      -0.0579         0.0697        -0.0476        -0.143
## 151 Aug ~      -0.0299         0.110          0.131         -0.219
## 152 Sep ~       0.199          0.220         -0.187          0.301
## 153 Oct ~      -0.0475        -0.119         -0.289          0.0147
## 154 Nov ~       0.0284        -0.0390        -0.155         -0.0448
## 155 Dec ~      -0.0878        -0.233         -0.246         -0.0732
## 156 Jan ~       0.0125        -0.133         -0.0411         0.0643
## 157 Feb ~      -0.144         -0.112         -0.189          0.0189
## 158 Mar ~      -0.00371       -0.0238         0.361          0.213
## 159 Apr ~       0.0766         0.109          0.344          0.396
## 160 May ~      -0.0773        -0.0883         0.129         -0.0881
## 161 Jun ~       0.103          0.331          0.183         -0.0429
## 162 Jul ~      -0.138          0.230          0.0472        -0.113
## 163 Aug ~       0.503          0.259          0.284          0.0900
## 164 Sep ~      -0.0481        -0.199         -0.171         -0.303
## 165 Oct ~      -0.0764        -0.0986        -0.0859        -0.192
## 166 Nov ~      -0.0169        -0.00991       -0.326         -0.126
## 167 Dec ~      -0.0102         0.0292        -0.268         -0.119
## 168 Jan ~       0.00820        0.00468       -0.249         -0.162
## 169 Feb ~       0.0189        -0.335         -0.223         -0.211
## 170 Mar ~      -0.0322        -0.296         -0.199         -0.205
## 171 Apr ~      -0.288         -0.222         -0.120         -0.165
## 172 May ~       0.0572         0.160          0.257          0.235
## 173 Jun ~       0.0376         0.166          0.158          0.221
## 174 Jul ~       0.0495         0.156          0.119          0.321
## 175 Aug ~       0.0635         0.0997         0.0472         0.280
```

```
## 176 Sep ~        0.0486          0.00183          0.00357          0.176
## 177 Oct ~       -0.0260         -0.0814          -0.112           0.0413
## 178 Nov ~       -0.0337         -0.0481          -0.0526          0.0440
## 179 Dec ~        0.0113          0.0113           0.0300         -0.0331
## 180 Jan ~       -0.0265         -0.0593           0.205           0.0177
## 181 Feb ~        0.00424        -0.0617           0.161          -0.00859
## 182 Mar ~       -0.0722         -0.00303          0.134          -0.0730
## 183 Apr ~        0.00645         0.226            0.103          -0.0866
## 184 May ~        0.0786          0.233            0.0770         -0.0418
## 185 Jun ~        0.116           0.0954          -0.0911         -0.0972
## 186 Jul ~       -0.0180         -0.115           -0.163          -0.182
## 187 Aug ~       -0.0122         -0.114           -0.156          -0.116
## 188 Sep ~       -0.0683         -0.211           -0.185          -0.0679
## 189 Oct ~       -0.0501         -0.0821          -0.157           0.0871
## 190 Nov ~       -0.107          -0.0245          -0.0658          0.137
## 191 Dec ~        0.0919          0.0371           0.0513          0.276
## 192 Jan ~       -0.0117         -0.0897           0.0380          0.417
## 193 Feb ~       -0.0440         -0.0102           0.0729          0.555
## 194 Mar ~       -0.0416          0.0856           0.171           0.796
## 195 Apr ~        0.0984          0.188            0.359           0.920
## 196 May ~        0.0365          0.0815           0.201           0.829
## 197 Jun ~        0.0370          0.0802           0.197           0.870
## 198 Jul ~        0.0239          0.163            0.304           0.671
## 199 Aug ~        0.0299          0.0958           0.447           0.737
## 200 Sep ~        0.127           0.112            0.645           0.797
## # ... with 927 more rows, and 1 more variable: portfl_return_60m <dbl>
```

(6) To calculate the long-short strategy for the above two portfolios

```
long_short <- left_join(ups, downs, by = "ym")

long_short$portfl_return_1m <- long_short$portfl_return_1m.x -
long_short$portfl_return_1m.y
long_short$portfl_return_3m <- long_short$portfl_return_3m.x -
long_short$portfl_return_3m.y
long_short$portfl_return_6m <- long_short$portfl_return_6m.x -
long_short$portfl_return_6m.y
long_short$portfl_return_12m <- long_short$portfl_return_12m.x -
long_short$portfl_return_12m.y
long_short$portfl_return_60m <- long_short$portfl_return_60m.x -
long_short$portfl_return_60m.y

umd <- long_short %>% select(ym, portfl_return_1m:portfl_return_60m)
print(umd, n = 200)

## # A tibble: 1,127 x 6
##      ym    portfl_return_1m portfl_return_3m portfl_return_6m portfl_return_1~
##      <yea>            <dbl>            <dbl>            <dbl>            <dbl>
##    1 Feb ~           0.0112          -0.0314         -0.00794           0.113
##    2 Mar ~           0.00559          0.0438          0.0306            0.114
##    3 Apr ~           0.0352           0.0317          0.186             0.230
```

```
##    4 May ~        -0.0299         0.0384         0.191          0.188
##    5 Jun ~         0.0151         0.0766         0.172          0.325
##    6 Jul ~         0.0104         0.120          0.206          0.315
##    7 Aug ~         0.0516         0.170          0.214          0.421
##    8 Sep ~         0.0575         0.108          0.244          0.389
##    9 Oct ~         0.0408         0.0848         0.195          0.306
##   10 Nov ~        -0.0440         0.0334         0.101          0.219
##   11 Dec ~         0.0537         0.103          0.151          0.162
##   12 Jan ~        -0.0140         0.0407         0.0594        -0.127
##   13 Feb ~         0.0408         0.138          0.116         -0.0258
##   14 Mar ~         0.0553         0.130          0.112         -0.0995
##   15 Apr ~         0.0681         0.111          0.0735        -0.280
##   16 May ~         0.0153         0.0523        -0.000270      -0.434
##   17 Jun ~         0.0424         0.0586        -0.0167        -0.201
##   18 Jul ~         0.00104        0.0407        -0.0427        -0.204
##   19 Aug ~         0.0374        -0.00618       -0.0798        -0.188
##   20 Sep ~         0.0142        -0.0437        -0.136         -0.272
##   21 Oct ~        -0.0573        -0.0939        -0.276         -0.453
##   22 Nov ~         0.0127        -0.0169        -0.226         -0.275
##   23 Dec ~         0.0222         0.0273        -0.0382         0.0868
##   24 Jan ~        -0.0579        -0.183         -0.155         -0.150
##   25 Feb ~         0.0567        -0.100          0.0540         0.0336
##   26 Mar ~        -0.0194        -0.0300         0.0299         0.117
##   27 Apr ~        -0.0394         0.0258         0.131          0.154
##   28 May ~         0.0129         0.115          0.248          0.199
##   29 Jun ~         0.0251         0.0858         0.259          0.319
##   30 Jul ~         0.0604         0.147          0.283          0.497
##   31 Aug ~         0.0324         0.104          0.197          0.359
##   32 Sep ~         0.0497         0.161          0.255          0.334
##   33 Oct ~         0.0830         0.134          0.264          0.128
##   34 Nov ~         0.0386         0.0825         0.0854         0.0136
##   35 Dec ~         0.0104         0.110          0.161          0.0492
##   36 Jan ~         0.0620         0.141          0.180          0.0644
##   37 Feb ~         0.0444         0.0352         0.146          0.0301
##   38 Mar ~         0.0592         0.0897         0.0978        -0.00106
##   39 Apr ~        -0.00963        0.0627         0.0224        -0.0422
##   40 May ~         0.0834         0.165          0.0395         0.00397
##   41 Jun ~         0.0180         0.130          0.112          0.0471
##   42 Jul ~         0.0888         0.0736         0.0500         0.0784
##   43 Aug ~         0.0731         0.0242         0.0343         0.0609
##   44 Sep ~        -0.0383         0.0588        -0.0719         0.0419
##   45 Oct ~         0.0346         0.0579         0.0648         0.188
##   46 Nov ~         0.150          0.0240        -0.0219         0.194
##   47 Dec ~        -0.118         -0.240          0.0639         0.332
##   48 Jan ~         0.00269       -0.0804         0.130          0.282
##   49 Feb ~        -0.0828         0.00183        0.162          0.209
##   50 Mar ~        -0.0303         0.126          0.238          0.166
##   51 Apr ~         0.0416         0.125          0.224          0.142
##   52 May ~         0.0853         0.135          0.193          0.142
##   53 Jun ~        -0.00899        0.126          0.235          0.130
```

```
##  54 Jul ~       0.0539       0.262       0.248       0.203
##  55 Aug ~       0.129        0.191       0.0761      0.0811
##  56 Sep ~       0.0966       0.190      -0.0351      0.138
##  57 Oct ~      -0.0232      -0.0205     -0.0382      0.134
##  58 Nov ~       0.142       -0.133       0.144       0.209
##  59 Dec ~      -0.114       -0.127      -0.0554      0.154
##  60 Jan ~      -0.159        0.0954      0.106       0.243
##  61 Feb ~       0.114        0.280       0.262       0.381
##  62 Mar ~       0.0919       0.0804      0.218       0.277
##  63 Apr ~       0.0969       0.0525      0.200       0.301
##  64 May ~      -0.214       -0.0906      0.178       0.224
##  65 Jun ~       0.111        0.235       0.338       0.268
##  66 Jul ~       0.00485      0.120       0.221       0.147
##  67 Aug ~       0.149        0.194       0.239       0.0683
##  68 Sep ~      -0.0190       0.265       0.291       0.114
##  69 Oct ~       0.0844       0.185       0.243       0.123
##  70 Nov ~       0.173        0.0853      0.227       0.201
##  71 Dec ~      -0.170        0.00194     0.162       0.0496
##  72 Jan ~       0.0281       0.250       0.183       0.163
##  73 Feb ~       0.124        0.225      -0.266       0.176
##  74 Mar ~       0.158        0.246      -0.321       0.0883
##  75 Apr ~       0.140       -0.211      -0.369      -0.515
##  76 May ~      -0.0251      -1.44       -0.415      -1.50
##  77 Jun ~      -0.470       -1.25       -0.455      -2.14
##  78 Jul ~      -0.564       -0.187      -0.0182     -0.628
##  79 Aug ~       0.0851       0.276       0.406       0.230
##  80 Sep ~       0.0932       0.222       0.314       0.687
##  81 Oct ~      -0.00127      0.133       0.236       0.528
##  82 Nov ~       0.0560       0.113      -0.162       0.108
##  83 Dec ~      -0.00783      0.0267     -0.549      -0.139
##  84 Jan ~       0.0221      -0.111      -0.263      -0.102
##  85 Feb ~       0.0307      -0.450      -0.457      -0.611
##  86 Mar ~      -0.266       -0.542      -0.00459    -0.372
##  87 Apr ~      -0.0810      -0.0326      0.151      -0.158
##  88 May ~      -0.0176       0.150       0.176       0.0104
##  89 Jun ~      -0.0182       0.0676      0.0859      0.0485
##  90 Jul ~       0.114       -0.0464      0.0610     -0.234
##  91 Aug ~      -0.0703      -0.0508      0.00261    -0.0372
##  92 Sep ~       0.00465      0.0788     -0.0314     -0.0418
##  93 Oct ~       0.0593      -0.0976     -0.00862     0.104
##  94 Nov ~       0.0420      -0.0627     -0.0148      0.100
##  95 Dec ~      -0.0785      -0.0293     -0.0652      0.0514
##  96 Jan ~       0.0195       0.0584      0.0260      0.110
##  97 Feb ~       0.0429      -0.0144      0.0398      0.0640
##  98 Mar ~      -0.0678      -0.126      -0.155      -0.179
##  99 Apr ~      -0.0751      -0.184      -0.139      -0.137
## 100 May ~      -0.0206      -0.0307      0.0402      0.0397
## 101 Jun ~       0.0787       0.0785      0.212       0.274
## 102 Jul ~       0.0462       0.113       0.228       0.264
## 103 Aug ~      -0.00997      0.111       0.301       0.0818
```

```
## 104 Sep ~      0.0892      0.149       0.371       0.219
## 105 Oct ~      0.00905     0.133       0.269       0.233
## 106 Nov ~      0.0885      0.237       0.200       0.125
## 107 Dec ~      0.0309      0.140       0.102       0.0555
## 108 Jan ~      0.140       0.0954      0.115      -0.174
## 109 Feb ~      0.0424     -0.0361     -0.134      -0.738
## 110 Mar ~     -0.0753     -0.0847     -0.182      -0.912
## 111 Apr ~      0.0128     -0.0738     -0.102      -0.479
## 112 May ~      0.0153     -0.104      -0.288      -0.510
## 113 Jun ~     -0.0291     -0.00286    -0.151      -0.320
## 114 Jul ~     -0.0345      0.0868     -0.403      -0.453
## 115 Aug ~      0.130       0.0922      0.00474     0.0409
## 116 Sep ~      0.0799      0.0382     -0.00581     0.00724
## 117 Oct ~     -0.0613     -0.105      -0.146      -0.103
## 118 Nov ~      0.105       0.0486      0.0609      0.145
## 119 Dec ~     -0.0220      0.0669      0.0335      0.0867
## 120 Jan ~     -0.0144     -0.00123     0.0820      0.0886
## 121 Feb ~      0.0567      0.0390      0.0453      0.0781
## 122 Mar ~     -0.102      -0.0918     -0.0414      0.131
## 123 Apr ~      0.0548      0.115       0.109       0.227
## 124 May ~     -0.0282      0.0506      0.0306      0.0794
## 125 Jun ~      0.0595      0.0919      0.0786      0.0418
## 126 Jul ~      0.0226     -0.00825     0.137       0.0887
## 127 Aug ~      0.00566    -0.00171     0.144       0.0282
## 128 Sep ~     -0.00862    -0.0131      0.152      -0.0569
## 129 Oct ~     -0.00110     0.0806      0.0685     -0.132
## 130 Nov ~      0.0179      0.0782      0.0535     -0.154
## 131 Dec ~      0.0304      0.0705      0.0474     -0.0922
## 132 Jan ~      0.0189      0.0565      0.0691     -0.130
## 133 Feb ~      0.0353      0.0434      0.0500     -0.114
## 134 Mar ~     -0.0269      0.0171     -0.0372     -0.118
## 135 Apr ~      0.0374      0.0459     -0.0675     -0.105
## 136 May ~      0.00920     0.00870    -0.113      -0.203
## 137 Jun ~     -0.0242     -0.0729     -0.103      -0.149
## 138 Jul ~      0.0162     -0.0491     -0.0702     -0.0729
## 139 Aug ~     -0.0327     -0.0807     -0.0845     -0.134
## 140 Sep ~     -0.0352     -0.0224     -0.0546     -0.0482
## 141 Oct ~     -0.00537     0.00820     0.0405     -0.0269
## 142 Nov ~      0.0468      0.00646     0.0913      0.0250
## 143 Dec ~     -0.0612      0.100      -0.0652     -0.113
## 144 Jan ~     -0.0482      0.116      -0.162       0.0183
## 145 Feb ~      0.202       0.192      -0.0437      0.00648
## 146 Mar ~     -0.107      -0.375      -0.396      -0.0468
## 147 Apr ~      0.0839     -0.415      -0.471       0.0876
## 148 May ~     -0.361      -0.479      -0.455      -0.0847
## 149 Jun ~     -0.125      -0.0431     -0.0930      0.341
## 150 Jul ~      0.0482      0.0214      0.180       0.330
## 151 Aug ~      0.0182     -0.0295      0.00391     0.272
## 152 Sep ~     -0.107      -0.0380      0.241      -0.141
## 153 Oct ~      0.0784      0.173       0.245       0.101
```

```
## 154 Nov ~        0.0769        0.105        0.130        0.0989
## 155 Dec ~        0.00203       0.0142       0.0612       0.115
## 156 Jan ~        0.0684       -0.0172       0.0589       0.00678
## 157 Feb ~       -0.0729        0.0153       0.0284       0.0305
## 158 Mar ~        0.0451        0.102       -0.0575       0.269
## 159 Apr ~        0.0492        0.120        0.00975      0.0610
## 160 May ~        0.00314       0.0391      -0.0160       0.00353
## 161 Jun ~        0.0996       -0.0721       0.111        0.0905
## 162 Jul ~        0.0372       -0.175        0.0273       0.0559
## 163 Aug ~       -0.364        -0.104       -0.0195       0.0163
## 164 Sep ~        0.102         0.297        0.359        0.340
## 165 Oct ~       -0.0225        0.0135       0.148        0.143
## 166 Nov ~        0.0864        0.107        0.214        0.228
## 167 Dec ~        0.00485       0.0647       0.149        0.128
## 168 Jan ~        0.0522        0.155        0.164        0.133
## 169 Feb ~        0.0325        0.101        0.0965       0.121
## 170 Mar ~        0.0919        0.0824       0.0669       0.102
## 171 Apr ~       -0.00431       0.0173       0.00214     -0.0504
## 172 May ~        0.0156       -0.000869     0.0520      -0.0752
## 173 Jun ~        0.0175       -0.0622       0.0845      -0.0309
## 174 Jul ~       -0.0362       -0.0333      -0.0506      -0.124
## 175 Aug ~       -0.0411        0.0314       0.00483     -0.109
## 176 Sep ~        0.0474        0.117        0.0212      -0.0556
## 177 Oct ~        0.0322        0.0617       0.0267      -0.0207
## 178 Nov ~        0.0583       -0.000895    -0.0419      -0.0626
## 179 Dec ~       -0.0690       -0.0734      -0.0778      -0.0308
## 180 Jan ~        0.00562      -0.00836     -0.0946       0.00901
## 181 Feb ~        0.00594       0.0267      -0.0254       0.0865
## 182 Mar ~        0.0294        0.0390      -0.0220       0.109
## 183 Apr ~        0.00989      -0.0131       0.0601       0.121
## 184 May ~       -0.00158      -0.0497       0.0611       0.0430
## 185 Jun ~        0.00267       0.00240      0.0805       0.0666
## 186 Jul ~        0.0144        0.0748       0.139        0.122
## 187 Aug ~       -0.00590       0.0672       0.119        0.101
## 188 Sep ~        0.0510        0.130        0.139        0.144
## 189 Oct ~        0.0471        0.0812       0.0500       0.0429
## 190 Nov ~        0.0445        0.0125      -0.00900      0.00653
## 191 Dec ~       -0.0108       -0.0164      -0.0360       0.0687
## 192 Jan ~       -0.00203      -0.0246      -0.0678      -0.161
## 193 Feb ~       -0.0204       -0.0759      -0.0531      -0.144
## 194 Mar ~       -0.0102       -0.117       -0.0332      -0.101
## 195 Apr ~       -0.0755       -0.104       -0.0612      -0.0687
## 196 May ~       -0.0382        0.00749      0.00239      0.0695
## 197 Jun ~        0.0241        0.0785       0.115        0.144
## 198 Jul ~        0.00823      -0.000622     0.00673      0.00590
## 199 Aug ~        0.0225        0.0349      -0.0494      -0.0699
## 200 Sep ~       -0.0477        0.0200      -0.174       -0.197
## # ... with 927 more rows, and 1 more variable: portfl_return_60m <dbl>
```

0.2.1 Analyzing Strategy performance and backtesting

(1)

```r
up_returns <- colMeans(ups[-1], na.rm = T)
down_returns <- colMeans(downs[-1], na.rm = T)
umd_returns <- colMeans(umd[-1], na.rm = T)

table1 <- up_returns %>% rbind(down_returns) %>% rbind(umd_returns)
rownames(table1) <- c("Ups", "Downs", "UMD")
colnames(table1) <- c("Average Return 1 m", "3m", "6m", "12m", "60m")

print(table1)
```

```
##         Average Return 1 m          3m          6m         12m          60m
## Ups            0.016006520  0.04615146  0.08721466  0.15620088   0.69029709
## Downs          0.003003658  0.01328026  0.03266768  0.10162398   0.77404925
## UMD            0.013002863  0.03287119  0.05454697  0.05457691  -0.08375216
```

(2) To do the t-test on top portfolios for 1m, 3m, 6m, 12m, and 60m returns

```r
apply(ups[-1], 2, t.test)
```

```
## $portfl_return_1m
##
##  One Sample t-test
##
## data:  newX[, i]
## t = 7.4142, df = 1125, p-value = 2.402e-13
## alternative hypothesis: true mean is not equal to 0
## 95 percent confidence interval:
##  0.01177057 0.02024247
## sample estimates:
##  mean of x
## 0.01600652
##
##
## $portfl_return_3m
##
##  One Sample t-test
##
## data:  newX[, i]
## t = 11.206, df = 1125, p-value < 2.2e-16
## alternative hypothesis: true mean is not equal to 0
## 95 percent confidence interval:
##  0.03807070 0.05423221
## sample estimates:
##  mean of x
## 0.04615146
##
##
## $portfl_return_6m
##
##  One Sample t-test
```

```
## 
## data:  newX[, i]
## t = 14.448, df = 1125, p-value < 2.2e-16
## alternative hypothesis: true mean is not equal to 0
## 95 percent confidence interval:
##  0.07537053 0.09905878
## sample estimates:
##  mean of x
## 0.08721466
## 
## 
## $portfl_return_12m
## 
##  One Sample t-test
## 
## data:  newX[, i]
## t = 17.676, df = 1125, p-value < 2.2e-16
## alternative hypothesis: true mean is not equal to 0
## 95 percent confidence interval:
##  0.1388627 0.1735391
## sample estimates:
## mean of x
## 0.1562009
## 
## 
## $portfl_return_60m
## 
##  One Sample t-test
## 
## data:  newX[, i]
## t = 30.574, df = 1125, p-value < 2.2e-16
## alternative hypothesis: true mean is not equal to 0
## 95 percent confidence interval:
##  0.6459972 0.7345970
## sample estimates:
## mean of x
## 0.6902971
```

To do the t-test on bottom portfolios for 1m, 3m, 6m, 12m, and 60m returns

```
apply(downs[-1], 2, t.test)
```

```
## $portfl_return_1m
## 
##  One Sample t-test
## 
## data:  newX[, i]
## t = 1.1199, df = 1125, p-value = 0.263
## alternative hypothesis: true mean is not equal to 0
## 95 percent confidence interval:
```

```
##  -0.002258682  0.008265997
## sample estimates:
##    mean of x
## 0.003003658
##
##
## $portfl_return_3m
##
##   One Sample t-test
##
## data:  newX[, i]
## t = 2.5305, df = 1125, p-value = 0.01153
## alternative hypothesis: true mean is not equal to 0
## 95 percent confidence interval:
##   0.002983151 0.023577375
## sample estimates:
##   mean of x
## 0.01328026
##
##
## $portfl_return_6m
##
##   One Sample t-test
##
## data:  newX[, i]
## t = 4.84, df = 1125, p-value = 1.479e-06
## alternative hypothesis: true mean is not equal to 0
## 95 percent confidence interval:
##   0.01942461 0.04591075
## sample estimates:
##   mean of x
## 0.03266768
##
##
## $portfl_return_12m
##
##   One Sample t-test
##
## data:  newX[, i]
## t = 10.103, df = 1125, p-value < 2.2e-16
## alternative hypothesis: true mean is not equal to 0
## 95 percent confidence interval:
##   0.0818869 0.1213610
## sample estimates:
## mean of x
##   0.101624
##
##
## $portfl_return_60m
##
```

```
##  One Sample t-test
##
## data:  newX[, i]
## t = 30.197, df = 1125, p-value < 2.2e-16
## alternative hypothesis: true mean is not equal to 0
## 95 percent confidence interval:
##  0.7237540 0.8243445
## sample estimates:
## mean of x
## 0.7740492
```

To do the t-test on the UMD short portfolios for 1m, 3m, 6m, 12m, and 60m returns

```
apply(umd[-1], 2, t.test)

## $portfl_return_1m
##
##  One Sample t-test
##
## data:  newX[, i]
## t = 7.356, df = 1125, p-value = 3.643e-13
## alternative hypothesis: true mean is not equal to 0
## 95 percent confidence interval:
##  0.009534606 0.016471119
## sample estimates:
##  mean of x
## 0.01300286
##
##
## $portfl_return_3m
##
##  One Sample t-test
##
## data:  newX[, i]
## t = 10.133, df = 1125, p-value < 2.2e-16
## alternative hypothesis: true mean is not equal to 0
## 95 percent confidence interval:
##  0.02650659 0.03923580
## sample estimates:
##  mean of x
## 0.03287119
##
##
## $portfl_return_6m
##
##  One Sample t-test
##
## data:  newX[, i]
## t = 14.217, df = 1125, p-value < 2.2e-16
## alternative hypothesis: true mean is not equal to 0
```

```
## 95 percent confidence interval:
##  0.04701898 0.06207497
## sample estimates:
##  mean of x
## 0.05454697
##
##
## $portfl_return_12m
##
##   One Sample t-test
##
## data:  newX[, i]
## t = 9.6224, df = 1125, p-value < 2.2e-16
## alternative hypothesis: true mean is not equal to 0
## 95 percent confidence interval:
##  0.04344824 0.06570557
## sample estimates:
##  mean of x
## 0.05457691
##
##
## $portfl_return_60m
##
##   One Sample t-test
##
## data:  newX[, i]
## t = -5.4481, df = 1125, p-value = 6.25e-08
## alternative hypothesis: true mean is not equal to 0
## 95 percent confidence interval:
##  -0.11391449 -0.05358982
## sample estimates:
##    mean of x
## -0.08375216
```

From the t-test, for winner stocks (up) portfolio, the t-test shows that the momentum can continue through 1 month up to 60 months;
For the loser stocks (down) portfolio, the 95 percent confidence interval is (-0.0023, 0.0083) for the 1 month returns, and the returns beyond 1 month through 60 months are positive at the 95% confidence intervals;
For the umd portfolio, returns are positive at the 95% confidence from 1 month to 12 months and negative in future 60 months.

```
setwd("C:/Users/Zhong/Desktop/")

FF <- read.csv('F-F_Research_Data_5_Factors_2x3.csv')
FF <- FF[1:687,]
FF <- apply(FF[1:7], 2, as.numeric)
FF <- FF %>% as.data.frame()
```

```
FF$ym <- FF$Date %>% as.character %>% paste("01") %>%  as.Date("%Y%m%d") %>%
as.yearmon()

one_month_returns <- ups[1:2] %>% merge(downs[1:2], by = "ym") %>% merge(umd[1:2],
by = "ym")
colnames(one_month_returns) <- c("ym", "ups", "downs", "umd")
one_month_returns <- one_month_returns %>% left_join(FF)

## Joining, by = "ym"

lm_ups_5_factor <- lm(data = one_month_returns, ups ~ Mkt.RF+SMB+HML+RMW+CMA)
lm_ups_5_factor %>% summary

##
## Call:
## lm(formula = ups ~ Mkt.RF + SMB + HML + RMW + CMA, data = one_month_returns)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.33032 -0.03502  0.00243  0.04101  0.35580
##
## Coefficients:
##               Estimate Std. Error t value Pr(>|t|)
## (Intercept)  1.700e-02  2.807e-03   6.055 2.34e-09 ***
## Mkt.RF       7.166e-04  6.980e-04   1.027   0.3049
## SMB          8.284e-04  9.777e-04   0.847   0.3971
## HML          9.711e-05  1.350e-03   0.072   0.9427
## RMW         -1.926e-03  1.357e-03  -1.419   0.1562
## CMA         -3.581e-03  2.009e-03  -1.782   0.0752 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.06977 on 671 degrees of freedom
##   (450 observations deleted due to missingness)
## Multiple R-squared:  0.02388,    Adjusted R-squared:  0.0166
## F-statistic: 3.283 on 5 and 671 DF,  p-value: 0.006162

lm_downs_5_factor <- lm(data = one_month_returns, downs ~ Mkt.RF+SMB+HML+RMW+CMA)
lm_downs_5_factor %>% summary

##
## Call:
## lm(formula = downs ~ Mkt.RF + SMB + HML + RMW + CMA, data = one_month_returns)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.28978 -0.04042 -0.00085  0.03960  0.34134
##
## Coefficients:
##               Estimate Std. Error t value Pr(>|t|)
## (Intercept)  0.0006170  0.0029627   0.208  0.83508
```

```
## Mkt.RF      0.0022068  0.0007367   2.996  0.00284 **
## SMB         0.0002151  0.0010319   0.208  0.83495
## HML         0.0014491  0.0014253   1.017  0.30968
## RMW        -0.0012491  0.0014321  -0.872  0.38340
## CMA        -0.0033649  0.0021208  -1.587  0.11307
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.07363 on 671 degrees of freedom
##   (450 observations deleted due to missingness)
## Multiple R-squared:  0.03049,    Adjusted R-squared:  0.02326
## F-statistic:  4.22 on 5 and 671 DF,  p-value: 0.0008759
```

```
lm_umd_5_factor <- lm(data = one_month_returns, umd ~ Mkt.RF+SMB+HML+RMW+CMA)
lm_umd_5_factor %>% summary
```

```
##
## Call:
## lm(formula = umd ~ Mkt.RF + SMB + HML + RMW + CMA, data = one_month_returns)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.34375 -0.02247  0.00304  0.02780  0.31688
##
## Coefficients:
##               Estimate Std. Error t value Pr(>|t|)
## (Intercept)  0.0163788  0.0021245   7.710 4.56e-14 ***
## Mkt.RF      -0.0014902  0.0005282  -2.821  0.00493 **
## SMB          0.0006133  0.0007399   0.829  0.40747
## HML         -0.0013520  0.0010221  -1.323  0.18636
## RMW         -0.0006769  0.0010269  -0.659  0.51001
## CMA         -0.0002160  0.0015208  -0.142  0.88709
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.0528 on 671 degrees of freedom
##   (450 observations deleted due to missingness)
## Multiple R-squared:  0.01534,    Adjusted R-squared:  0.008
## F-statistic:  2.09 on 5 and 671 DF,  p-value: 0.0648
```

To get table 2 from the regression models

```
alpha_ups <- summary(lm_ups_5_factor)$coefficient[1,c(1,4)]
alpha_downs <- summary(lm_downs_5_factor)$coefficient[1,c(1,4)]
alpha_umd <- summary(lm_umd_5_factor)$coefficient[1,c(1,4)]

table2 <- alpha_ups %>% rbind(alpha_downs) %>% rbind(alpha_umd)
rownames(table2) <- c("Alpha Up", "Alpha Down", "Alpha UMD")
```

To print table 2

```
print(table2)
```

```
##                  Estimate       Pr(>|t|)
## Alpha Up    0.0169958152 2.343999e-09
## Alpha Down  0.0006170462 8.350792e-01
## Alpha UMD   0.0163787690 4.563066e-14
```

From the regression models, both up and umd portfolios show positive and significant contribution to the momentum strategy's alpha whereas the down portfolio does not show statistically significant alpha to the momentum strategy. Moreover, up contributes more to the momentum strategy's alpha with intercept as 1.70%.

```
cum_returns <- one_month_returns %>% mutate(cum_ups = cumprod(1+ups)-1,
                              cum_downs = cumprod(1+downs)-1,
                              cum_umd = cumprod(1+umd)-1) %>%
                     select(ym, cum_ups, cum_downs, cum_umd)
```

```
cum_returns %>% melt(measure.vars = c("cum_ups", "cum_downs", "cum_umd")) %>%
  ggplot(aes(ym, value, group = variable, color = variable)) +
  geom_line() + xlab("Date") + ylab("Cumulative Returns") +
  ggtitle("Cumulative return to the Up, Down, and UMD one-month strategy") +
  scale_color_discrete(labels = c("Up", "Down", "UMD"), name = "Portfolio") +
  theme_bw()
```

```
## Warning: Removed 3 row(s) containing missing values (geom_path).
```


Cumulative return to the Up, Down, and UMD one-m
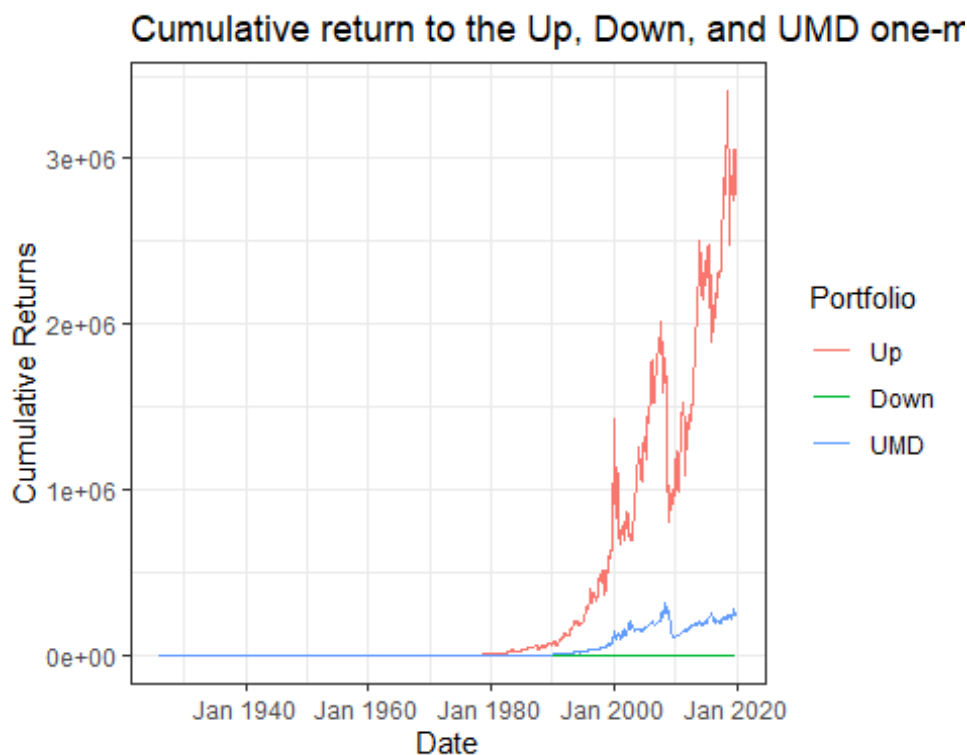
```
one_month_returns %>% top_n(-5, umd) %>% select(ym, umd)
```

```
##          ym         umd
## 1 Jun 1932 -0.4704567
## 2 Jul 1932 -0.5636353
## 3 May 1938 -0.3608699
## 4 Aug 1939 -0.3644617
## 5 Mar 2009 -0.3426048

one_month_returns %>% filter((ym >= 1932 & ym < 1933) |
                             (ym >= 1938 & ym < 1940) |
                             (ym >= 2009 & ym < 2010)) %>% select(ym, ups)

##          ym          ups
## 1  Jan 1932  0.030086889
## 2  Feb 1932 -0.049919543
## 3  Mar 1932 -0.082428209
## 4  Apr 1932 -0.172195816
## 5  May 1932  0.011109156
## 6  Jun 1932  0.165608281
## 7  Jul 1932  0.298030825
## 8  Aug 1932 -0.020793780
## 9  Sep 1932 -0.094574708
## 10 Oct 1932 -0.069321545
## 11 Nov 1932  0.003230952
## 12 Dec 1932 -0.018741700
## 13 Jan 1938  0.039513541
## 14 Feb 1938 -0.181869161
## 15 Mar 1938  0.136032836
## 16 Apr 1938 -0.003385898
## 17 May 1938  0.105908948
## 18 Jun 1938  0.064410667
## 19 Jul 1938 -0.009684500
## 20 Aug 1938 -0.011727460
## 21 Sep 1938  0.091916317
## 22 Oct 1938  0.030875906
## 23 Nov 1938  0.105355476
## 24 Dec 1938 -0.085749968
## 25 Jan 1939  0.080858000
## 26 Feb 1939 -0.216712492
## 27 Mar 1939  0.041366200
## 28 Apr 1939  0.125829083
## 29 May 1939 -0.074193787
## 30 Jun 1939  0.203015458
## 31 Jul 1939 -0.100992672
## 32 Aug 1939  0.138666119
## 33 Sep 1939  0.053599646
## 34 Oct 1939 -0.098814031
## 35 Nov 1939  0.069455286
## 36 Dec 1939 -0.005386238
## 37 Jan 2009 -0.115786569
## 38 Feb 2009  0.060650653
```

```
## 39 Mar 2009  0.034541409
## 40 Apr 2009  0.021937944
## 41 May 2009  0.029404609
## 42 Jun 2009  0.053350011
## 43 Jul 2009 -0.010817616
## 44 Aug 2009  0.032538277
## 45 Sep 2009 -0.082587297
## 46 Oct 2009  0.040933670
## 47 Nov 2009  0.076453085
## 48 Dec 2009 -0.054844772
```

The one-month momentum strategy of UMD incurred its 5 largest losses in 1932, 1938, 1939, and 2009, which are immediately after the financial crises and market crashes in 1932, 1938, and 2008.

The UMD for future 1 month return had huge losses mainly because the portfolio was shorting the "downs" that was having a rapid rebound and recovery from the preceding market crash during the recessions.

The Up portfolio performed did not perform very well in most months of those years, although there are several months in which the portfolio generated positive returns in those years. So the losses of UMD in those years are mainly because of the shorting previous "downs" than buying the previous "ups".

```r
rolling_3_yr_return_ups <- rollapplyr(one_month_returns$ups, 36, function(x) prod(1
+ x) - 1, fill = NA)
rolling_3_yr_return_downs <- rollapplyr(one_month_returns$downs, 36, function(x)
prod(1 + x) - 1, fill = NA)
rolling_3_yr_return_umd <- rollapplyr(one_month_returns$umd, 36, function(x) prod(1
+ x) - 1, fill = NA)

rolling_3_yr_return <- cbind(rolling_3_yr_return_ups, rolling_3_yr_return_downs)
%>%
                    cbind(rolling_3_yr_return_umd)

rolling_3_yr_return <- rolling_3_yr_return %>% as.data.frame()
rownames(rolling_3_yr_return) <- months[3:1129]
colnames(rolling_3_yr_return) <- c("Ups", "Downs", "UMD")
```

To show the signs of the 3 year rolling window returns of up, down, and umd portfolios

```r
table(sign(rolling_3_yr_return$Ups))
```

```
##
## -1   1
## 144 947
```

```r
table(sign(rolling_3_yr_return$Downs))
```

```
##
##  -1    1
## 526 565
```

```
table(sign(rolling_3_yr_return$UMD))
```

```
##
##  -1    1
## 121 970
```

To calculate the percentage

```
table(rolling_3_yr_return$Ups < 0)[[2]]/table(!is.na(rolling_3_yr_return$Ups))[[2]]
```

```
## [1] 0.131989
```

```
table(rolling_3_yr_return$Downs <
0)[[2]]/table(!is.na(rolling_3_yr_return$Downs))[[2]]
```

```
## [1] 0.4821265
```

```
table(rolling_3_yr_return$UMD < 0)[[2]]/table(!is.na(rolling_3_yr_return$UMD))[[2]]
```

```
## [1] 0.1109074
```

Among all periods with no NA values (starting after 36 months after the first month): For ups, 13.20% of the 3-year overlapping periods exhibit negative returns For downs, 48.21% of the 3-year overlapping periods exhibit negative returns For umd, 11.10% of the 3-year overlapping periods exhibit negative returns

Table 1

```
print(table1)
```

```
##         Average Return 1 m          3m         6m        12m         60m
## Ups           0.016006520 0.04615146 0.08721466 0.15620088  0.69029709
## Downs         0.003003658 0.01328026 0.03266768 0.10162398  0.77404925
## UMD           0.013002863 0.03287119 0.05454697 0.05457691 -0.08375216
```

Table 2

```
print(table2)
```

```
##                 Estimate      Pr(>|t|)
## Alpha Up    0.0169958152 2.343999e-09
## Alpha Down  0.0006170462 8.350792e-01
## Alpha UMD   0.0163787690 4.563066e-14
```