Strategy Design (ML Fin Data - Project 1)

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Libraries

0. Scraping the SP500

In order to test the logic within the strategy, I have fetched functions that retrieve a number of sample stocks by sector from the SP500.

```
# to obtain relative paths
library(here)

# Load code into environment
source(here("functions", "fetch_sp500_sectors.R"))
```

```
## Getting holdings for SP500
```

0.0.1 SP500 Economic Sectors

The following function fetches and extract the economic sectors from the SP500, taken from Wikipedia.

```
# fetch the sectors as a dataframe
sp500_sectors <- f_get_sp500_sectors()
head(sp500_sectors)
```

```
##   tickers                sectors
## 1     MMM             Industrials
## 2     AOS             Industrials
## 3     ABT             Health Care
## 4    ABBV             Health Care
## 5     ACN Information Technology
## 6    ATVI Communication Services
```

0.0.2 SP500 Sector Weight

```
# wrap into a single argument funciton
fetch_sp500_sector_data <- function(x){f_fetch_sector_data(x, sp500, sp500_sectors)}

# call the function
head(fetch_sp500_sector_data("Information Technology"))
```

```
##   ticker                 sector       weight shares_held
## 1   AAPL Information Technology 0.0693923725   163961069
## 2    ACN Information Technology 0.0052491270     7038653
## 3   ADBE Information Technology 0.0063642314     5085993
## 4    ADI Information Technology 0.0024472905     5594984
## 5   ADSK Information Technology 0.0012292724     2384796
## 6   AKAM Information Technology 0.0004519769     1702979
```

0.0.3 Retrieving top sectors and stocks

Pack everything into one function to retrieve all the data

```
# Retrieve top 10 stocks by weight for each sector in the top 5 sectors from the SP500 (by weight)
sector_list <- f_retrieve_top_sp500(top_n_sectors = 6, top_n_stocks = 15, only_tickers=TRUE)
sector_list
```

```
## $Industrials
##  [1] "ADP" "BA"  "CAT" "CSX" "DE"  "ETN" "FDX" "GE"  "HON" "ITW" "LMT" "NOC"
## [13] "RTX" "UNP" "UPS"
##
## $`Health Care`
##  [1] "ABBV" "ABT"  "AMGN" "BMY"  "DHR"  "ELV"  "GILD" "ISRG" "JNJ"  "LLY"
## [11] "MDT"  "MRK"  "PFE"  "TMO"  "UNH"
##
## $`Information Technology`
##  [1] "AAPL" "ACN"  "ADBE" "AMD"  "AVGO" "CRM"  "CSCO" "IBM"  "INTC" "INTU"
## [11] "MSFT" "NVDA" "ORCL" "QCOM" "TXN"
##
## $`Communication Services`
##  [1] "ATVI"  "CHTR"  "CMCSA" "DIS"   "EA"    "GOOG"  "GOOGL" "META"  "NFLX"
## [10] "OMC"   "T"     "TMUS"  "TTWO"  "VZ"    "WBD"
##
## $Financials
##  [1] "AXP"  "BAC"  "BLK"  "C"    "CB"   "GS"   "JPM"  "MA"   "MMC"  "MS"
## [11] "PGR"  "SCHW" "SPGI" "V"    "WFC"
##
## $`Consumer Discretionary`
##  [1] "ABNB" "AMZN" "AZO"  "BKNG" "CMG"  "F"    "GM"   "HD"   "MAR"  "MCD"
## [11] "NKE"  "ORLY" "SBUX" "TJX"  "TSLA"
```

This logic is implemented under **functions/fetch_sp500_sectors.R**

0.0.4 Retrieving top sectors and stocks

```
# function to fetch all the information for one ticker into a nice xts dataframe
sp500_stocks <- lapply(sector_list,
                       f_fetch_all_tickers,
                       start_date="2018-01-01",
                       end_date="2022-12-01")
```

```
# Show the available sectors
names(sp500_stocks)
```

```
## [1] "Industrials"            "Health Care"            "Information Technology"
## [4] "Communication Services" "Financials"             "Consumer Discretionary"
```

```
# Show available stocks for Industrials
names(sp500_stocks$Industrials)
```

```
##  [1] "ADP" "BA"  "CAT" "CSX" "DE"  "ETN" "FDX" "GE"  "HON" "ITW" "LMT" "NOC"
## [13] "RTX" "UNP" "UPS"
```

```
# access the xts of the stocks in industrials
tail(sp500_stocks$Industrials$ADP)
```

```
##            direction_lead realized_returns actual_returns adjclose_lag1
## 2022-10-26              1      0.009733847    0.008113141   0.039930970
## 2022-11-02              1      0.012306105    0.009733847   0.008113141
## 2022-11-09              1      0.053615962    0.012306105   0.009733847
## 2022-11-16              1      0.034718645    0.053615962   0.012306105
## 2022-11-23              1      0.005923518    0.034718645   0.053615962
## 2022-11-30             NA               NA    0.005923518   0.034718645
##            adjclose_lag2 adjclose_lag3       atr      adx aaron        bb
## 2022-10-26  -0.064535730   0.030150913  9.676399 13.39493   100 0.6110784
## 2022-11-02   0.039930970  -0.064535730  9.885942 13.58997   100 0.6303335
## 2022-11-09   0.008113141   0.039930970  9.762661 13.77107    50 0.6307783
## 2022-11-16   0.009733847   0.008113141 10.232471 14.68326   100 0.8325740
## 2022-11-23   0.012306105   0.009733847 10.243009 15.95273   100 0.9310325
## 2022-11-30   0.053615962   0.012306105 10.247795 16.53998   100 0.8907336
##            chaikin_vol        clv         emv     macd      mfi      sar
## 2022-10-26 -1.49750300 -0.1320576 -0.01707202 2.049576 51.52422 260.0428
## 2022-11-02  2.90314600 -0.2863719  0.02711271 1.939312 49.23300 258.6055
## 2022-11-09 -0.09676625 -0.3920529  0.04765004 1.866926 49.20839 257.2257
## 2022-11-16 -0.38397100 -0.4461119  0.09074850 1.906715 48.83463 256.7200
## 2022-11-23 -0.20180520 -0.3205142  0.11758529 2.068291 49.31528 224.1100
## 2022-11-30  0.48394890 -0.1089895  0.12144667 2.300754 42.97382 224.1100
##                  smi     volat month_index
## 2022-10-26  8.131402 0.2269538          58
## 2022-11-02  5.546375 0.2606250          59
## 2022-11-09  3.943959 0.2653165          59
## 2022-11-16  6.291102 0.2641173          59
## 2022-11-23 11.099826 0.2624611          59
## 2022-11-30 16.713518 0.2759187          59
```

BACKTESTING LOGIC

Adding a numeric index

First, we need to create a corresponding index for each week:

```
# count number of weeks in data from one of the dataframes
sample_xts <- sp500_stocks$Industrials$CSX
tail(sample_xts, 10)
```

```
##            direction_lead realized_returns actual_returns adjclose_lag1
## 2022-09-28              1      0.006853026   -0.053209662  -0.069267344
## 2022-10-05             -1     -0.042966085    0.006853026  -0.053209662
## 2022-10-12              1      0.046554253   -0.042966085   0.006853026
## 2022-10-19              1      0.029989854    0.046554253  -0.042966085
## 2022-10-26             -1     -0.008377028    0.029989854   0.046554253
## 2022-11-02              1      0.031058456   -0.008377028   0.029989854
## 2022-11-09              1      0.059684716    0.031058456  -0.008377028
## 2022-11-16              1      0.026221648    0.059684716   0.031058456
## 2022-11-23              1      0.022307781    0.026221648   0.059684716
## 2022-11-30             NA               NA    0.022307781   0.026221648
##            adjclose_lag2 adjclose_lag3      atr      adx aaron         bb
## 2022-09-28  -0.020913290   0.007554286 1.441481 16.24190  -100 0.04467755
## 2022-10-05  -0.069267344  -0.020913290 1.384232 17.10559   -50 0.13495813
## 2022-10-12  -0.053209662  -0.069267344 1.379644 18.24157   -50 0.07457368
```

```
## 2022-10-19   0.006853026  -0.053209662 1.394670 18.58490    50 0.23730603
## 2022-10-26  -0.042966085   0.006853026 1.398622 18.20787   100 0.36428555
## 2022-11-02   0.046554253  -0.042966085 1.385863 17.63796   100 0.36718737
## 2022-11-09   0.029989854   0.046554253 1.385444 17.00435    50 0.43456871
## 2022-11-16  -0.008377028   0.029989854 1.429341 16.04316   100 0.61239403
## 2022-11-23   0.031058456  -0.008377028 1.395102 15.54651   100 0.68335600
## 2022-11-30   0.059684716   0.031058456 1.369024 15.36369   100 0.70213009
##             chaikin_vol         clv           emv      macd      mfi      sar
## 2022-09-28  2.43234200  0.21475805 -1.787304e-04 -2.031918 46.90353 34.67000
## 2022-10-05 -0.44268680  0.22116568 -2.096124e-04 -2.290153 46.43088 34.38840
## 2022-10-12  0.43839330  0.07934922 -3.472192e-04 -2.649750 46.62430 34.11806
## 2022-10-19 -1.12835800  0.03125187 -3.458817e-04 -2.983549 54.92321 33.66998
## 2022-10-26  0.36773750 -0.10430028 -2.858648e-04 -3.232381 56.20916 33.24878
## 2022-11-02 -8.91414900 -0.26417408 -1.913069e-04 -3.420978 48.82911 32.85285
## 2022-11-09 -0.08886197 -0.35167976 -1.696224e-04 -3.505779 48.94612 32.48068
## 2022-11-16 -0.69757770 -0.28307675 -6.177828e-05 -3.415472 46.83053 32.13084
## 2022-11-23 -2.77541900 -0.16462184  6.920197e-05 -3.168499 45.87661 26.65000
## 2022-11-30 -0.65517410  0.02947430  2.043992e-04 -2.797269 55.72098 26.65000
##                   smi     volat month_index
## 2022-09-28 -18.01681 0.2279791          57
## 2022-10-05 -22.89976 0.2353109          58
## 2022-10-12 -28.89441 0.2481376          58
## 2022-10-19 -32.89471 0.2465206          58
## 2022-10-26 -34.78229 0.2484444          58
## 2022-11-02 -36.26677 0.2806964          59
## 2022-11-09 -36.24474 0.2819226          59
## 2022-11-16 -32.84559 0.2767814          59
## 2022-11-23 -26.53377 0.2587499          59
## 2022-11-30 -18.89848 0.2672197          59
```

```
sample_xts[, c( "month_index")]
```

```
##             month_index
## 2018-01-03           1
## 2018-01-10           1
## 2018-01-17           1
## 2018-01-24           1
## 2018-01-31           1
## 2018-02-07           2
## 2018-02-14           2
## 2018-02-21           2
## 2018-02-28           2
## 2018-03-07           3
##         ...
## 2022-09-28          57
## 2022-10-05          58
## 2022-10-12          58
## 2022-10-19          58
## 2022-10-26          58
## 2022-11-02          59
## 2022-11-09          59
## 2022-11-16          59
## 2022-11-23          59
## 2022-11-30          59
```

BACKTESTING_PROCEDURE

1. Assume we have N_{years} years of weekly data, giving a total of N_{months} many months. 2. We want to fix a window of $N_W = 12$ months at the time (i.e. a year of data).

2. The total number of runs is given by

$$N^{runs} = \left\lfloor \frac{N_{months} - N_W}{s} \right\rfloor + 1$$

, where $s = 1$ is the number of months to move at the time (because of monthly rebalance).

i.e., we can move N^{runs} times when predicting one month at the time, starting with having all the data until month 12.

That is, $\tau = 1, \ldots, 48$

```
# Set up backtesting simulation parameters
sample_xts <- sp500_stocks$Industrials$ADP
sectors <- names(sp500_stocks)
N_sector_best_stocks <- 3

# Formula parameters
slide <- 1
N_months <- length(names(split.xts(sample_xts, f= "months")))
N_window <- 12 # number of months in size for each window
N_runs <- floor((N_months - N_window)/slide)

# setup initial portfolio tracking variables
initial_capital <- 500000
num_tickers <- length(sectors)*N_sector_best_stocks
initial_tickers <- rep(NA, num_tickers)
weights <- rep(1/num_tickers, num_tickers) # initialize to 1/n
returns <- rep(NA, N_runs)

# repack the portfolio
portfolio <- list(tickers = initial_tickers,
                  weights = weights,
                  capital = initial_capital,
                  returns = returns,
                  data = NA
                  )
portfolio
```

```
## $tickers
##  [1] NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA
##
## $weights
##  [1] 0.05555556 0.05555556 0.05555556 0.05555556 0.05555556 0.05555556
##  [7] 0.05555556 0.05555556 0.05555556 0.05555556 0.05555556 0.05555556
## [13] 0.05555556 0.05555556 0.05555556 0.05555556 0.05555556 0.05555556
##
## $capital
## [1] 5e+05
##
## $returns
##  [1] NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA
## [26] NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA
##
## $data
## [1] NA
```

```
# Initiate backtesting
print(paste(rep("-", 100), collapse = ""))
```

```
## [1] "----------------------------------------------------------------------------------------------------"
```

```r
print("BACKTESTING")
```

```
## [1] "BACKTESTING"
```

```r
print(paste(rep("-", 100), collapse = ""))
```

```
## [1] "----------------------------------------------------------------------------------------------------"
```

```r
print("")
```

```
## [1] ""
```

```r
# for every run (sliding window of time to consider)
for(tau in seq(N_runs)){
  # close any positions
  print(paste0("(tau=", tau, ") CLOSE all positions."))

  # Calculate and record profit-loss
  print("(1) COMPUTE_P/L(portfolio)")
  portfolio$capital <- portfolio$capital * (1 + runif(1, -0.05, 0.10))
  print(paste0("--> Capital:", portfolio$capital, "$"))

  # keep index counter for sectors
  i_sector <- 1

  # current portf
  cur_tickers <- rep(NA, num_tickers)

  print("")
  print("(2) PORTFOLIO_LOOP:")
  # loop through all the sectors
  for(G in sectors){
    # execute sector procedure
    print(paste0("    SECTOR_PROCEDURE(G=", G, ", tau=",tau, ")"))

    # return top 3 best stocks according to procedure
    top_sector_stocks <- sample(names(sp500_stocks[[G]]), 3 )

    # assign best stocks to portfolio (NEED TO UPDATE LOGIC!)
    i_replace <- c(i_sector, i_sector+1, i_sector+2)
    cur_tickers[i_replace] <- top_sector_stocks
    i_sector <- i_sector + 3
  }

  # Assign tickers for this simulation
  portfolio$tickers <- as.vector(cur_tickers)

  # Display selected portfolio tickers
  print("Cur Portfolio:")
  print(portfolio$tickers)

  # Optimize portfolio weights using modified min_variance
  print("")
  print("(3) OPTIMIZE_PORTFOLIO(portfolio)")
  # simulate the optimization
  portfolio$weights <- runif(length(portfolio$weights)) / sum(runif(length(portfolio$weights)))
  print("weights: ")
```

```
  print(paste(" ", portfolio$weights))

  print("")
  print("(4) LONG PORTFOLIO()")

  # Separate similuation (over)
  print(paste(rep("-", 100), collapse = ""))
}
```

```
## [1] "(tau=1) CLOSE all positions."
## [1] "(1) COMPUTE_P/L(portfolio)"
## [1] "--> Capital:505755.982123083$"
## [1] ""
## [1] "(2) PORTFOLIO_LOOP:"
## [1] "    SECTOR_PROCEDURE(G=Industrials, tau=1)"
## [1] "    SECTOR_PROCEDURE(G=Health Care, tau=1)"
## [1] "    SECTOR_PROCEDURE(G=Information Technology, tau=1)"
## [1] "    SECTOR_PROCEDURE(G=Communication Services, tau=1)"
## [1] "    SECTOR_PROCEDURE(G=Financials, tau=1)"
## [1] "    SECTOR_PROCEDURE(G=Consumer Discretionary, tau=1)"
## [1] "Cur Portfolio:"
##  [1] "RTX"  "ETN"  "NOC"  "AMGN" "ABT"  "TMO"  "INTC" "AVGO" "CRM"  "CHTR"
## [11] "NFLX" "GOOG" "WFC"  "MA"   "GS"   "ORLY" "ABNB" "HD"
## [1] ""
## [1] "(3) OPTIMIZE_PORTFOLIO(portfolio)"
## [1] "weights: "
##  [1] "  0.0880928918294413"  "  0.0462277673364815"  "  0.0930215707286544"
##  [4] "  0.0933371230659891"  "  0.00985258976055418" "  0.0559164993458943"
##  [7] "  0.104817806956351"   "  0.012452210212932"   "  0.115761399931166"
## [10] "  0.0978285920528701"  "  0.0391520506885016"  "  0.0192900355485121"
## [13] "  0.105985896973591"   "  0.101955682849489"   "  0.046860552239948"
## [16] "  0.0131973967181284"  "  0.0143395141500883"  "  0.0167931138435464"
## [1] ""
## [1] "(4) LONG PORTFOLIO()"
## [1] "----------------------------------------------------------------------------------------------------"
## [1] "(tau=2) CLOSE all positions."
## [1] "(1) COMPUTE_P/L(portfolio)"
## [1] "--> Capital:527930.869057071$"
## [1] ""
## [1] "(2) PORTFOLIO_LOOP:"
## [1] "    SECTOR_PROCEDURE(G=Industrials, tau=2)"
## [1] "    SECTOR_PROCEDURE(G=Health Care, tau=2)"
## [1] "    SECTOR_PROCEDURE(G=Information Technology, tau=2)"
## [1] "    SECTOR_PROCEDURE(G=Communication Services, tau=2)"
## [1] "    SECTOR_PROCEDURE(G=Financials, tau=2)"
## [1] "    SECTOR_PROCEDURE(G=Consumer Discretionary, tau=2)"
## [1] "Cur Portfolio:"
##  [1] "ITW"  "HON"  "GE"   "ISRG" "AMGN" "ABBV" "AAPL" "ORCL" "ACN"  "ATVI"
## [11] "NFLX" "TTWO" "AXP"  "CB"   "V"    "SBUX" "CMG"  "AZO"
## [1] ""
## [1] "(3) OPTIMIZE_PORTFOLIO(portfolio)"
## [1] "weights: "
##  [1] "  0.000398637331503152" "  0.073108088915487"    "  0.0366111276753487"
##  [4] "  0.0749472384178725"   "  0.096306213147265"    "  0.00515598729343458"
##  [7] "  0.0877503627684543"   "  0.0427199428843613"   "  0.0467110221369235"
## [10] "  0.0200980261515921"   "  0.0933078076311886"   "  0.0384006294457801"
## [13] "  0.0799378493859558"   "  0.0343924609771903"   "  0.0635543592564615"
## [16] "  0.100172108345964"    "  0.0608442227309933"   "  0.0772754472999429"
## [1] ""
```

```
## [1] "(4) LONG PORTFOLIO()"
## [1] "------------------------------------------------------------------------------------------------------"
## [1] "(tau=3) CLOSE all positions."
## [1] "(1) COMPUTE_P/L(portfolio)"
## [1] "--> Capital:525011.160842931$"
## [1] ""
## [1] "(2) PORTFOLIO_LOOP:"
## [1] "    SECTOR_PROCEDURE(G=Industrials, tau=3)"
## [1] "    SECTOR_PROCEDURE(G=Health Care, tau=3)"
## [1] "    SECTOR_PROCEDURE(G=Information Technology, tau=3)"
## [1] "    SECTOR_PROCEDURE(G=Communication Services, tau=3)"
## [1] "    SECTOR_PROCEDURE(G=Financials, tau=3)"
## [1] "    SECTOR_PROCEDURE(G=Consumer Discretionary, tau=3)"
## [1] "Cur Portfolio:"
##  [1] "ITW"  "CAT"  "ETN"  "MDT"  "UNH"  "PFE"  "QCOM" "ADBE" "MSFT" "NFLX"
## [11] "CHTR" "TMUS" "GS"   "BLK"  "MS"   "SBUX" "GM"   "TSLA"
## [1] ""
## [1] "(3) OPTIMIZE_PORTFOLIO(portfolio)"
## [1] "weights: "
##  [1] "  0.0140447713652802"  "  0.0424152271039848"  "  0.0983518672282657"
##  [4] "  0.0336981440481416"  "  0.0989319705113555"  "  0.100235113215682"
##  [7] "  0.139702406852353"   "  0.0997770549154951"  "  0.0707165673458304"
## [10] "  0.0307696605029038"  "  0.0977811260304045"  "  0.0581871871110228"
## [13] "  0.0822754012340846"  "  0.00221947300514769" "  0.00717634041299179"
## [16] "  0.0737137787532957"  "  0.0990979504736766"  "  0.00974662196435741"
## [1] ""
## [1] "(4) LONG PORTFOLIO()"
## [1] "------------------------------------------------------------------------------------------------------"
## [1] "(tau=4) CLOSE all positions."
## [1] "(1) COMPUTE_P/L(portfolio)"
## [1] "--> Capital:500482.03954878$"
## [1] ""
## [1] "(2) PORTFOLIO_LOOP:"
## [1] "    SECTOR_PROCEDURE(G=Industrials, tau=4)"
## [1] "    SECTOR_PROCEDURE(G=Health Care, tau=4)"
## [1] "    SECTOR_PROCEDURE(G=Information Technology, tau=4)"
## [1] "    SECTOR_PROCEDURE(G=Communication Services, tau=4)"
## [1] "    SECTOR_PROCEDURE(G=Financials, tau=4)"
## [1] "    SECTOR_PROCEDURE(G=Consumer Discretionary, tau=4)"
## [1] "Cur Portfolio:"
##  [1] "UPS"  "ADP"  "DE"   "DHR"  "ELV"  "TMO"  "IBM"  "CRM"  "NVDA" "META"
## [11] "DIS"  "EA"   "MMC"  "MA"   "PGR"  "AZO"  "MAR"  "GM"
## [1] ""
## [1] "(3) OPTIMIZE_PORTFOLIO(portfolio)"
## [1] "weights: "
##  [1] "  0.0527777085561261"  "  0.00552219649226467" "  0.00143286614356053"
##  [4] "  0.067762012246884"   "  0.0431196867824484"  "  0.0537776760782367"
##  [7] "  0.0690587561607276"  "  0.0337200385025572"  "  0.0333032923132789"
## [10] "  0.0635523986682626"  "  0.00441357885333289" "  0.0207354469372155"
## [13] "  0.0364697226990929"  "  0.113524804242815"   "  0.0776132251071722"
## [16] "  0.0476416619383587"  "  0.0904731696870899"  "  0.0849628324063598"
## [1] ""
## [1] "(4) LONG PORTFOLIO()"
## [1] "------------------------------------------------------------------------------------------------------"
## [1] "(tau=5) CLOSE all positions."
## [1] "(1) COMPUTE_P/L(portfolio)"
## [1] "--> Capital:502835.785769762$"
## [1] ""
## [1] "(2) PORTFOLIO_LOOP:"
## [1] "    SECTOR_PROCEDURE(G=Industrials, tau=5)"
```

```
## [1] "    SECTOR_PROCEDURE(G=Health Care, tau=5)"
## [1] "    SECTOR_PROCEDURE(G=Information Technology, tau=5)"
## [1] "    SECTOR_PROCEDURE(G=Communication Services, tau=5)"
## [1] "    SECTOR_PROCEDURE(G=Financials, tau=5)"
## [1] "    SECTOR_PROCEDURE(G=Consumer Discretionary, tau=5)"
## [1] "Cur Portfolio:"
##  [1] "BA"   "CSX"  "UNP"  "MDT"  "PFE"  "DHR"  "QCOM" "ORCL" "AAPL" "TMUS"
## [11] "OMC"  "ATVI" "MS"   "SCHW" "PGR"  "HD"   "MAR"  "GM"
## [1] ""
## [1] "(3) OPTIMIZE_PORTFOLIO(portfolio)"
## [1] "weights: "
##  [1] "  0.00340719037908076" "  0.101148291441667"   "  0.0354761762117795"
##  [4] "  0.106842839208693"   "  0.0209548080080396"  "  0.0960523856978378"
##  [7] "  0.0164356274484233"  "  0.0729985215740543"  "  0.101390021553607"
## [10] "  0.0579522378780587"  "  0.0724597762219723"  "  0.0460438746552682"
## [13] "  0.073794664361693"   "  0.0892292013177627"  "  0.041029829859717"
## [16] "  0.0581163655843664"  "  0.0806015898716247"  "  0.0192519539835279"
## [1] ""
## [1] "(4) LONG PORTFOLIO()"
## [1] "-------------------------------------------------------------------------------------------------------"
## [1] "(tau=6) CLOSE all positions."
## [1] "(1) COMPUTE_P/L(portfolio)"
## [1] "--> Capital:495615.781678894$"
## [1] ""
## [1] "(2) PORTFOLIO_LOOP:"
## [1] "    SECTOR_PROCEDURE(G=Industrials, tau=6)"
## [1] "    SECTOR_PROCEDURE(G=Health Care, tau=6)"
## [1] "    SECTOR_PROCEDURE(G=Information Technology, tau=6)"
## [1] "    SECTOR_PROCEDURE(G=Communication Services, tau=6)"
## [1] "    SECTOR_PROCEDURE(G=Financials, tau=6)"
## [1] "    SECTOR_PROCEDURE(G=Consumer Discretionary, tau=6)"
## [1] "Cur Portfolio:"
##  [1] "HON"  "CSX"  "UPS"  "ABT"  "TMO"  "JNJ"  "QCOM" "TXN"  "CRM"  "EA"
## [11] "TTWO" "DIS"  "AXP"  "SPGI" "V"    "BKNG" "F"    "TSLA"
## [1] ""
## [1] "(3) OPTIMIZE_PORTFOLIO(portfolio)"
## [1] "weights: "
##  [1] "  0.0733613734407431" "  0.106151111649747"  "  0.0955283078302964"
##  [4] "  0.068568314578808"  "  0.0685303562916389" "  0.033020651810864"
##  [7] "  0.0772686992234557" "  0.0114874071158413" "  0.033185956015111"
## [10] "  0.029658770378986"  "  0.0777210650047521" "  0.031339808654165"
## [13] "  0.0655027671877486" "  0.0388610954209117" "  0.126682095653022"
## [16] "  0.117515682425445"  "  0.0429830816769824" "  0.111873013797433"
## [1] ""
## [1] "(4) LONG PORTFOLIO()"
## [1] "-------------------------------------------------------------------------------------------------------"
## [1] "(tau=7) CLOSE all positions."
## [1] "(1) COMPUTE_P/L(portfolio)"
## [1] "--> Capital:473837.171051385$"
## [1] ""
## [1] "(2) PORTFOLIO_LOOP:"
## [1] "    SECTOR_PROCEDURE(G=Industrials, tau=7)"
## [1] "    SECTOR_PROCEDURE(G=Health Care, tau=7)"
## [1] "    SECTOR_PROCEDURE(G=Information Technology, tau=7)"
## [1] "    SECTOR_PROCEDURE(G=Communication Services, tau=7)"
## [1] "    SECTOR_PROCEDURE(G=Financials, tau=7)"
## [1] "    SECTOR_PROCEDURE(G=Consumer Discretionary, tau=7)"
## [1] "Cur Portfolio:"
##  [1] "UPS"  "CSX"  "FDX"  "TMO"  "MDT"  "ISRG" "IBM"  "QCOM" "ADBE" "TMUS"
## [11] "CHTR" "DIS"  "AXP"  "SPGI" "PGR"  "CMG"  "NKE"  "TSLA"
```

```
## [1] ""
## [1] "(3) OPTIMIZE_PORTFOLIO(portfolio)"
## [1] "weights: "
##  [1] "  0.0906587584946611"  "  0.0473881712641521"  "  0.00875246735025479"
##  [4] "  0.0244512041454204"  "  0.0122063748758537"  "  0.0759290689332166"
##  [7] "  0.0104479220761421"  "  0.00904835561956927" "  0.0150583411241536"
## [10] "  0.025692783248718"   "  0.0493288428656267"  "  0.0324566341018973"
## [13] "  0.0788832077453312"  "  0.0369183050171898"  "  0.088037123138443"
## [16] "  0.0461900262347289"  "  0.0772218683307829"  "  0.0912699291856731"
## [1] ""
## [1] "(4) LONG PORTFOLIO()"
## [1] "-------------------------------------------------------------------------------------------------------"
## [1] "(tau=8) CLOSE all positions."
## [1] "(1) COMPUTE_P/L(portfolio)"
## [1] "--> Capital:497408.601298545$"
## [1] ""
## [1] "(2) PORTFOLIO_LOOP:"
## [1] "    SECTOR_PROCEDURE(G=Industrials, tau=8)"
## [1] "    SECTOR_PROCEDURE(G=Health Care, tau=8)"
## [1] "    SECTOR_PROCEDURE(G=Information Technology, tau=8)"
## [1] "    SECTOR_PROCEDURE(G=Communication Services, tau=8)"
## [1] "    SECTOR_PROCEDURE(G=Financials, tau=8)"
## [1] "    SECTOR_PROCEDURE(G=Consumer Discretionary, tau=8)"
## [1] "Cur Portfolio:"
##  [1] "ETN"  "RTX"  "CSX"  "PFE"  "DHR"  "AMGN" "CSCO" "AMD"  "QCOM" "DIS"
## [11] "CHTR" "TTWO" "CB"   "WFC"  "MS"   "AZO"  "CMG"  "MAR"
## [1] ""
## [1] "(3) OPTIMIZE_PORTFOLIO(portfolio)"
## [1] "weights: "
##  [1] "  0.0145910809424942"  "  0.0645472937329581"  "  0.0276683029448513"
##  [4] "  0.0665629083687913"  "  0.0297423857810088"  "  0.027162066621623"
##  [7] "  0.04002194599434"    "  0.0884286265121558"  "  0.0592753732005611"
## [10] "  0.00435432519059076" "  0.088721214019158"   "  0.00620725004236827"
## [13] "  0.0565036905885832"  "  0.0778025457529762"  "  0.086967081683158"
## [16] "  0.0818765898461419"  "  0.042626320757241"   "  0.0816359450038148"
## [1] ""
## [1] "(4) LONG PORTFOLIO()"
## [1] "-------------------------------------------------------------------------------------------------------"
## [1] "(tau=9) CLOSE all positions."
## [1] "(1) COMPUTE_P/L(portfolio)"
## [1] "--> Capital:540906.430001066$"
## [1] ""
## [1] "(2) PORTFOLIO_LOOP:"
## [1] "    SECTOR_PROCEDURE(G=Industrials, tau=9)"
## [1] "    SECTOR_PROCEDURE(G=Health Care, tau=9)"
## [1] "    SECTOR_PROCEDURE(G=Information Technology, tau=9)"
## [1] "    SECTOR_PROCEDURE(G=Communication Services, tau=9)"
## [1] "    SECTOR_PROCEDURE(G=Financials, tau=9)"
## [1] "    SECTOR_PROCEDURE(G=Consumer Discretionary, tau=9)"
## [1] "Cur Portfolio:"
##  [1] "UPS"   "ETN"   "FDX"   "JNJ"   "LLY"   "MRK"   "ORCL"  "INTC"  "QCOM"
## [10] "TMUS"  "CMCSA" "GOOG"  "WFC"   "AXP"   "MA"    "TSLA"  "NKE"   "MAR"
## [1] ""
## [1] "(3) OPTIMIZE_PORTFOLIO(portfolio)"
## [1] "weights: "
##  [1] "  0.0335568415309982"  "  0.102686376302516"   "  0.0294339659066413"
##  [4] "  0.0308367012268381"  "  0.122877168683169"   "  0.0449976297688113"
##  [7] "  0.0695832858442425"  "  0.00749102301159617" "  0.0776686008417498"
## [10] "  0.0231581556689871"  "  0.0652624790458368"  "  0.0723303182375552"
## [13] "  0.0701317674792704"  "  0.125565711033297"   "  0.0408771247896284"
```

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## [16] "  0.0138759507105422"  "  0.0290036242544652"  "  0.0615475246165439"
## [1] ""
## [1] "(4) LONG PORTFOLIO()"
## [1] "-------------------------------------------------------------------------------------------------------"
## [1] "(tau=10) CLOSE all positions."
## [1] "(1) COMPUTE_P/L(portfolio)"
## [1] "--> Capital:572768.936981803$"
## [1] ""
## [1] "(2) PORTFOLIO_LOOP:"
## [1] "    SECTOR_PROCEDURE(G=Industrials, tau=10)"
## [1] "    SECTOR_PROCEDURE(G=Health Care, tau=10)"
## [1] "    SECTOR_PROCEDURE(G=Information Technology, tau=10)"
## [1] "    SECTOR_PROCEDURE(G=Communication Services, tau=10)"
## [1] "    SECTOR_PROCEDURE(G=Financials, tau=10)"
## [1] "    SECTOR_PROCEDURE(G=Consumer Discretionary, tau=10)"
## [1] "Cur Portfolio:"
##  [1] "BA"    "GE"    "DE"    "PFE"   "UNH"   "ABBV"  "AVGO"  "INTU"  "AMD"
## [10] "DIS"   "TMUS"  "CMCSA" "MS"    "PGR"   "MMC"   "CMG"   "ABNB"  "MCD"
## [1] ""
## [1] "(3) OPTIMIZE_PORTFOLIO(portfolio)"
## [1] "weights: "
##  [1] "  0.0138209105058709" "  0.124638127012254"  "  0.122970993334025"
##  [4] "  0.0180460670156015" "  0.056657654882899"  "  0.133034839314306"
##  [7] "  0.0274769085102626" "  0.0305060914750162" "  0.0401531091940394"
## [10] "  0.0447596758029101" "  0.0881705786668068" "  0.0825254604439692"
## [13] "  0.0192502387993446" "  0.0720808136704045" "  0.0238748856503929"
## [16] "  0.0518761591973738" "  0.0455069528380482" "  0.115049436105035"
## [1] ""
## [1] "(4) LONG PORTFOLIO()"
## [1] "-------------------------------------------------------------------------------------------------------"
## [1] "(tau=11) CLOSE all positions."
## [1] "(1) COMPUTE_P/L(portfolio)"
## [1] "--> Capital:576352.485614722$"
## [1] ""
## [1] "(2) PORTFOLIO_LOOP:"
## [1] "    SECTOR_PROCEDURE(G=Industrials, tau=11)"
## [1] "    SECTOR_PROCEDURE(G=Health Care, tau=11)"
## [1] "    SECTOR_PROCEDURE(G=Information Technology, tau=11)"
## [1] "    SECTOR_PROCEDURE(G=Communication Services, tau=11)"
## [1] "    SECTOR_PROCEDURE(G=Financials, tau=11)"
## [1] "    SECTOR_PROCEDURE(G=Consumer Discretionary, tau=11)"
## [1] "Cur Portfolio:"
##  [1] "DE"   "RTX"  "BA"   "BMY"  "ELV"  "PFE"  "ACN"  "MSFT" "TXN"  "VZ"
## [11] "DIS"  "T"    "V"    "WFC"  "GS"   "ORLY" "AMZN" "CMG"
## [1] ""
## [1] "(3) OPTIMIZE_PORTFOLIO(portfolio)"
## [1] "weights: "
##  [1] "  0.0882004495870688"  "  0.0331014330156045"  "  0.0498150054571149"
##  [4] "  0.0586652764071114"  "  0.0537160078272953"  "  0.0484889095853508"
##  [7] "  0.0718854184853924"  "  0.0218524918422643"  "  0.0935103470478582"
## [10] "  0.0131811334913266"  "  0.0759199262159706"  "  0.0114179948426711"
## [13] "  0.0643152160747292"  "  0.0883798539932184"  "  0.0376449650452091"
## [16] "  0.00915871865284641" "  0.0186369495026636"  "  0.0552434286756848"
## [1] ""
## [1] "(4) LONG PORTFOLIO()"
## [1] "-------------------------------------------------------------------------------------------------------"
## [1] "(tau=12) CLOSE all positions."
## [1] "(1) COMPUTE_P/L(portfolio)"
## [1] "--> Capital:567473.748962763$"
## [1] ""
```

```
## [1] "(2) PORTFOLIO_LOOP:"
## [1] "    SECTOR_PROCEDURE(G=Industrials, tau=12)"
## [1] "    SECTOR_PROCEDURE(G=Health Care, tau=12)"
## [1] "    SECTOR_PROCEDURE(G=Information Technology, tau=12)"
## [1] "    SECTOR_PROCEDURE(G=Communication Services, tau=12)"
## [1] "    SECTOR_PROCEDURE(G=Financials, tau=12)"
## [1] "    SECTOR_PROCEDURE(G=Consumer Discretionary, tau=12)"
## [1] "Cur Portfolio:"
##  [1] "DE"    "ADP"   "NOC"   "ISRG"  "UNH"   "LLY"   "INTC"  "CRM"   "AMD"
## [10] "WBD"   "CMCSA" "DIS"   "BLK"   "MA"    "C"     "GM"    "BKNG"  "TJX"
## [1] ""
## [1] "(3) OPTIMIZE_PORTFOLIO(portfolio)"
## [1] "weights: "
##  [1] "  0.0992245655268737"  "  0.1001204541007"     "  0.0200635570899105"
##  [4] "  0.101035324370789"   "  0.0513663458699562"  "  0.0993479718184394"
##  [7] "  0.0905742502630226"  "  0.0739971400345323"  "  0.0350224625105656"
## [10] "  0.138509836405829"   "  0.00946254304646293" "  0.0165565625188674"
## [13] "  0.0121018521247204"  "  0.0797025892159468"  "  0.0829558940209803"
## [16] "  0.0613279116765553"  "  0.0698031412342329"  "  0.0175571513125267"
## [1] ""
## [1] "(4) LONG PORTFOLIO()"
## [1] "--------------------------------------------------------------------------------------------------------"
## [1] "(tau=13) CLOSE all positions."
## [1] "(1) COMPUTE_P/L(portfolio)"
## [1] "--> Capital:592566.678503581$"
## [1] ""
## [1] "(2) PORTFOLIO_LOOP:"
## [1] "    SECTOR_PROCEDURE(G=Industrials, tau=13)"
## [1] "    SECTOR_PROCEDURE(G=Health Care, tau=13)"
## [1] "    SECTOR_PROCEDURE(G=Information Technology, tau=13)"
## [1] "    SECTOR_PROCEDURE(G=Communication Services, tau=13)"
## [1] "    SECTOR_PROCEDURE(G=Financials, tau=13)"
## [1] "    SECTOR_PROCEDURE(G=Consumer Discretionary, tau=13)"
## [1] "Cur Portfolio:"
##  [1] "CAT"   "UPS"   "FDX"   "MDT"   "UNH"   "BMY"   "INTC"  "ORCL"  "QCOM"
## [10] "GOOGL" "NFLX"  "VZ"    "AXP"   "V"     "BLK"   "MCD"   "AMZN"  "NKE"
## [1] ""
## [1] "(3) OPTIMIZE_PORTFOLIO(portfolio)"
## [1] "weights: "
##  [1] "  0.0158679063490062"  "  0.0908970861160086"  "  0.0291768533842272"
##  [4] "  0.0982304842359742"  "  0.0115581650381786"  "  0.0381885260137089"
##  [7] "  0.0393152494824149"  "  0.0110364854806825"  "  0.0665028833603478"
## [10] "  0.0179350524043185"  "  0.0622682573524811"  "  0.0341779991984119"
## [13] "  0.0614130706015577"  "  0.0500108193011934"  "  0.00909557525799532"
## [16] "  0.0301145588630478"  "  0.0149045219296709"  "  0.0385411399685762"
## [1] ""
## [1] "(4) LONG PORTFOLIO()"
## [1] "--------------------------------------------------------------------------------------------------------"
## [1] "(tau=14) CLOSE all positions."
## [1] "(1) COMPUTE_P/L(portfolio)"
## [1] "--> Capital:596458.397020446$"
## [1] ""
## [1] "(2) PORTFOLIO_LOOP:"
## [1] "    SECTOR_PROCEDURE(G=Industrials, tau=14)"
## [1] "    SECTOR_PROCEDURE(G=Health Care, tau=14)"
## [1] "    SECTOR_PROCEDURE(G=Information Technology, tau=14)"
## [1] "    SECTOR_PROCEDURE(G=Communication Services, tau=14)"
## [1] "    SECTOR_PROCEDURE(G=Financials, tau=14)"
## [1] "    SECTOR_PROCEDURE(G=Consumer Discretionary, tau=14)"
## [1] "Cur Portfolio:"
```

```
##  [1] "UNP"  "ADP"  "LMT"  "TMO"  "BMY"  "MRK"  "TXN"  "AAPL" "ADBE" "DIS"
## [11] "EA"   "VZ"   "BLK"  "MS"   "GS"   "TSLA" "SBUX" "BKNG"
## [1] ""
## [1] "(3) OPTIMIZE_PORTFOLIO(portfolio)"
## [1] "weights: "
##  [1] "  0.0998652094157888"  "  0.0470927594713445"  "  0.0907546414942176"
##  [4] "  0.0346685757445112"  "  0.0119014012979245"  "  0.0591471641681169"
##  [7] "  0.0584580081681933"  "  0.0949044695982866"  "  0.00544189214678905"
## [10] "  0.0336658538687138"  "  0.0496585668870598"  "  0.106519842206739"
## [13] "  0.0566062245528649"  "  0.00214734939271092" "  0.0866820660339969"
## [16] "  0.0794199018967823"  "  0.0981894907844311"  "  0.0272744803625368"
## [1] ""
## [1] "(4) LONG PORTFOLIO()"
## [1] "--------------------------------------------------------------------------------------------------------"
## [1] "(tau=15) CLOSE all positions."
## [1] "(1) COMPUTE_P/L(portfolio)"
## [1] "--> Capital:598753.75866086$"
## [1] ""
## [1] "(2) PORTFOLIO_LOOP:"
## [1] "    SECTOR_PROCEDURE(G=Industrials, tau=15)"
## [1] "    SECTOR_PROCEDURE(G=Health Care, tau=15)"
## [1] "    SECTOR_PROCEDURE(G=Information Technology, tau=15)"
## [1] "    SECTOR_PROCEDURE(G=Communication Services, tau=15)"
## [1] "    SECTOR_PROCEDURE(G=Financials, tau=15)"
## [1] "    SECTOR_PROCEDURE(G=Consumer Discretionary, tau=15)"
## [1] "Cur Portfolio:"
##  [1] "GE"   "ETN"  "DE"   "BMY"  "GILD" "TMO"  "NVDA" "ACN"  "AMD"  "TTWO"
## [11] "META" "NFLX" "BAC"  "V"    "SCHW" "F"    "MAR"  "ABNB"
## [1] ""
## [1] "(3) OPTIMIZE_PORTFOLIO(portfolio)"
## [1] "weights: "
##  [1] "  0.0460944681063227" "  0.0574898882299035" "  0.0794537049995276"
##  [4] "  0.0568691053424809" "  0.0313327010654971" "  0.0501516270632475"
##  [7] "  0.0879232150546959" "  0.0384799272360318" "  0.0799356977329998"
## [10] "  0.0428877770945579" "  0.0138590726522646" "  0.0215694652232406"
## [13] "  0.0830068163287065" "  0.0431525006877617" "  0.0275575683916532"
## [16] "  0.0486586321596145" "  0.0836377280914528" "  0.063790279336737"
## [1] ""
## [1] "(4) LONG PORTFOLIO()"
## [1] "--------------------------------------------------------------------------------------------------------"
## [1] "(tau=16) CLOSE all positions."
## [1] "(1) COMPUTE_P/L(portfolio)"
## [1] "--> Capital:649816.649733231$"
## [1] ""
## [1] "(2) PORTFOLIO_LOOP:"
## [1] "    SECTOR_PROCEDURE(G=Industrials, tau=16)"
## [1] "    SECTOR_PROCEDURE(G=Health Care, tau=16)"
## [1] "    SECTOR_PROCEDURE(G=Information Technology, tau=16)"
## [1] "    SECTOR_PROCEDURE(G=Communication Services, tau=16)"
## [1] "    SECTOR_PROCEDURE(G=Financials, tau=16)"
## [1] "    SECTOR_PROCEDURE(G=Consumer Discretionary, tau=16)"
## [1] "Cur Portfolio:"
##  [1] "UPS"  "LMT"  "NOC"  "GILD" "TMO"  "ELV"  "INTU" "IBM"  "AVGO" "EA"
## [11] "DIS"  "ATVI" "BLK"  "C"    "SCHW" "ORLY" "MCD"  "HD"
## [1] ""
## [1] "(3) OPTIMIZE_PORTFOLIO(portfolio)"
## [1] "weights: "
##  [1] "  0.00495043339043793" "  0.0832222895739436"  "  0.0119883538367049"
##  [4] "  0.00492100998271381" "  0.0556257035614718"  "  0.00701774138314188"
##  [7] "  0.0231218382542145"  "  0.0669245471785209"  "  0.0249839515468306"
```

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## [10] "  0.0280871206984184"  "  0.0237459235790963"  "  0.025195358507436"
## [13] "  0.103572972801538"   "  0.068983780657571"   "  0.00631679070025211"
## [16] "  0.064089275068273"   "  0.0291653264051672"  "  0.0904046161795029"
## [1] ""
## [1] "(4) LONG PORTFOLIO()"
## [1] "-------------------------------------------------------------------------------------------------------"
## [1] "(tau=17) CLOSE all positions."
## [1] "(1) COMPUTE_P/L(portfolio)"
## [1] "--> Capital:649232.613017826$"
## [1] ""
## [1] "(2) PORTFOLIO_LOOP:"
## [1] "    SECTOR_PROCEDURE(G=Industrials, tau=17)"
## [1] "    SECTOR_PROCEDURE(G=Health Care, tau=17)"
## [1] "    SECTOR_PROCEDURE(G=Information Technology, tau=17)"
## [1] "    SECTOR_PROCEDURE(G=Communication Services, tau=17)"
## [1] "    SECTOR_PROCEDURE(G=Financials, tau=17)"
## [1] "    SECTOR_PROCEDURE(G=Consumer Discretionary, tau=17)"
## [1] "Cur Portfolio:"
##  [1] "CSX"   "UPS"   "NOC"   "TMO"   "MDT"   "ISRG"  "AMD"   "INTC"  "AAPL"
## [10] "T"     "CHTR"  "GOOGL" "MS"    "CB"    "BAC"   "MAR"   "AMZN"  "BKNG"
## [1] ""
## [1] "(3) OPTIMIZE_PORTFOLIO(portfolio)"
## [1] "weights: "
##  [1] "  0.00806009911214952" "  0.0807377632976385"  "  0.00381273263160712"
##  [4] "  0.00650995354312007" "  0.0579559686999545"  "  0.0504186987448743"
##  [7] "  0.0791574384844854"  "  0.0124436566097969"  "  0.061494747945203"
## [10] "  0.00378099079160307" "  0.0492217774878035"  "  0.0381820511866188"
## [13] "  0.0782658311580938"  "  0.0553472306756951"  "  0.114615810653951"
## [16] "  0.0123437902369664"  "  0.00943530328854826" "  0.10627792777792"
## [1] ""
## [1] "(4) LONG PORTFOLIO()"
## [1] "-------------------------------------------------------------------------------------------------------"
## [1] "(tau=18) CLOSE all positions."
## [1] "(1) COMPUTE_P/L(portfolio)"
## [1] "--> Capital:657280.847048445$"
## [1] ""
## [1] "(2) PORTFOLIO_LOOP:"
## [1] "    SECTOR_PROCEDURE(G=Industrials, tau=18)"
## [1] "    SECTOR_PROCEDURE(G=Health Care, tau=18)"
## [1] "    SECTOR_PROCEDURE(G=Information Technology, tau=18)"
## [1] "    SECTOR_PROCEDURE(G=Communication Services, tau=18)"
## [1] "    SECTOR_PROCEDURE(G=Financials, tau=18)"
## [1] "    SECTOR_PROCEDURE(G=Consumer Discretionary, tau=18)"
## [1] "Cur Portfolio:"
##  [1] "LMT"  "GE"   "BA"   "DHR"  "LLY"  "ELV"  "AVGO" "IBM"  "INTU" "EA"
## [11] "GOOG" "OMC"  "JPM"  "SCHW" "MA"   "SBUX" "TJX"  "GM"
## [1] ""
## [1] "(3) OPTIMIZE_PORTFOLIO(portfolio)"
## [1] "weights: "
##  [1] "  0.0527399814464686"  "  0.034483402978073"   "  0.0537006333974801"
##  [4] "  0.00884435749541477" "  0.0936474127369615"  "  0.0664832257044922"
##  [7] "  0.0488687211561063"  "  0.0433309030543874"  "  0.0494342584594275"
## [10] "  0.0882162023231966"  "  0.0744359077932351"  "  0.0384471324172732"
## [13] "  0.0155071431459345"  "  0.0838327998892971"  "  0.0308740432744078"
## [16] "  0.00883271798048296" "  0.0958911570271854"  "  0.0452070987636219"
## [1] ""
## [1] "(4) LONG PORTFOLIO()"
## [1] "-------------------------------------------------------------------------------------------------------"
## [1] "(tau=19) CLOSE all positions."
## [1] "(1) COMPUTE_P/L(portfolio)"
```

```
## [1] "--> Capital:689102.972731023$"
## [1] ""
## [1] "(2) PORTFOLIO_LOOP:"
## [1] "    SECTOR_PROCEDURE(G=Industrials, tau=19)"
## [1] "    SECTOR_PROCEDURE(G=Health Care, tau=19)"
## [1] "    SECTOR_PROCEDURE(G=Information Technology, tau=19)"
## [1] "    SECTOR_PROCEDURE(G=Communication Services, tau=19)"
## [1] "    SECTOR_PROCEDURE(G=Financials, tau=19)"
## [1] "    SECTOR_PROCEDURE(G=Consumer Discretionary, tau=19)"
## [1] "Cur Portfolio:"
##  [1] "ADP"   "BA"    "HON"   "ABBV"  "JNJ"   "AMGN"  "CSCO"  "AAPL"  "IBM"
## [10] "T"     "CMCSA" "DIS"   "JPM"   "BLK"   "GS"    "CMG"   "MCD"   "F"
## [1] ""
## [1] "(3) OPTIMIZE_PORTFOLIO(portfolio)"
## [1] "weights: "
##  [1] "  0.0699859332862732"  "  0.00624878825350004" "  0.00139797779847592"
##  [4] "  0.062228430262784"   "  0.0467846275021658"  "  0.00974469769716287"
##  [7] "  0.0811744737787336"  "  0.0172433175528324"  "  0.012585137745274"
## [10] "  0.00845266416754674" "  0.0441056842455077"  "  0.0725617265899043"
## [13] "  0.0544312548867181"  "  0.0494902277695009"  "  0.0824127180642838"
## [16] "  0.0311946310463222"  "  0.0458380001127623"  "  0.0316510723704581"
## [1] ""
## [1] "(4) LONG PORTFOLIO()"
## [1] "-------------------------------------------------------------------------------------------------------"
## [1] "(tau=20) CLOSE all positions."
## [1] "(1) COMPUTE_P/L(portfolio)"
## [1] "--> Capital:715163.793348029$"
## [1] ""
## [1] "(2) PORTFOLIO_LOOP:"
## [1] "    SECTOR_PROCEDURE(G=Industrials, tau=20)"
## [1] "    SECTOR_PROCEDURE(G=Health Care, tau=20)"
## [1] "    SECTOR_PROCEDURE(G=Information Technology, tau=20)"
## [1] "    SECTOR_PROCEDURE(G=Communication Services, tau=20)"
## [1] "    SECTOR_PROCEDURE(G=Financials, tau=20)"
## [1] "    SECTOR_PROCEDURE(G=Consumer Discretionary, tau=20)"
## [1] "Cur Portfolio:"
##  [1] "LMT"  "CSX"  "BA"   "MDT"  "GILD" "ISRG" "CRM"  "AMD"  "INTC" "DIS"
## [11] "EA"   "ATVI" "MA"   "PGR"  "GS"   "AMZN" "TSLA" "TJX"
## [1] ""
## [1] "(3) OPTIMIZE_PORTFOLIO(portfolio)"
## [1] "weights: "
##  [1] "  0.0994944021813922"  "  0.0777830405908054"  "  0.0472194746779019"
##  [4] "  0.095520692778435"   "  0.0666387517683298"  "  0.0126426401805182"
##  [7] "  0.0377521481715555"  "  0.0924692427475184"  "  0.0478437744039441"
## [10] "  0.0340111335631725"  "  0.0639606878788841"  "  0.0153941601924909"
## [13] "  0.016838150048852"   "  0.0480210858613187"  "  0.0583140886894446"
## [16] "  0.103094073499002"   "  0.0696925971236634"  "  0.00934382462145418"
## [1] ""
## [1] "(4) LONG PORTFOLIO()"
## [1] "-------------------------------------------------------------------------------------------------------"
## [1] "(tau=21) CLOSE all positions."
## [1] "(1) COMPUTE_P/L(portfolio)"
## [1] "--> Capital:743627.223567231$"
## [1] ""
## [1] "(2) PORTFOLIO_LOOP:"
## [1] "    SECTOR_PROCEDURE(G=Industrials, tau=21)"
## [1] "    SECTOR_PROCEDURE(G=Health Care, tau=21)"
## [1] "    SECTOR_PROCEDURE(G=Information Technology, tau=21)"
## [1] "    SECTOR_PROCEDURE(G=Communication Services, tau=21)"
## [1] "    SECTOR_PROCEDURE(G=Financials, tau=21)"
```

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## [1] "    SECTOR_PROCEDURE(G=Consumer Discretionary, tau=21)"
## [1] "Cur Portfolio:"
##  [1] "ETN"  "GE"   "FDX"  "AMGN" "MRK"  "UNH"  "INTC" "ACN"  "AVGO" "DIS"
## [11] "T"    "EA"   "PGR"  "MMC"  "SCHW" "MCD"  "HD"   "F"
## [1] ""
## [1] "(3) OPTIMIZE_PORTFOLIO(portfolio)"
## [1] "weights: "
##  [1] "  0.0184619945321507" "  0.0988245647637687" "  0.0887202188616362"
##  [4] "  0.0886878768276393" "  0.0966081869094189" "  0.0185540236949117"
##  [7] "  0.070178656036428"  "  0.0391510312006637" "  0.0728954717173039"
## [10] "  0.0893296181627494" "  0.0743642612542195" "  0.031183306847179"
## [13] "  0.0754608262126231" "  0.0719595400305942" "  0.0763054463829045"
## [16] "  0.0564969939240026" "  0.0422183368048574" "  0.0884013066128867"
## [1] ""
## [1] "(4) LONG PORTFOLIO()"
## [1] "-------------------------------------------------------------------------------------------------------"
## [1] "(tau=22) CLOSE all positions."
## [1] "(1) COMPUTE_P/L(portfolio)"
## [1] "--> Capital:707196.920159139$"
## [1] ""
## [1] "(2) PORTFOLIO_LOOP:"
## [1] "    SECTOR_PROCEDURE(G=Industrials, tau=22)"
## [1] "    SECTOR_PROCEDURE(G=Health Care, tau=22)"
## [1] "    SECTOR_PROCEDURE(G=Information Technology, tau=22)"
## [1] "    SECTOR_PROCEDURE(G=Communication Services, tau=22)"
## [1] "    SECTOR_PROCEDURE(G=Financials, tau=22)"
## [1] "    SECTOR_PROCEDURE(G=Consumer Discretionary, tau=22)"
## [1] "Cur Portfolio:"
##  [1] "CAT"   "GE"    "ETN"   "DHR"   "PFE"   "GILD"  "CRM"   "IBM"   "INTU"
## [10] "OMC"   "GOOGL" "TTWO"  "PGR"   "CB"    "BAC"   "GM"    "F"     "BKNG"
## [1] ""
## [1] "(3) OPTIMIZE_PORTFOLIO(portfolio)"
## [1] "weights: "
##  [1] "  0.0996126619120856"  "  0.0730533228836671"  "  0.0943930432280608"
##  [4] "  0.0906572163728122"  "  0.00655253603497379" "  0.0102177559233739"
##  [7] "  0.0720945666802279"  "  0.120397015502183"   "  0.122013673780573"
## [10] "  0.0821733186465661"  "  0.019533571744413"   "  0.00923522061034418"
## [13] "  0.0397627846412108"  "  0.111389690108907"   "  0.00955622075796133"
## [16] "  0.00904398219438139" "  0.028712652547556"   "  0.0694008240354984"
## [1] ""
## [1] "(4) LONG PORTFOLIO()"
## [1] "-------------------------------------------------------------------------------------------------------"
## [1] "(tau=23) CLOSE all positions."
## [1] "(1) COMPUTE_P/L(portfolio)"
## [1] "--> Capital:726191.818315346$"
## [1] ""
## [1] "(2) PORTFOLIO_LOOP:"
## [1] "    SECTOR_PROCEDURE(G=Industrials, tau=23)"
## [1] "    SECTOR_PROCEDURE(G=Health Care, tau=23)"
## [1] "    SECTOR_PROCEDURE(G=Information Technology, tau=23)"
## [1] "    SECTOR_PROCEDURE(G=Communication Services, tau=23)"
## [1] "    SECTOR_PROCEDURE(G=Financials, tau=23)"
## [1] "    SECTOR_PROCEDURE(G=Consumer Discretionary, tau=23)"
## [1] "Cur Portfolio:"
##  [1] "DE"   "UNP"  "CSX"  "ABT"  "UNH"  "MDT"  "ORCL" "MSFT" "QCOM" "WBD"
## [11] "NFLX" "META" "BAC"  "MS"   "SPGI" "CMG"  "ORLY" "HD"
## [1] ""
## [1] "(3) OPTIMIZE_PORTFOLIO(portfolio)"
## [1] "weights: "
##  [1] "  0.115862683951819"   "  0.0660810834670989"  "  0.0732513684237738"
```

```
##  [4] "  0.0116137626804226"  "  0.00270421054354607" "  0.0965990259857608"
##  [7] "  0.0296421431707033"  "  0.120308648690097"   "  0.0620135024282419"
## [10] "  0.10710623776418"    "  0.124007220919563"   "  0.027986261928073"
## [13] "  0.0302454289431569"  "  0.00983417612493411" "  0.0222070847178963"
## [16] "  0.060599103139713"   "  0.0697720868584062"  "  0.124065490076211"
## [1] ""
## [1] "(4) LONG PORTFOLIO()"
## [1] "-------------------------------------------------------------------------------------------------------"
## [1] "(tau=24) CLOSE all positions."
## [1] "(1) COMPUTE_P/L(portfolio)"
## [1] "--> Capital:700022.823156309$"
## [1] ""
## [1] "(2) PORTFOLIO_LOOP:"
## [1] "    SECTOR_PROCEDURE(G=Industrials, tau=24)"
## [1] "    SECTOR_PROCEDURE(G=Health Care, tau=24)"
## [1] "    SECTOR_PROCEDURE(G=Information Technology, tau=24)"
## [1] "    SECTOR_PROCEDURE(G=Communication Services, tau=24)"
## [1] "    SECTOR_PROCEDURE(G=Financials, tau=24)"
## [1] "    SECTOR_PROCEDURE(G=Consumer Discretionary, tau=24)"
## [1] "Cur Portfolio:"
##  [1] "ETN"  "DE"   "NOC"  "AMGN" "ELV"  "GILD" "INTC" "QCOM" "INTU" "VZ"
## [11] "EA"   "WBD"  "JPM"  "GS"   "MA"   "ORLY" "HD"   "MCD"
## [1] ""
## [1] "(3) OPTIMIZE_PORTFOLIO(portfolio)"
## [1] "weights: "
##  [1] "  0.0132342453520055"   "  0.0714764993355897"   "  0.102173292389498"
##  [4] "  0.0336648716496072"   "  0.0469590433242082"   "  0.0319527863894742"
##  [7] "  0.0222320113097823"   "  0.00846968871932118"  "  0.0623010263005583"
## [10] "  0.0542330823980607"   "  0.0306673964928244"   "  0.00512931773813441"
## [13] "  0.000536172710721833" "  0.066450683198276"    "  0.0302425394078587"
## [16] "  0.0719901617994745"   "  0.013749173443039"    "  0.104831425184694"
## [1] ""
## [1] "(4) LONG PORTFOLIO()"
## [1] "-------------------------------------------------------------------------------------------------------"
## [1] "(tau=25) CLOSE all positions."
## [1] "(1) COMPUTE_P/L(portfolio)"
## [1] "--> Capital:672953.769631102$"
## [1] ""
## [1] "(2) PORTFOLIO_LOOP:"
## [1] "    SECTOR_PROCEDURE(G=Industrials, tau=25)"
## [1] "    SECTOR_PROCEDURE(G=Health Care, tau=25)"
## [1] "    SECTOR_PROCEDURE(G=Information Technology, tau=25)"
## [1] "    SECTOR_PROCEDURE(G=Communication Services, tau=25)"
## [1] "    SECTOR_PROCEDURE(G=Financials, tau=25)"
## [1] "    SECTOR_PROCEDURE(G=Consumer Discretionary, tau=25)"
## [1] "Cur Portfolio:"
##  [1] "LMT"  "GE"   "DE"   "MRK"  "PFE"  "GILD" "AVGO" "TXN"  "NVDA" "CHTR"
## [11] "T"    "DIS"  "MS"   "WFC"  "SPGI" "AZO"  "MAR"  "TSLA"
## [1] ""
## [1] "(3) OPTIMIZE_PORTFOLIO(portfolio)"
## [1] "weights: "
##  [1] "  0.0366366276854454" "  0.0381837735061059" "  0.01130320643849"
##  [4] "  0.0851506336067894" "  0.0507674687284379" "  0.0716693941842477"
##  [7] "  0.0184092975661672" "  0.0977272933045581" "  0.0213149476500479"
## [10] "  0.0785829421296144" "  0.0196149220420077" "  0.0882686144342616"
## [13] "  0.0640481275481067" "  0.0927799753429733" "  0.0735925344538889"
## [16] "  0.0802188360860439" "  0.0478237284025208" "  0.0841668666953213"
## [1] ""
## [1] "(4) LONG PORTFOLIO()"
## [1] "-------------------------------------------------------------------------------------------------------"
```

```
## [1] "(tau=26) CLOSE all positions."
## [1] "(1) COMPUTE_P/L(portfolio)"
## [1] "--> Capital:695685.262004539$"
## [1] ""
## [1] "(2) PORTFOLIO_LOOP:"
## [1] "    SECTOR_PROCEDURE(G=Industrials, tau=26)"
## [1] "    SECTOR_PROCEDURE(G=Health Care, tau=26)"
## [1] "    SECTOR_PROCEDURE(G=Information Technology, tau=26)"
## [1] "    SECTOR_PROCEDURE(G=Communication Services, tau=26)"
## [1] "    SECTOR_PROCEDURE(G=Financials, tau=26)"
## [1] "    SECTOR_PROCEDURE(G=Consumer Discretionary, tau=26)"
## [1] "Cur Portfolio:"
##  [1] "DE"   "FDX"  "GE"   "MRK"  "MDT"  "BMY"  "ORCL" "NVDA" "ADBE" "CHTR"
## [11] "ATVI" "TTWO" "MS"   "SPGI" "WFC"  "NKE"  "HD"   "TJX"
## [1] ""
## [1] "(3) OPTIMIZE_PORTFOLIO(portfolio)"
## [1] "weights: "
##  [1] "  0.0356619818006693" "  0.122897106861066"  "  0.0584893390578506"
##  [4] "  0.0222401830030047" "  0.0798916754829597" "  0.0920039622792243"
##  [7] "  0.0542730594030775" "  0.0831861469734061" "  0.0771305702638925"
## [10] "  0.0786538836975963" "  0.0378848861411011" "  0.114184118874507"
## [13] "  0.0217260496901812" "  0.0756770651639719" "  0.0161672170204697"
## [16] "  0.0080151892468698" "  0.0563849948319218" "  0.0567063407983576"
## [1] ""
## [1] "(4) LONG PORTFOLIO()"
## [1] "------------------------------------------------------------------------------------------------------"
## [1] "(tau=27) CLOSE all positions."
## [1] "(1) COMPUTE_P/L(portfolio)"
## [1] "--> Capital:663495.214932235$"
## [1] ""
## [1] "(2) PORTFOLIO_LOOP:"
## [1] "    SECTOR_PROCEDURE(G=Industrials, tau=27)"
## [1] "    SECTOR_PROCEDURE(G=Health Care, tau=27)"
## [1] "    SECTOR_PROCEDURE(G=Information Technology, tau=27)"
## [1] "    SECTOR_PROCEDURE(G=Communication Services, tau=27)"
## [1] "    SECTOR_PROCEDURE(G=Financials, tau=27)"
## [1] "    SECTOR_PROCEDURE(G=Consumer Discretionary, tau=27)"
## [1] "Cur Portfolio:"
##  [1] "CAT"  "UPS"  "ADP"  "MRK"  "MDT"  "PFE"  "NVDA" "INTC" "TXN"  "META"
## [11] "TTWO" "DIS"  "JPM"  "BAC"  "BLK"  "MAR"  "CMG"  "NKE"
## [1] ""
## [1] "(3) OPTIMIZE_PORTFOLIO(portfolio)"
## [1] "weights: "
##  [1] "  0.104896525765789"  "  0.0630281958425037" "  0.0717490639824703"
##  [4] "  0.0420069485598688" "  0.0542967898780336" "  0.0860254829309565"
##  [7] "  0.0298669180118359" "  0.0734018386745025" "  0.0337842121086318"
## [10] "  0.0793907948908417" "  0.0341100806630716" "  0.0556632795358865"
## [13] "  0.0139333074305925" "  0.0913595398300677" "  0.0519363226927725"
## [16] "  0.0577167611588403" "  0.0984884759962444" "  0.0703694694072444"
## [1] ""
## [1] "(4) LONG PORTFOLIO()"
## [1] "------------------------------------------------------------------------------------------------------"
## [1] "(tau=28) CLOSE all positions."
## [1] "(1) COMPUTE_P/L(portfolio)"
## [1] "--> Capital:716484.595915922$"
## [1] ""
## [1] "(2) PORTFOLIO_LOOP:"
## [1] "    SECTOR_PROCEDURE(G=Industrials, tau=28)"
## [1] "    SECTOR_PROCEDURE(G=Health Care, tau=28)"
## [1] "    SECTOR_PROCEDURE(G=Information Technology, tau=28)"
```

```
## [1] "    SECTOR_PROCEDURE(G=Communication Services, tau=28)"
## [1] "    SECTOR_PROCEDURE(G=Financials, tau=28)"
## [1] "    SECTOR_PROCEDURE(G=Consumer Discretionary, tau=28)"
## [1] "Cur Portfolio:"
##  [1] "GE"   "UPS"  "DE"   "MDT"  "BMY"  "ISRG" "INTC" "AMD"  "ACN"  "NFLX"
## [11] "VZ"   "WBD"  "PGR"  "MS"   "WFC"  "ORLY" "BKNG" "MCD"
## [1] ""
## [1] "(3) OPTIMIZE_PORTFOLIO(portfolio)"
## [1] "weights: "
##  [1] "  0.114967622117523"   "  0.0499428791509786"  "  0.0284320407699636"
##  [4] "  0.0585293374749121"  "  0.0358200559312541"  "  0.0186287156352406"
##  [7] "  0.0618099967827187"  "  0.0059529685635475"  "  0.0524414352867176"
## [10] "  0.0646065776011203"  "  0.018778872907595"   "  0.0306074051523964"
## [13] "  0.11253301023386"    "  0.0522160317324113"  "  0.00911512900634407"
## [16] "  0.0951500383672811"  "  0.0775201587803056"  "  0.0421948663417261"
## [1] ""
## [1] "(4) LONG PORTFOLIO()"
## [1] "-------------------------------------------------------------------------------------------------------"
## [1] "(tau=29) CLOSE all positions."
## [1] "(1) COMPUTE_P/L(portfolio)"
## [1] "--> Capital:719137.458510233$"
## [1] ""
## [1] "(2) PORTFOLIO_LOOP:"
## [1] "    SECTOR_PROCEDURE(G=Industrials, tau=29)"
## [1] "    SECTOR_PROCEDURE(G=Health Care, tau=29)"
## [1] "    SECTOR_PROCEDURE(G=Information Technology, tau=29)"
## [1] "    SECTOR_PROCEDURE(G=Communication Services, tau=29)"
## [1] "    SECTOR_PROCEDURE(G=Financials, tau=29)"
## [1] "    SECTOR_PROCEDURE(G=Consumer Discretionary, tau=29)"
## [1] "Cur Portfolio:"
##  [1] "CAT"  "FDX"  "LMT"  "ABT"  "BMY"  "ABBV" "ORCL" "CSCO" "ADBE" "GOOG"
## [11] "WBD"  "ATVI" "SPGI" "JPM"  "MMC"  "TJX"  "MAR"  "ABNB"
## [1] ""
## [1] "(3) OPTIMIZE_PORTFOLIO(portfolio)"
## [1] "weights: "
##  [1] "  0.0676780900992557" "  0.047053978229395"  "  0.0743845242915854"
##  [4] "  0.0119932720067252" "  0.0924328629300911" "  0.0147969085147691"
##  [7] "  0.0756303456774904" "  0.0828940542733816" "  0.101828798271638"
## [10] "  0.0978782123324955" "  0.0929685764402049" "  0.0718469069418732"
## [13] "  0.0606681080629429" "  0.0423052905724853" "  0.0587893582158365"
## [16] "  0.0643670369930919" "  0.0307372272401388" "  0.0399833331911231"
## [1] ""
## [1] "(4) LONG PORTFOLIO()"
## [1] "-------------------------------------------------------------------------------------------------------"
## [1] "(tau=30) CLOSE all positions."
## [1] "(1) COMPUTE_P/L(portfolio)"
## [1] "--> Capital:754392.567900573$"
## [1] ""
## [1] "(2) PORTFOLIO_LOOP:"
## [1] "    SECTOR_PROCEDURE(G=Industrials, tau=30)"
## [1] "    SECTOR_PROCEDURE(G=Health Care, tau=30)"
## [1] "    SECTOR_PROCEDURE(G=Information Technology, tau=30)"
## [1] "    SECTOR_PROCEDURE(G=Communication Services, tau=30)"
## [1] "    SECTOR_PROCEDURE(G=Financials, tau=30)"
## [1] "    SECTOR_PROCEDURE(G=Consumer Discretionary, tau=30)"
## [1] "Cur Portfolio:"
##  [1] "UPS"  "CSX"  "ITW"  "ABBV" "GILD" "JNJ"  "ACN"  "QCOM" "ADBE" "META"
## [11] "ATVI" "OMC"  "AXP"  "MA"   "SCHW" "ABNB" "TSLA" "ORLY"
## [1] ""
## [1] "(3) OPTIMIZE_PORTFOLIO(portfolio)"
```

```
## [1] "weights: "
##  [1] "  0.02808395206168"   "  0.0440092308820261" "  0.007901884964511"
##  [4] "  0.0898395558373135" "  0.0708024325327843" "  0.0972413548873349"
##  [7] "  0.0837075150576321" "  0.0506770881595797" "  0.108968260875382"
## [10] "  0.0720730882047275" "  0.0274612824024532" "  0.0450529442310855"
## [13] "  0.11663067269358"   "  0.0316589980259309" "  0.0496643276803378"
## [16] "  0.0431549324978921" "  0.0232160402357943" "  0.0649061633249395"
## [1] ""
## [1] "(4) LONG PORTFOLIO()"
## [1] "-------------------------------------------------------------------------------------------------------"
## [1] "(tau=31) CLOSE all positions."
## [1] "(1) COMPUTE_P/L(portfolio)"
## [1] "--> Capital:725937.940859301$"
## [1] ""
## [1] "(2) PORTFOLIO_LOOP:"
## [1] "    SECTOR_PROCEDURE(G=Industrials, tau=31)"
## [1] "    SECTOR_PROCEDURE(G=Health Care, tau=31)"
## [1] "    SECTOR_PROCEDURE(G=Information Technology, tau=31)"
## [1] "    SECTOR_PROCEDURE(G=Communication Services, tau=31)"
## [1] "    SECTOR_PROCEDURE(G=Financials, tau=31)"
## [1] "    SECTOR_PROCEDURE(G=Consumer Discretionary, tau=31)"
## [1] "Cur Portfolio:"
##  [1] "ITW"  "ETN"  "CAT"  "ELV"  "MRK"  "LLY"  "ORCL" "NVDA" "ADBE" "EA"
## [11] "T"    "TTWO" "MMC"  "MA"   "C"    "TJX"  "ORLY" "GM"
## [1] ""
## [1] "(3) OPTIMIZE_PORTFOLIO(portfolio)"
## [1] "weights: "
##  [1] "  0.0376692098731354"   "  0.101882201968068"    "  0.000942349674143826"
##  [4] "  0.0240446142426687"   "  0.0238335355382534"   "  0.00159092186326948"
##  [7] "  0.0790519132291835"   "  0.118452681287759"    "  0.11214569879004"
## [10] "  0.0841602209568426"   "  0.0338442797438753"   "  0.0719122365298801"
## [13] "  0.119302727145547"    "  0.0100837310877931"   "  0.0813568792976368"
## [16] "  0.120464018662426"    "  0.0130800878144145"   "  0.0749990053411933"
## [1] ""
## [1] "(4) LONG PORTFOLIO()"
## [1] "-------------------------------------------------------------------------------------------------------"
## [1] "(tau=32) CLOSE all positions."
## [1] "(1) COMPUTE_P/L(portfolio)"
## [1] "--> Capital:693423.175728228$"
## [1] ""
## [1] "(2) PORTFOLIO_LOOP:"
## [1] "    SECTOR_PROCEDURE(G=Industrials, tau=32)"
## [1] "    SECTOR_PROCEDURE(G=Health Care, tau=32)"
## [1] "    SECTOR_PROCEDURE(G=Information Technology, tau=32)"
## [1] "    SECTOR_PROCEDURE(G=Communication Services, tau=32)"
## [1] "    SECTOR_PROCEDURE(G=Financials, tau=32)"
## [1] "    SECTOR_PROCEDURE(G=Consumer Discretionary, tau=32)"
## [1] "Cur Portfolio:"
##  [1] "NOC"  "RTX"  "HON"  "BMY"  "ELV"  "MRK"  "AMD"  "INTU" "TXN"  "CHTR"
## [11] "GOOG" "TTWO" "C"    "SCHW" "WFC"  "SBUX" "CMG"  "TSLA"
## [1] ""
## [1] "(3) OPTIMIZE_PORTFOLIO(portfolio)"
## [1] "weights: "
##  [1] "  0.0565947053193283"  "  0.0253595795743583"  "  0.0164182503081015"
##  [4] "  0.0742003634197573"  "  0.108438594236059"   "  0.0716718458149258"
##  [7] "  0.00660458377993785" "  0.0654397786874932"  "  0.0497115676679645"
## [10] "  0.00555479059959863" "  0.100924493210837"   "  0.0761625014077385"
## [13] "  0.0687181271520239"  "  0.0602042097575952"  "  0.0997081697169304"
## [16] "  0.0707633143545234"  "  0.0725557883338947"  "  0.0449845058831539"
## [1] ""
```

```
## [1] "(4) LONG PORTFOLIO()"
## [1] "-------------------------------------------------------------------------------------------------------"
## [1] "(tau=33) CLOSE all positions."
## [1] "(1) COMPUTE_P/L(portfolio)"
## [1] "--> Capital:725056.384289075$"
## [1] ""
## [1] "(2) PORTFOLIO_LOOP:"
## [1] "    SECTOR_PROCEDURE(G=Industrials, tau=33)"
## [1] "    SECTOR_PROCEDURE(G=Health Care, tau=33)"
## [1] "    SECTOR_PROCEDURE(G=Information Technology, tau=33)"
## [1] "    SECTOR_PROCEDURE(G=Communication Services, tau=33)"
## [1] "    SECTOR_PROCEDURE(G=Financials, tau=33)"
## [1] "    SECTOR_PROCEDURE(G=Consumer Discretionary, tau=33)"
## [1] "Cur Portfolio:"
##  [1] "LMT"  "NOC"  "HON"  "JNJ"  "ABT"  "AMGN" "ORCL" "ADBE" "AMD"  "EA"
## [11] "DIS"  "WBD"  "GS"   "PGR"  "JPM"  "AMZN" "HD"   "F"
## [1] ""
## [1] "(3) OPTIMIZE_PORTFOLIO(portfolio)"
## [1] "weights: "
##  [1] "  0.00631232386495979" "  0.125801741061522"   "  0.0549517752011825"
##  [4] "  0.0117808560090514"  "  0.0368017684588528"  "  0.0255639376131999"
##  [7] "  0.0713582119414085"  "  0.0460302293894445"  "  0.0897415720415371"
## [10] "  0.0192849810237537"  "  0.0444389287692166"  "  0.110027505471972"
## [13] "  0.0972984894516687"  "  0.0235164645359371"  "  0.0044283937282268"
## [16] "  0.004820535881011"   "  0.109475858590106"   "  0.121802996514981"
## [1] ""
## [1] "(4) LONG PORTFOLIO()"
## [1] "-------------------------------------------------------------------------------------------------------"
## [1] "(tau=34) CLOSE all positions."
## [1] "(1) COMPUTE_P/L(portfolio)"
## [1] "--> Capital:692020.775001411$"
## [1] ""
## [1] "(2) PORTFOLIO_LOOP:"
## [1] "    SECTOR_PROCEDURE(G=Industrials, tau=34)"
## [1] "    SECTOR_PROCEDURE(G=Health Care, tau=34)"
## [1] "    SECTOR_PROCEDURE(G=Information Technology, tau=34)"
## [1] "    SECTOR_PROCEDURE(G=Communication Services, tau=34)"
## [1] "    SECTOR_PROCEDURE(G=Financials, tau=34)"
## [1] "    SECTOR_PROCEDURE(G=Consumer Discretionary, tau=34)"
## [1] "Cur Portfolio:"
##  [1] "ADP"   "BA"    "LMT"   "DHR"   "BMY"   "ISRG"  "IBM"   "ACN"   "INTC"
## [10] "WBD"   "GOOGL" "META"  "AXP"   "MMC"   "CB"    "F"     "GM"    "AMZN"
## [1] ""
## [1] "(3) OPTIMIZE_PORTFOLIO(portfolio)"
## [1] "weights: "
##  [1] "  0.0204328189050897" "  0.0200975957140623" "  0.0834217439747566"
##  [4] "  0.0668522963813557" "  0.0995934733696826" "  0.110310083718343"
##  [7] "  0.0033685329360927" "  0.111082022034053"  "  0.07062541412934"
## [10] "  0.126010077667755"  "  0.0268150292845626" "  0.032040081312856"
## [13] "  0.0910266928508976" "  0.0743945785125614" "  0.0171985680969153"
## [16] "  0.12243945928868"   "  0.08248120516791"   "  0.102826832832043"
## [1] ""
## [1] "(4) LONG PORTFOLIO()"
## [1] "-------------------------------------------------------------------------------------------------------"
## [1] "(tau=35) CLOSE all positions."
## [1] "(1) COMPUTE_P/L(portfolio)"
## [1] "--> Capital:673077.394054583$"
## [1] ""
## [1] "(2) PORTFOLIO_LOOP:"
## [1] "    SECTOR_PROCEDURE(G=Industrials, tau=35)"
```

```
## [1] "    SECTOR_PROCEDURE(G=Health Care, tau=35)"
## [1] "    SECTOR_PROCEDURE(G=Information Technology, tau=35)"
## [1] "    SECTOR_PROCEDURE(G=Communication Services, tau=35)"
## [1] "    SECTOR_PROCEDURE(G=Financials, tau=35)"
## [1] "    SECTOR_PROCEDURE(G=Consumer Discretionary, tau=35)"
## [1] "Cur Portfolio:"
##  [1] "FDX"  "UNP"  "RTX"  "DHR"  "AMGN" "ELV"  "INTU" "AMD"  "AVGO" "T"
## [11] "NFLX" "GOOG" "SPGI" "AXP"  "MA"   "MAR"  "ABNB" "ORLY"
## [1] ""
## [1] "(3) OPTIMIZE_PORTFOLIO(portfolio)"
## [1] "weights: "
##  [1] "  0.0608307383312035" "  0.0157048823636707" "  0.0411931749945291"
##  [4] "  0.0166146281766758" "  0.0442873655484791" "  0.0210243439021934"
##  [7] "  0.0483181651908672" "  0.0830618046037795" "  0.0864243241964669"
## [10] "  0.0419302674038262" "  0.0326565850241193" "  0.0804265561221858"
## [13] "  0.0798584521183562" "  0.0979891127378132" "  0.0360195526763402"
## [16] "  0.0549851774251577" "  0.0943380486242098" "  0.019766812533689"
## [1] ""
## [1] "(4) LONG PORTFOLIO()"
## [1] "-------------------------------------------------------------------------------------------------------"
## [1] "(tau=36) CLOSE all positions."
## [1] "(1) COMPUTE_P/L(portfolio)"
## [1] "--> Capital:655936.554155373$"
## [1] ""
## [1] "(2) PORTFOLIO_LOOP:"
## [1] "    SECTOR_PROCEDURE(G=Industrials, tau=36)"
## [1] "    SECTOR_PROCEDURE(G=Health Care, tau=36)"
## [1] "    SECTOR_PROCEDURE(G=Information Technology, tau=36)"
## [1] "    SECTOR_PROCEDURE(G=Communication Services, tau=36)"
## [1] "    SECTOR_PROCEDURE(G=Financials, tau=36)"
## [1] "    SECTOR_PROCEDURE(G=Consumer Discretionary, tau=36)"
## [1] "Cur Portfolio:"
##  [1] "LMT"  "ETN"  "DE"   "MRK"  "LLY"  "DHR"  "AVGO" "QCOM" "ADBE" "WBD"
## [11] "DIS"  "GOOG" "MS"   "MMC"  "AXP"  "MAR"  "ORLY" "TJX"
## [1] ""
## [1] "(3) OPTIMIZE_PORTFOLIO(portfolio)"
## [1] "weights: "
##  [1] "  0.044541751908662"   "  0.0634904081922634"  "  0.0645996595901091"
##  [4] "  0.0109579797506586"  "  0.0115882268177857"  "  0.0659824539462431"
##  [7] "  0.0220501450014763"  "  0.0443662063642487"  "  0.0323536164858143"
## [10] "  0.00400036291931162" "  0.0770133658850348"  "  0.0218658872935274"
## [13] "  0.0361323373035569"  "  0.0456639688584129"  "  0.00611740256366879"
## [16] "  0.0021544360064517"  "  0.0246307466633907"  "  0.0635423960688644"
## [1] ""
## [1] "(4) LONG PORTFOLIO()"
## [1] "-------------------------------------------------------------------------------------------------------"
## [1] "(tau=37) CLOSE all positions."
## [1] "(1) COMPUTE_P/L(portfolio)"
## [1] "--> Capital:644811.757837723$"
## [1] ""
## [1] "(2) PORTFOLIO_LOOP:"
## [1] "    SECTOR_PROCEDURE(G=Industrials, tau=37)"
## [1] "    SECTOR_PROCEDURE(G=Health Care, tau=37)"
## [1] "    SECTOR_PROCEDURE(G=Information Technology, tau=37)"
## [1] "    SECTOR_PROCEDURE(G=Communication Services, tau=37)"
## [1] "    SECTOR_PROCEDURE(G=Financials, tau=37)"
## [1] "    SECTOR_PROCEDURE(G=Consumer Discretionary, tau=37)"
## [1] "Cur Portfolio:"
##  [1] "HON"   "BA"    "CSX"   "MDT"   "LLY"   "UNH"   "AMD"   "AVGO"  "QCOM"
## [10] "CMCSA" "T"     "OMC"   "MMC"   "AXP"   "MS"    "ABNB"  "MAR"   "CMG"
```

```
## [1] ""
## [1] "(3) OPTIMIZE_PORTFOLIO(portfolio)"
## [1] "weights: "
##  [1] "  0.0019793851312639"  "  0.0618356681862519"  "  0.127160350183309"
##  [4] "  0.121626965790526"   "  0.0891128154054168"  "  0.0540741410724769"
##  [7] "  0.048450895074818"   "  0.0574992432429704"  "  0.0135983248148541"
## [10] "  0.0278850562625553"  "  0.08384748803638"    "  0.115549980964391"
## [13] "  0.0242630926091494"  "  0.00966334244904286" "  0.107393403959623"
## [16] "  0.00820938431178266" "  0.0907520945924597"  "  0.0242209732626141"
## [1] ""
## [1] "(4) LONG PORTFOLIO()"
## [1] "-------------------------------------------------------------------------------------------------------"
## [1] "(tau=38) CLOSE all positions."
## [1] "(1) COMPUTE_P/L(portfolio)"
## [1] "--> Capital:623582.636771808$"
## [1] ""
## [1] "(2) PORTFOLIO_LOOP:"
## [1] "    SECTOR_PROCEDURE(G=Industrials, tau=38)"
## [1] "    SECTOR_PROCEDURE(G=Health Care, tau=38)"
## [1] "    SECTOR_PROCEDURE(G=Information Technology, tau=38)"
## [1] "    SECTOR_PROCEDURE(G=Communication Services, tau=38)"
## [1] "    SECTOR_PROCEDURE(G=Financials, tau=38)"
## [1] "    SECTOR_PROCEDURE(G=Consumer Discretionary, tau=38)"
## [1] "Cur Portfolio:"
##  [1] "ETN"  "HON"  "BA"   "ISRG" "BMY"  "JNJ"  "MSFT" "AVGO" "TXN"  "NFLX"
## [11] "TMUS" "VZ"   "CB"   "JPM"  "BAC"  "BKNG" "AZO"  "GM"
## [1] ""
## [1] "(3) OPTIMIZE_PORTFOLIO(portfolio)"
## [1] "weights: "
##  [1] "  0.0986068278802227"   "  0.0432297976613972"   "  0.0115642419697874"
##  [4] "  0.0439325028479924"   "  0.0480791872455101"   "  0.0776712605740768"
##  [7] "  0.0726475673123059"   "  0.00298770899747405"  "  0.0282059031894894"
## [10] "  0.0341994111702805"   "  0.000397655124594658" "  0.013068438574775"
## [13] "  0.07608770033003"     "  0.0813103683400753"   "  0.0360366388337383"
## [16] "  0.034743874512641"    "  0.00720406445363827"  "  0.0173156076065199"
## [1] ""
## [1] "(4) LONG PORTFOLIO()"
## [1] "-------------------------------------------------------------------------------------------------------"
## [1] "(tau=39) CLOSE all positions."
## [1] "(1) COMPUTE_P/L(portfolio)"
## [1] "--> Capital:596589.287233973$"
## [1] ""
## [1] "(2) PORTFOLIO_LOOP:"
## [1] "    SECTOR_PROCEDURE(G=Industrials, tau=39)"
## [1] "    SECTOR_PROCEDURE(G=Health Care, tau=39)"
## [1] "    SECTOR_PROCEDURE(G=Information Technology, tau=39)"
## [1] "    SECTOR_PROCEDURE(G=Communication Services, tau=39)"
## [1] "    SECTOR_PROCEDURE(G=Financials, tau=39)"
## [1] "    SECTOR_PROCEDURE(G=Consumer Discretionary, tau=39)"
## [1] "Cur Portfolio:"
##  [1] "NOC"   "FDX"   "LMT"   "BMY"   "AMGN"  "ABBV"  "IBM"   "CRM"   "TXN"
## [10] "META"  "CMCSA" "GOOGL" "C"     "BLK"   "JPM"   "F"     "TJX"   "MAR"
## [1] ""
## [1] "(3) OPTIMIZE_PORTFOLIO(portfolio)"
## [1] "weights: "
##  [1] "  0.0256379554624422" "  0.0713959102106305" "  0.0804877762842908"
##  [4] "  0.0630703958414249" "  0.081909084815012"  "  0.0978241118544791"
##  [7] "  0.0619868857335665" "  0.0140638764688294" "  0.0263776955655325"
## [10] "  0.0496237075945592" "  0.100723693065007"  "  0.0873956841994417"
## [13] "  0.0464042924581878" "  0.0270768976463934" "  0.0839774798199714"
```

```
## [16] "  0.0957483725450562" "  0.0126151025578158" "  0.0351717703204036"
## [1] ""
## [1] "(4) LONG PORTFOLIO()"
## [1] "-------------------------------------------------------------------------------------------------------"
## [1] "(tau=40) CLOSE all positions."
## [1] "(1) COMPUTE_P/L(portfolio)"
## [1] "--> Capital:611834.472855305$"
## [1] ""
## [1] "(2) PORTFOLIO_LOOP:"
## [1] "    SECTOR_PROCEDURE(G=Industrials, tau=40)"
## [1] "    SECTOR_PROCEDURE(G=Health Care, tau=40)"
## [1] "    SECTOR_PROCEDURE(G=Information Technology, tau=40)"
## [1] "    SECTOR_PROCEDURE(G=Communication Services, tau=40)"
## [1] "    SECTOR_PROCEDURE(G=Financials, tau=40)"
## [1] "    SECTOR_PROCEDURE(G=Consumer Discretionary, tau=40)"
## [1] "Cur Portfolio:"
##  [1] "CAT"   "UPS"   "FDX"   "ISRG"  "JNJ"   "TMO"   "TXN"   "QCOM"  "AVGO"
## [10] "TMUS"  "NFLX"  "CMCSA" "SPGI"  "BLK"   "MA"    "ORLY"  "SBUX"  "CMG"
## [1] ""
## [1] "(3) OPTIMIZE_PORTFOLIO(portfolio)"
## [1] "weights: "
##  [1] "  0.0303094695586788"  "  0.0122412836360461"  "  0.0674428038206092"
##  [4] "  0.0402519530012877"  "  0.0476384148731142"  "  0.0805385927295175"
##  [7] "  0.0752186602232491"  "  0.0380341786963692"  "  0.0651403661339692"
## [10] "  0.0120063332787184"  "  0.0706824866303914"  "  0.0245223606337135"
## [13] "  0.046105788881648"   "  0.0568265699871789"  "  0.0722038581190812"
## [16] "  0.00592994217777679" "  0.0747431617609067"  "  0.0539789684679886"
## [1] ""
## [1] "(4) LONG PORTFOLIO()"
## [1] "-------------------------------------------------------------------------------------------------------"
## [1] "(tau=41) CLOSE all positions."
## [1] "(1) COMPUTE_P/L(portfolio)"
## [1] "--> Capital:604686.970270249$"
## [1] ""
## [1] "(2) PORTFOLIO_LOOP:"
## [1] "    SECTOR_PROCEDURE(G=Industrials, tau=41)"
## [1] "    SECTOR_PROCEDURE(G=Health Care, tau=41)"
## [1] "    SECTOR_PROCEDURE(G=Information Technology, tau=41)"
## [1] "    SECTOR_PROCEDURE(G=Communication Services, tau=41)"
## [1] "    SECTOR_PROCEDURE(G=Financials, tau=41)"
## [1] "    SECTOR_PROCEDURE(G=Consumer Discretionary, tau=41)"
## [1] "Cur Portfolio:"
##  [1] "NOC"   "UNP"   "FDX"   "ABBV"  "AMGN"  "TMO"   "INTU"  "INTC"  "TXN"
## [10] "CMCSA" "CHTR"  "TTWO"  "JPM"   "SPGI"  "GS"    "AMZN"  "ABNB"  "TSLA"
## [1] ""
## [1] "(3) OPTIMIZE_PORTFOLIO(portfolio)"
## [1] "weights: "
##  [1] "  0.0955659578744881"  "  0.00417813205841569" "  0.121089655450713"
##  [4] "  0.0274448583420321"  "  0.118817936138189"   "  0.0244153750033528"
##  [7] "  0.0759889038060119"  "  0.0844388201746602"  "  0.0903279718223487"
## [10] "  0.0839783003489928"  "  0.109179576479355"   "  0.117236359980297"
## [13] "  0.0845964725787942"  "  0.0686368229001865"  "  0.0263533397183322"
## [16] "  0.119560847049004"   "  0.00390606747850657" "  0.0926850433112673"
## [1] ""
## [1] "(4) LONG PORTFOLIO()"
## [1] "-------------------------------------------------------------------------------------------------------"
## [1] "(tau=42) CLOSE all positions."
## [1] "(1) COMPUTE_P/L(portfolio)"
## [1] "--> Capital:640759.342051899$"
## [1] ""
```

```
## [1] "(2) PORTFOLIO_LOOP:"
## [1] "    SECTOR_PROCEDURE(G=Industrials, tau=42)"
## [1] "    SECTOR_PROCEDURE(G=Health Care, tau=42)"
## [1] "    SECTOR_PROCEDURE(G=Information Technology, tau=42)"
## [1] "    SECTOR_PROCEDURE(G=Communication Services, tau=42)"
## [1] "    SECTOR_PROCEDURE(G=Financials, tau=42)"
## [1] "    SECTOR_PROCEDURE(G=Consumer Discretionary, tau=42)"
## [1] "Cur Portfolio:"
##  [1] "ETN"   "UNP"   "CSX"   "PFE"   "LLY"   "MRK"   "CRM"   "INTC"  "MSFT"
## [10] "VZ"    "META"  "GOOGL" "GS"    "JPM"   "WFC"   "BKNG"  "SBUX"  "NKE"
## [1] ""
## [1] "(3) OPTIMIZE_PORTFOLIO(portfolio)"
## [1] "weights: "
##  [1] "  0.0274550222342823"  "  0.0989021432742348"  "  0.0157408464501053"
##  [4] "  0.0840443414115912"  "  0.052724206897557"   "  0.00379818500271325"
##  [7] "  0.0354213516794121"  "  0.107433387082744"   "  0.060557204522664"
## [10] "  0.0391571880854175"  "  0.0780795879415647"  "  0.00878874988355039"
## [13] "  0.0709917643780976"  "  0.0264213204559821"  "  0.0767015054175895"
## [16] "  0.0659646522259038"  "  0.0913935904188533"  "  0.09203850322035"
## [1] ""
## [1] "(4) LONG PORTFOLIO()"
## [1] "--------------------------------------------------------------------------------------------------------"
## [1] "(tau=43) CLOSE all positions."
## [1] "(1) COMPUTE_P/L(portfolio)"
## [1] "--> Capital:650838.308525663$"
## [1] ""
## [1] "(2) PORTFOLIO_LOOP:"
## [1] "    SECTOR_PROCEDURE(G=Industrials, tau=43)"
## [1] "    SECTOR_PROCEDURE(G=Health Care, tau=43)"
## [1] "    SECTOR_PROCEDURE(G=Information Technology, tau=43)"
## [1] "    SECTOR_PROCEDURE(G=Communication Services, tau=43)"
## [1] "    SECTOR_PROCEDURE(G=Financials, tau=43)"
## [1] "    SECTOR_PROCEDURE(G=Consumer Discretionary, tau=43)"
## [1] "Cur Portfolio:"
##  [1] "UNP"  "NOC"  "RTX"  "ISRG" "MRK"  "AMGN" "AVGO" "TXN"  "IBM"  "T"
## [11] "WBD"  "TMUS" "C"    "SCHW" "V"    "TJX"  "BKNG" "TSLA"
## [1] ""
## [1] "(3) OPTIMIZE_PORTFOLIO(portfolio)"
## [1] "weights: "
##  [1] "  0.017533213258128"  "  0.0811638054109647" "  0.057452377316122"
##  [4] "  0.0640691256023263" "  0.101702024411905"  "  0.0690899000983699"
##  [7] "  0.0646018236939421" "  0.104905312920382"  "  0.0498680767670455"
## [10] "  0.0788914840390343" "  0.0915441854449172" "  0.040242962790402"
## [13] "  0.047361400374025"  "  0.108841574179132"  "  0.0131809146445084"
## [16] "  0.0397044557973701" "  0.0248847924554941" "  0.10233551889249"
## [1] ""
## [1] "(4) LONG PORTFOLIO()"
## [1] "--------------------------------------------------------------------------------------------------------"
## [1] "(tau=44) CLOSE all positions."
## [1] "(1) COMPUTE_P/L(portfolio)"
## [1] "--> Capital:658064.082938334$"
## [1] ""
## [1] "(2) PORTFOLIO_LOOP:"
## [1] "    SECTOR_PROCEDURE(G=Industrials, tau=44)"
## [1] "    SECTOR_PROCEDURE(G=Health Care, tau=44)"
## [1] "    SECTOR_PROCEDURE(G=Information Technology, tau=44)"
## [1] "    SECTOR_PROCEDURE(G=Communication Services, tau=44)"
## [1] "    SECTOR_PROCEDURE(G=Financials, tau=44)"
## [1] "    SECTOR_PROCEDURE(G=Consumer Discretionary, tau=44)"
## [1] "Cur Portfolio:"
```

```
##  [1] "ITW"  "DE"   "FDX"  "MDT"  "PFE"  "DHR"  "IBM"  "INTC" "CRM"  "META"
## [11] "CHTR" "T"    "PGR"  "MA"   "WFC"  "AMZN" "F"    "TSLA"
## [1] ""
## [1] "(3) OPTIMIZE_PORTFOLIO(portfolio)"
## [1] "weights: "
##  [1] "  0.065662403386172"   "  0.0862089394250347"  "  0.0559287184480955"
##  [4] "  0.0749409759071416"  "  0.0828821935164985"  "  0.101268025829695"
##  [7] "  0.039410888118438"   "  0.06550653834333"    "  0.0745839005379038"
## [10] "  0.0690662773280715"  "  0.00743386674781958" "  0.0855020667113137"
## [13] "  0.024846507426334"   "  0.0553484840731869"  "  0.0341925130503701"
## [16] "  0.10601132950678"    "  0.082996436960693"   "  0.040045940157091"
## [1] ""
## [1] "(4) LONG PORTFOLIO()"
## [1] "-------------------------------------------------------------------------------------------------------"
## [1] "(tau=45) CLOSE all positions."
## [1] "(1) COMPUTE_P/L(portfolio)"
## [1] "--> Capital:641878.593602926$"
## [1] ""
## [1] "(2) PORTFOLIO_LOOP:"
## [1] "    SECTOR_PROCEDURE(G=Industrials, tau=45)"
## [1] "    SECTOR_PROCEDURE(G=Health Care, tau=45)"
## [1] "    SECTOR_PROCEDURE(G=Information Technology, tau=45)"
## [1] "    SECTOR_PROCEDURE(G=Communication Services, tau=45)"
## [1] "    SECTOR_PROCEDURE(G=Financials, tau=45)"
## [1] "    SECTOR_PROCEDURE(G=Consumer Discretionary, tau=45)"
## [1] "Cur Portfolio:"
##  [1] "LMT"  "RTX"  "CSX"  "ELV"  "ABT"  "MDT"  "ADBE" "QCOM" "IBM"  "EA"
## [11] "OMC"  "TTWO" "SCHW" "WFC"  "CB"   "HD"   "MCD"  "MAR"
## [1] ""
## [1] "(3) OPTIMIZE_PORTFOLIO(portfolio)"
## [1] "weights: "
##  [1] "  0.0379303649605666"  "  0.0240890494152792"  "  0.0384691362446267"
##  [4] "  0.0610570527881101"  "  0.0484386490777877"  "  0.0561512482772715"
##  [7] "  0.0493264766757432"  "  0.0477729163051554"  "  0.0104505052818369"
## [10] "  0.0245138226272982"  "  0.0918371510681895"  "  0.0167023617086526"
## [13] "  0.0256876325920645"  "  0.0683497582383413"  "  0.0207262455955682"
## [16] "  0.00699600986465368" "  0.0988884692606825"  "  0.0065615034080533"
## [1] ""
## [1] "(4) LONG PORTFOLIO()"
## [1] "-------------------------------------------------------------------------------------------------------"
## [1] "(tau=46) CLOSE all positions."
## [1] "(1) COMPUTE_P/L(portfolio)"
## [1] "--> Capital:649408.336342453$"
## [1] ""
## [1] "(2) PORTFOLIO_LOOP:"
## [1] "    SECTOR_PROCEDURE(G=Industrials, tau=46)"
## [1] "    SECTOR_PROCEDURE(G=Health Care, tau=46)"
## [1] "    SECTOR_PROCEDURE(G=Information Technology, tau=46)"
## [1] "    SECTOR_PROCEDURE(G=Communication Services, tau=46)"
## [1] "    SECTOR_PROCEDURE(G=Financials, tau=46)"
## [1] "    SECTOR_PROCEDURE(G=Consumer Discretionary, tau=46)"
## [1] "Cur Portfolio:"
##  [1] "CAT"   "ITW"   "DE"    "JNJ"   "DHR"   "BMY"   "NVDA"  "AAPL"  "AMD"
## [10] "CMCSA" "NFLX"  "TMUS"  "MS"    "JPM"   "AXP"   "BKNG"  "SBUX"  "TSLA"
## [1] ""
## [1] "(3) OPTIMIZE_PORTFOLIO(portfolio)"
## [1] "weights: "
##  [1] "  0.0639909716453977" "  0.082937674666204"  "  0.0950212135182635"
##  [4] "  0.0670539788146616" "  0.0253063967841017" "  0.0431527590598102"
##  [7] "  0.0705769632951751" "  0.0575378608267136" "  0.0545438200511994"
```

```
## [10] "  0.0926555823109445" "  0.0750216813530508" "  0.0938216644085351"
## [13] "  0.0126466155941058" "  0.0203996643594263" "  0.0871763734779453"
## [16] "  0.0305730154452867" "  0.0103489459444807" "  0.0705278843722359"
## [1] ""
## [1] "(4) LONG PORTFOLIO()"
## [1] "-------------------------------------------------------------------------------------------------------"
## [1] "(tau=47) CLOSE all positions."
## [1] "(1) COMPUTE_P/L(portfolio)"
## [1] "--> Capital:710714.340079547$"
## [1] ""
## [1] "(2) PORTFOLIO_LOOP:"
## [1] "    SECTOR_PROCEDURE(G=Industrials, tau=47)"
## [1] "    SECTOR_PROCEDURE(G=Health Care, tau=47)"
## [1] "    SECTOR_PROCEDURE(G=Information Technology, tau=47)"
## [1] "    SECTOR_PROCEDURE(G=Communication Services, tau=47)"
## [1] "    SECTOR_PROCEDURE(G=Financials, tau=47)"
## [1] "    SECTOR_PROCEDURE(G=Consumer Discretionary, tau=47)"
## [1] "Cur Portfolio:"
##  [1] "DE"    "ETN"   "CSX"   "AMGN"  "UNH"   "JNJ"   "CSCO"  "CRM"   "IBM"
## [10] "T"     "EA"    "GOOGL" "MS"    "SPGI"  "PGR"   "CMG"   "AMZN"  "ORLY"
## [1] ""
## [1] "(3) OPTIMIZE_PORTFOLIO(portfolio)"
## [1] "weights: "
##  [1] "  0.0397020954351938" "  0.0779283603115217" "  0.0373126483883962"
##  [4] "  0.0149057350614967" "  0.0595372665895424" "  0.0607205830890119"
##  [7] "  0.0380324129325287" "  0.0950681385329472" "  0.0482856253141078"
## [10] "  0.103707273878652"  "  0.0107322249304434" "  0.0716053588029575"
## [13] "  0.0527014465046973" "  0.0555380028421184" "  0.0957305014314001"
## [16] "  0.0363886847646334" "  0.039038214813098"  "  0.0738643418392287"
## [1] ""
## [1] "(4) LONG PORTFOLIO()"
## [1] "-------------------------------------------------------------------------------------------------------"
```

SECTOR_PROCEDURE

1. Sector G contains tickers $\{S_1, S_1, \ldots, S_{|G|}\}$, where $|G|$= number of stocks per sector (before selection).
2. For each ticker, want to calculate **current window:**

$$[t_1 = \text{week } W_{s\times\tau} \ , \ t_{12} = \text{week } W_{s\times\tau+11}]$$

e.g. with $s = 1$ (slide one month at the time)

$$\begin{cases} \tau = 1 \implies [t_1 = W_1 \ , \ t_{12} = W_{12}] \\ \tau = 2 \implies [t_1 = W_2 \ , \ t_{12} = W_{13}] \\ \vdots \\ \tau = i \implies [t_1 = W_i \ , \ t_{12} = W_{i+11}] \\ \vdots \\ \tau = 48 \implies [t_1 = W_{48} \ , \ t_{12} = W_{59}] \end{cases}$$

EXTRACT_STATIC_FEATURES()

We had a set of features for some stock:

```
# sample stock dataframe
sample_xts <- sp500_stocks$Industrials$ADP
head(sample_xts, 5)
```

```
##            direction_lead realized_returns actual_returns adjclose_lag1
## 2018-01-03              1      0.003405679             NA            NA
## 2018-01-10              1      0.036716874    0.003405679            NA
## 2018-01-17             -1     -0.009798086    0.036716874   0.003405679
## 2018-01-24              1      0.022660365   -0.009798086   0.036716874
## 2018-01-31             -1     -0.084962139    0.022660365  -0.009798086
##            adjclose_lag2 adjclose_lag3 atr adx aaron bb chaikin_vol clv emv
## 2018-01-03            NA            NA  NA  NA    NA NA          NA  NA  NA
## 2018-01-10            NA            NA  NA  NA    50 NA          NA  NA  NA
## 2018-01-17            NA            NA  NA  NA   100 NA          NA  NA  NA
## 2018-01-24   0.003405679            NA  NA  NA   100 NA          NA  NA  NA
## 2018-01-31   0.036716874   0.003405679  NA  NA   100 NA          NA  NA  NA
##            macd mfi      sar smi volat month_index
## 2018-01-03   NA  NA 115.3586  NA    NA           1
## 2018-01-10   NA  NA 115.4054  NA    NA           1
## 2018-01-17   NA  NA 115.5252  NA    NA           1
## 2018-01-24   NA  NA 115.9245  NA    NA           1
## 2018-01-31   NA  NA 116.4665  NA    NA           1
```

```
# source the feature engineering file
library("here")
source(here("functions", "feature_engineering.R"))

# test out for a sample run
tau = 3 # run number 3
sample_xts_train_val <- f_extract_train_val_features(sample_xts, # stock xts
                                                     tau=tau, # current run
                                                     n_months = N_window, # size of window
                                                     val_lag = 1 # validation month
                                                     )

# display some columns for the extracted data
head(sample_xts_train_val$train[,c("direction_lead", "clv", "volat", "month_index")])
```

```
##            direction_lead         clv     volat month_index
## 2018-03-07              1  0.09611807 0.2378317           3
## 2018-03-14              1 -0.01263276 0.2396534           3
## 2018-03-21             -1  0.01666702 0.2438210           3
## 2018-03-28              1 -0.07869991 0.2438491           3
## 2018-04-04             -1  0.09133686 0.2588964           4
## 2018-04-11              1  0.17369444 0.2347659           4
```

```
print("")
```

```
## [1] ""
```

```
head(sample_xts_train_val$val[,c("direction_lead", "clv", "volat", "month_index")])
```

```
##            direction_lead       clv     volat month_index
## 2019-01-02              1 0.1343496 0.3075128          13
## 2019-01-09              1 0.2247946 0.2944110          13
## 2019-01-16              1 0.1977441 0.2686413          13
## 2019-01-23              1 0.3050403 0.2661614          13
## 2019-01-30              1 0.3445775 0.2928734          13
## 2019-02-06              1 0.3295154 0.2836786          14
```

```r
# show how the train and validation set look together
rbind(sample_xts_train_val$train[,c("direction_lead", "clv", "volat", "month_index")],
      sample_xts_train_val$val[,c("direction_lead", "clv", "volat", "month_index")])
```

```
##            direction_lead         clv     volat month_index
## 2018-03-07              1  0.09611807 0.2378317           3
## 2018-03-14              1 -0.01263276 0.2396534           3
## 2018-03-21             -1  0.01666702 0.2438210           3
## 2018-03-28              1 -0.07869991 0.2438491           3
## 2018-04-04             -1  0.09133686 0.2588964           4
## 2018-04-11              1  0.17369444 0.2347659           4
## 2018-04-18             -1  0.14485520 0.2102715           4
## 2018-04-25              1  0.27162722 0.1961045           4
## 2018-05-02              1  0.21488924 0.2072958           5
## 2018-05-09              1  0.20153923 0.2096722           5
## 2018-05-16              1  0.22325723 0.2071152           5
## 2018-05-23              1  0.35647310 0.2009671           5
## 2018-05-30              1  0.18500844 0.1984168           5
## 2018-06-06              1  0.29731426 0.1955207           6
## 2018-06-13             -1  0.33611598 0.1803464           6
## 2018-06-20             -1  0.11443629 0.1788406           6
## 2018-06-27              1 -0.07351575 0.1828804           6
## 2018-07-11              1 -0.01152440 0.1822324           7
## 2018-07-18              1  0.03784545 0.1499739           7
## 2018-07-25             -1  0.18316399 0.1467714           7
## 2018-08-01              1  0.28834410 0.1667054           8
## 2018-08-08              1  0.26152964 0.1653636           8
## 2018-08-15              1  0.31924260 0.1662480           8
## 2018-08-22              1  0.35350756 0.1629357           8
## 2018-08-29             -1  0.42834871 0.1629302           8
## 2018-09-05              1  0.50100406 0.1650939           9
## 2018-09-12              1  0.47690236 0.1513876           9
## 2018-09-19              1  0.31486842 0.1481179           9
## 2018-09-26              1  0.20393883 0.1538378           9
## 2018-10-03             -1  0.02693449 0.1561483          10
## 2018-10-10              1 -0.15119139 0.1754848          10
## 2018-10-17             -1 -0.02365831 0.1796058          10
## 2018-10-24              1 -0.17714401 0.2041302          10
## 2018-10-31              1 -0.06240819 0.2396180          10
## 2018-11-07             -1  0.11508357 0.2410186          11
## 2018-11-14             -1 -0.06719844 0.2469845          11
## 2018-11-21              1 -0.05040641 0.2588357          11
## 2018-11-28             -1  0.13484063 0.2620686          11
## 2018-12-12             -1 -0.05777075 0.2618763          12
## 2018-12-19             -1 -0.12734963 0.2948417          12
## 2018-12-26              1  0.07306322 0.3069959          12
## 2019-01-02              1  0.13434960 0.3075128          13
## 2019-01-09              1  0.22479459 0.2944110          13
## 2019-01-16              1  0.19774412 0.2686413          13
## 2019-01-23              1  0.30504032 0.2661614          13
## 2019-01-30              1  0.34457750 0.2928734          13
## 2019-02-06              1  0.32951542 0.2836786          14
## 2019-02-13              1  0.22975413 0.2810487          14
## 2019-02-20              1  0.32580808 0.2785103          14
## 2019-02-27             -1  0.36061402 0.2407584          14
```

EXTRACT_DYNAMIC_FEATURES

```
# add GARCH features only
sample_xts_with_garch <- f_add_garch_forecast(sample_xts, volat_col="volat")

# display
tail(sample_xts_with_garch, 3)
```

```
##            direction_lead realized_returns actual_returns adjclose_lag1
## 2022-11-16              1      0.034718645    0.053615962    0.01230611
## 2022-11-23              1      0.005923518    0.034718645    0.05361596
## 2022-11-30             NA               NA    0.005923518    0.03471865
##            adjclose_lag2 adjclose_lag3      atr      adx aaron        bb
## 2022-11-16   0.009733847   0.008113141 10.23247 14.68326   100 0.8325740
## 2022-11-23   0.012306105   0.009733847 10.24301 15.95273   100 0.9310325
## 2022-11-30   0.053615962   0.012306105 10.24779 16.53998   100 0.8907336
##            chaikin_vol        clv       emv     macd      mfi    sar       smi
## 2022-11-16  -0.3839710 -0.4461119 0.0907485 1.906715 48.83463 256.72  6.291102
## 2022-11-23  -0.2018052 -0.3205142 0.1175853 2.068291 49.31528 224.11 11.099826
## 2022-11-30   0.4839489 -0.1089895 0.1214467 2.300754 42.97382 224.11 16.713518
##                volat month_index vol_forecast
## 2022-11-16 0.2641173          59    0.2676915
## 2022-11-23 0.2624611          59    0.2702396
## 2022-11-30 0.2759187          59    0.2727449
```

```
# Example usage
sample_xts_with_arima <- f_add_arima_forecast(sample_xts_with_garch,
                                              return_col="realized_returns")
tail(sample_xts_with_arima)
```

```
##            direction_lead realized_returns actual_returns adjclose_lag1
## 2022-10-26              1      0.009733847    0.008113141   0.039930970
## 2022-11-02              1      0.012306105    0.009733847   0.008113141
## 2022-11-09              1      0.053615962    0.012306105   0.009733847
## 2022-11-16              1      0.034718645    0.053615962   0.012306105
## 2022-11-23              1      0.005923518    0.034718645   0.053615962
## 2022-11-30             NA               NA    0.005923518   0.034718645
##            adjclose_lag2 adjclose_lag3       atr      adx aaron        bb
## 2022-10-26  -0.064535730   0.030150913  9.676399 13.39493   100 0.6110784
## 2022-11-02   0.039930970  -0.064535730  9.885942 13.58997   100 0.6303335
## 2022-11-09   0.008113141   0.039930970  9.762661 13.77107    50 0.6307783
## 2022-11-16   0.009733847   0.008113141 10.232471 14.68326   100 0.8325740
## 2022-11-23   0.012306105   0.009733847 10.243009 15.95273   100 0.9310325
## 2022-11-30   0.053615962   0.012306105 10.247795 16.53998   100 0.8907336
##            chaikin_vol        clv         emv     macd      mfi      sar
## 2022-10-26 -1.49750300 -0.1320576 -0.01707202 2.049576 51.52422 260.0428
## 2022-11-02  2.90314600 -0.2863719  0.02711271 1.939312 49.23300 258.6055
## 2022-11-09 -0.09676625 -0.3920529  0.04765004 1.866926 49.20839 257.2257
## 2022-11-16 -0.38397100 -0.4461119  0.09074850 1.906715 48.83463 256.7200
## 2022-11-23 -0.20180520 -0.3205142  0.11758529 2.068291 49.31528 224.1100
## 2022-11-30  0.48394890 -0.1089895  0.12144667 2.300754 42.97382 224.1100
##                 smi     volat month_index vol_forecast arima_100_001
## 2022-10-26  8.131402 0.2269538          58    0.2624611   0.006232441
## 2022-11-02  5.546375 0.2606250          59    0.2759187   0.003807869
## 2022-11-09  3.943959 0.2653165          59    0.2650991   0.003629730
## 2022-11-16  6.291102 0.2641173          59    0.2676915   0.003614731
## 2022-11-23 11.099826 0.2624611          59    0.2702396   0.003613468
## 2022-11-30 16.713518 0.2759187          59    0.2727449   0.003613362
```

```
##            arima_010_001 arima_110_001 arima_020_001 arima_120_001
## 2022-10-26   0.034718645    0.04298263    0.01582133    0.05385412
## 2022-11-02   0.005923517    0.01851591   -0.02287161   -0.01661918
## 2022-11-09   0.005923517    0.01300913   -0.05166674   -0.04311152
## 2022-11-16   0.005923517    0.01541730   -0.08046187   -0.06710888
## 2022-11-23   0.005923517    0.01436418   -0.10925699   -0.09268232
## 2022-11-30   0.005923517    0.01482472   -0.13805212   -0.11726015
##            arima_100_011 arima_010_011 arima_110_011 arima_020_011
## 2022-10-26   0.006232441   0.034718645    0.04298263    0.01582133
## 2022-11-02   0.003807869   0.005923517    0.01851591   -0.02287161
## 2022-11-09   0.003629730   0.005923517    0.01300913   -0.05166674
## 2022-11-16   0.003614731   0.005923517    0.01541730   -0.08046187
## 2022-11-23   0.003613468   0.005923517    0.01436418   -0.10925699
## 2022-11-30   0.003613362   0.005923517    0.01482472   -0.13805212
##            arima_120_011
## 2022-10-26    0.05385412
## 2022-11-02   -0.01661918
## 2022-11-09   -0.04311152
## 2022-11-16   -0.06710888
## 2022-11-23   -0.09268232
## 2022-11-30   -0.11726015
```

```
sample_xts_with_arima[, c("actual_returns", "vol_forecast")]
```

```
##            actual_returns vol_forecast
## 2018-01-03             NA           NA
## 2018-01-10    0.003405679           NA
## 2018-01-17    0.036716874           NA
## 2018-01-24   -0.009798086           NA
## 2018-01-31    0.022660365           NA
## 2018-02-07   -0.084962139    0.2378317
## 2018-02-14   -0.007512988    0.2396534
## 2018-02-21    0.029633804    0.2438210
## 2018-02-28   -0.006741056    0.2438491
## 2018-03-07   -0.001214733    0.2588964
##        ...
## 2022-09-28    0.006618137    0.2269538
## 2022-10-05    0.030150913    0.2606250
## 2022-10-12   -0.064535730    0.2653165
## 2022-10-19    0.039930970    0.2641173
## 2022-10-26    0.008113141    0.2624611
## 2022-11-02    0.009733847    0.2759187
## 2022-11-09    0.012306105    0.2650991
## 2022-11-16    0.053615962    0.2676915
## 2022-11-23    0.034718645    0.2702396
## 2022-11-30    0.005923518    0.2727449
```

```
# Example usage
sample_xts_full <- f_extract_dynamic_features(sample_xts_with_garch,
                                              return_col="realized_returns")
tail(sample_xts_full)
```

```
##            direction_lead realized_returns actual_returns adjclose_lag1
## 2022-10-26              1      0.009733847    0.008113141   0.039930970
## 2022-11-02              1      0.012306105    0.009733847   0.008113141
## 2022-11-09              1      0.053615962    0.012306105   0.009733847
## 2022-11-16              1      0.034718645    0.053615962   0.012306105
## 2022-11-23              1      0.005923518    0.034718645   0.053615962
## 2022-11-30             NA               NA    0.005923518   0.034718645
```

```
##            adjclose_lag2 adjclose_lag3       atr      adx aaron        bb
## 2022-10-26  -0.064535730   0.030150913  9.676399 13.39493   100 0.6110784
## 2022-11-02   0.039930970  -0.064535730  9.885942 13.58997   100 0.6303335
## 2022-11-09   0.008113141   0.039930970  9.762661 13.77107    50 0.6307783
## 2022-11-16   0.009733847   0.008113141 10.232471 14.68326   100 0.8325740
## 2022-11-23   0.012306105   0.009733847 10.243009 15.95273   100 0.9310325
## 2022-11-30   0.053615962   0.012306105 10.247795 16.53998   100 0.8907336
##            chaikin_vol        clv         emv     macd      mfi      sar
## 2022-10-26 -1.49750300 -0.1320576 -0.01707202 2.049576 51.52422 260.0428
## 2022-11-02  2.90314600 -0.2863719  0.02711271 1.939312 49.23300 258.6055
## 2022-11-09 -0.09676625 -0.3920529  0.04765004 1.866926 49.20839 257.2257
## 2022-11-16 -0.38397100 -0.4461119  0.09074850 1.906715 48.83463 256.7200
## 2022-11-23 -0.20180520 -0.3205142  0.11758529 2.068291 49.31528 224.1100
## 2022-11-30  0.48394890 -0.1089895  0.12144667 2.300754 42.97382 224.1100
##                  smi     volat month_index vol_forecast arima_100_001
## 2022-10-26  8.131402 0.2269538          58    0.2624611   0.006232441
## 2022-11-02  5.546375 0.2606250          59    0.2759187   0.003807869
## 2022-11-09  3.943959 0.2653165          59    0.2650991   0.003629730
## 2022-11-16  6.291102 0.2641173          59    0.2676915   0.003614731
## 2022-11-23 11.099826 0.2624611          59    0.2702396   0.003613468
## 2022-11-30 16.713518 0.2759187          59    0.2727449   0.003613362
##            arima_010_001 arima_110_001 arima_020_001 arima_120_001
## 2022-10-26   0.034718645    0.04298263    0.01582133    0.05385412
## 2022-11-02   0.005923517    0.01851591   -0.02287161   -0.01661918
## 2022-11-09   0.005923517    0.01300913   -0.05166674   -0.04311152
## 2022-11-16   0.005923517    0.01541730   -0.08046187   -0.06710888
## 2022-11-23   0.005923517    0.01436418   -0.10925699   -0.09268232
## 2022-11-30   0.005923517    0.01482472   -0.13805212   -0.11726015
##            arima_100_011 arima_010_011 arima_110_011 arima_020_011
## 2022-10-26   0.006232441   0.034718645    0.04298263    0.01582133
## 2022-11-02   0.003807869   0.005923517    0.01851591   -0.02287161
## 2022-11-09   0.003629730   0.005923517    0.01300913   -0.05166674
## 2022-11-16   0.003614731   0.005923517    0.01541730   -0.08046187
## 2022-11-23   0.003613468   0.005923517    0.01436418   -0.10925699
## 2022-11-30   0.003613362   0.005923517    0.01482472   -0.13805212
##            arima_120_011
## 2022-10-26    0.05385412
## 2022-11-02   -0.01661918
## 2022-11-09   -0.04311152
## 2022-11-16   -0.06710888
## 2022-11-23   -0.09268232
## 2022-11-30   -0.11726015
```

SECTOR PROCEDURE

```
SECTOR_PROCEDURE <- function(G, tau){
  ##
  ## Params:
  ##  - G (str): Economic sector name; will be used to fetch the  List of lists
  ## which are the pre-selected stocks for that sector.
  ##  - tau (numeric): Integer that corresponds to the actual run of the backtest.
  ##

  print(paste0("SECTOR_PROCEDURE(G=", G, ", tau=",tau, ")"))

  # retrieve sector data
  sector_data <- sp500_stocks[[G]]
```

```r
  # stocks for sector provided
  sector_tickers <- names(sector_data)

  # to store subset features for window
  sector_stocks_window <- rep(NA, length(sector_tickers))
  names(sector_stocks_window) <- sector_tickers

  # extract static train-val for all stocks
  list_train_val_sector <- lapply(sector_data,
                                  f_extract_train_val_features,
                                  tau=tau, # current run
                                  n_months = 12, # size of window
                                  val_lag = 2 # months to use in val set
                                  )

  # return top 3 best stocks according to modelling procedure
  print("  MODELLING_PROCEDURE(list_train_val_sector)")
  top_sector_stocks <- sample(names(sp500_stocks[[G]]), 3 )

  ########## Inside MODELLING_PROCEDURE ########################

  # Stack the train and val splitted data for all stocks in sector
  sector_stocks <- lapply(list_train_val_sector, function(stock) {
    # Concatenate 'train' and 'val' xts objects within each stock
    concatenated_xts <- rbind(stock$train, stock$val)
    return(concatenated_xts)
  })

  # NOTE: MODELLLING_PROCEDURE should also compute dynamic features for concatenated data
  sector_stocks <- lapply(sector_stocks, f_extract_dynamic_features)

  # should return the train-val list for the chosen stocks
  chosen_stocks <- sector_stocks[names(sector_stocks) %in% top_sector_stocks]

  ########## Inside MODELLING_PROCEDURE ########################

  return(chosen_stocks) # not actual return value!
}

# peform the sector procedure
G = names(sp500_stocks)[[1]]
tau = 5
sector_stocks_window <- SECTOR_PROCEDURE(G, tau)
```

```
## [1] "SECTOR_PROCEDURE(G=Industrials, tau=5)"
## [1] "  MODELLING_PROCEDURE(list_train_val_sector)"
```

```r
names(sector_stocks_window) # names are tickers, values are list of train-val xts
```

```
## [1] "ADP" "ETN" "UPS"
```

```r
head(sector_stocks_window[[2]]) # names are train and val, value for each are xts
```

```
##            direction_lead realized_returns actual_returns adjclose_lag1
## 2018-05-02              1       0.04736349    -0.05230192   -0.03155747
## 2018-05-09              1       0.02183229     0.04736349   -0.05230192
## 2018-05-16              1       0.02136570     0.02183229    0.04736349
```

```
## 2018-05-23             -1      -0.01389310     0.02136570    0.02183229
## 2018-05-30              1       0.02996611    -0.01389310    0.02136570
## 2018-06-06             -1      -0.00286930     0.02996611   -0.01389310
##            adjclose_lag2 adjclose_lag3      atr adx aaron        bb chaikin_vol
## 2018-05-02    0.02583949   -0.01810666 2.323740  NA  -100        NA          NA
## 2018-05-09   -0.03155747    0.02583949 2.364902  NA   -50        NA          NA
## 2018-05-16   -0.05230192   -0.03155747 2.355265  NA   100 0.2701690          NA
## 2018-05-23    0.04736349   -0.05230192 2.313461  NA   100 0.4039530   0.5836027
## 2018-05-30    0.02183229    0.04736349 2.285356  NA    50 0.3340777  -0.1086513
## 2018-06-06    0.02136570    0.02183229 2.291402  NA    50 0.5254195  -0.1363018
##                    clv           emv macd      mfi      sar smi     volat
## 2018-05-02 0.09068298 -0.0051825174   NA 10.90546 81.40469  NA 0.1954454
## 2018-05-09 0.23419606 -0.0033052082   NA 15.44633 80.03114  NA 0.1914451
## 2018-05-16 0.21434277 -0.0023958014   NA 22.31797 78.87735  NA 0.1928687
## 2018-05-23 0.31173543 -0.0023410497   NA 29.97705 72.82000  NA 0.1890839
## 2018-05-30 0.34033505 -0.0020221158   NA 30.61978 72.82000  NA 0.1883994
## 2018-06-06 0.46027413  0.0005728134   NA 38.68716 73.07120  NA 0.1895387
##            month_index arima_100_001 arima_010_001 arima_110_001 arima_020_001
## 2018-05-02           5  0.0011061170  -0.013893098   0.001875736   -0.04915189
## 2018-05-09           5  0.0053497849   0.029966113   0.010350906    0.07382532
## 2018-05-16           5  0.0021727421  -0.002869300   0.011815720   -0.03570471
## 2018-05-23           5 -0.0001342210  -0.026712255  -0.016048942   -0.05055521
## 2018-05-30           5 -0.0009351733  -0.034990267  -0.031288082   -0.04326828
## 2018-06-06           6  0.0030910537   0.006621646  -0.011988499    0.04823356
##            arima_120_001 arima_100_011 arima_010_011 arima_110_011
## 2018-05-02   -0.02776650  0.0011061170  -0.013893098   0.001875736
## 2018-05-09    0.02519461  0.0053497849   0.029966113   0.010350906
## 2018-05-16    0.01143644  0.0021727421  -0.002869300   0.011815720
## 2018-05-23   -0.05608252 -0.0001342210  -0.026712255  -0.016048942
## 2018-05-30   -0.05283543 -0.0009351733  -0.034990267  -0.031288082
## 2018-06-06    0.01756820  0.0030910537   0.006621646  -0.011988499
##            arima_020_011 arima_120_011 vol_forecast
## 2018-05-02   -0.04915189   -0.02776650    0.1883994
## 2018-05-09    0.07382532    0.02519461    0.1895387
## 2018-05-16   -0.03570471    0.01143644    0.1729633
## 2018-05-23   -0.05055521   -0.05608252    0.1722953
## 2018-05-30   -0.04326828   -0.05283543    0.1794626
## 2018-06-06    0.04823356    0.01756820    0.1670667
```

Aside: Format for Portfolio Optimization

```
## This chunk of code simply obtains some portfolio stock tickers
## in a way that will be similar to the final result

# repack the portfolio (repeated from before)
portfolio <- list(tickers = initial_tickers,
                  weights = weights,
                  capital = initial_capital,
                  returns = returns,
                  data = NA
                  )
portfolio
```

```
## $tickers
##  [1] NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA
##
## $weights
##  [1] 0.05555556 0.05555556 0.05555556 0.05555556 0.05555556 0.05555556
```

```
##  [7] 0.05555556 0.05555556 0.05555556 0.05555556 0.05555556 0.05555556
## [13] 0.05555556 0.05555556 0.05555556 0.05555556 0.05555556 0.05555556
##
## $capital
## [1] 5e+05
##
## $returns
##  [1] NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA
## [26] NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA
##
## $data
## [1] NA
```

The following simulates best tickers that would be obtained after modelling procedure for all sectors

```
# Set up backtesting simulation parameters
sample_xts <- sp500_stocks$Industrials$ADP
sectors <- names(sp500_stocks)
N_sector_best_stocks <- 3
tau <- 3

# store ticker for current portfolio
cur_tickers <- rep(NA, num_tickers)

# store actual data for each run
portf_stocks_data <- as.list(rep(NA, length(sectors)))
names(portf_stocks_data) <- sectors

# keep index counter for sectors yfu,uyfyu
i_sector <- 1

print("")
```

```
## [1] ""
```

```
print("(2) PORTFOLIO_LOOP:")
```

```
## [1] "(2) PORTFOLIO_LOOP:"
```

```
# loop through all the sectors
for(G in sectors){

  # return top 3 best stocks (xts data) according to procedure
  top_sector_stocks <- SECTOR_PROCEDURE(G, tau)

  # assign best stocks to portfolio (NEED TO UPDATE LOGIC!)
  i_replace <- c(i_sector, i_sector+1, i_sector+2)
  cur_tickers[i_replace] <- names(top_sector_stocks)
  i_sector <- i_sector + 3

  # assign the data to the portfolio
  portf_stocks_data[[G]] <- top_sector_stocks
}
```

```
## [1] "SECTOR_PROCEDURE(G=Industrials, tau=3)"
## [1] "  MODELLING_PROCEDURE(list_train_val_sector)"
## [1] "SECTOR_PROCEDURE(G=Health Care, tau=3)"
## [1] "  MODELLING_PROCEDURE(list_train_val_sector)"
```

```
## [1] "SECTOR_PROCEDURE(G=Information Technology, tau=3)"
## [1] "  MODELLING_PROCEDURE(list_train_val_sector)"
## [1] "SECTOR_PROCEDURE(G=Communication Services, tau=3)"
## [1] "  MODELLING_PROCEDURE(list_train_val_sector)"
## [1] "SECTOR_PROCEDURE(G=Financials, tau=3)"
## [1] "  MODELLING_PROCEDURE(list_train_val_sector)"
## [1] "SECTOR_PROCEDURE(G=Consumer Discretionary, tau=3)"
## [1] "  MODELLING_PROCEDURE(list_train_val_sector)"
```

```
# Portfolio tickers get updated
portfolio$tickers <- cur_tickers
```

```
# unlist data best stocks data format into a singles list
portf_data <- f_unlist_portf_data(portf_stocks_data)

# assign list to portfolio
portfolio$data <- portf_data
```

Data format for portfoli optimization

Note that at this point, the portfolio will have the tickers and the weights attributes.

```
# Checko out the resulting portfolio
portfolio$tickers
```

```
##  [1] "GE"   "NOC"  "UNP"  "ABT"  "BMY"  "MDT"  "CSCO" "INTU" "MSFT" "ATVI"
## [11] "DIS"  "GOOG" "GS"   "SCHW" "WFC"  "AMZN" "MCD"  "TJX"
```

```
portfolio$capital
```

```
## [1] 5e+05
```

```
portfolio$returns
```

```
##  [1] NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA
## [26] NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA
```

```
print("")
```

```
## [1] ""
```

```
# inspect the names and data for one stock
names(portfolio$data)
```

```
##  [1] "GE"   "NOC"  "UNP"  "ABT"  "BMY"  "MDT"  "CSCO" "INTU" "MSFT" "ATVI"
## [11] "DIS"  "GOOG" "GS"   "SCHW" "WFC"  "AMZN" "MCD"  "TJX"
```

```
head(portfolio$data[[1]])
```

```
##            direction_lead realized_returns actual_returns adjclose_lag1
## 2018-03-07             -1      -0.01667881     0.02795409   -0.01833302
## 2018-03-14             -1      -0.02771053    -0.01667881    0.02795409
## 2018-03-21             -1      -0.01451403    -0.02771053   -0.01667881
## 2018-03-28             -1      -0.02967535    -0.01451403   -0.02771053
```

```
## 2018-04-04             -1      -0.02362030    -0.02967535   -0.01451403
## 2018-04-11              1       0.05183274    -0.02362030   -0.02967535
##            adjclose_lag2 adjclose_lag3      atr adx aaron bb chaikin_vol
## 2018-03-07   -0.02790249   -0.02321811       NA  NA   -50 NA          NA
## 2018-03-14   -0.01833302   -0.02790249       NA  NA     0 NA          NA
## 2018-03-21    0.02795409   -0.01833302       NA  NA   -50 NA          NA
## 2018-03-28   -0.01667881    0.02795409       NA  NA  -100 NA          NA
## 2018-04-04   -0.02771053   -0.01667881       NA  NA  -100 NA          NA
## 2018-04-11   -0.01451403   -0.02771053 4.443644  NA   -50 NA          NA
##                     clv          emv macd      mfi       sar smi     volat
## 2018-03-07 -0.24260438 -0.003245361   NA       NA 103.30003  NA 0.3038732
## 2018-03-14 -0.34914294 -0.004091888   NA       NA 100.70015  NA 0.3084621
## 2018-03-21 -0.17843706 -0.004271745   NA       NA  98.46425  NA 0.3128322
## 2018-03-28 -0.07834066 -0.003556861   NA       NA  96.04571  NA 0.3792407
## 2018-04-04  0.10346064 -0.003983976   NA       NA  93.54401  NA 0.3251574
## 2018-04-11  0.09255501 -0.003435409   NA 13.61963  90.78428  NA 0.3258117
##            month_index arima_100_001 arima_010_001 arima_110_001 arima_020_001
## 2018-03-07           3  -0.005062004  -0.029675350  -0.019436944  -0.044836667
## 2018-03-14           3  -0.005801960  -0.023620298  -0.027709262  -0.017565246
## 2018-03-21           3  -0.015022683   0.051832736   0.000879458   0.127285769
## 2018-03-28           3  -0.012128634   0.028150777   0.044143155   0.004468819
## 2018-04-04           4  -0.009813986   0.009210046   0.022000683  -0.009730686
## 2018-04-11           4  -0.012422808   0.030557994   0.016141769   0.051905942
##            arima_120_001 arima_100_011 arima_010_011 arima_110_011
## 2018-03-07   -0.02363373  -0.005062004  -0.029675350  -0.019436944
## 2018-03-14   -0.03342857  -0.005801960  -0.023620298  -0.027709262
## 2018-03-21    0.07539739  -0.015022683   0.051832736   0.000879458
## 2018-03-28    0.07859135  -0.012128634   0.028150777   0.044143155
## 2018-04-04   -0.01327567  -0.009813986   0.009210046   0.022000683
## 2018-04-11    0.02178238  -0.012422808   0.030557994   0.016141769
##            arima_020_011 arima_120_011 vol_forecast
## 2018-03-07  -0.044836667   -0.02363373    0.3251574
## 2018-03-14  -0.017565246   -0.03342857    0.3258117
## 2018-03-21   0.127285769    0.07539739    0.3254401
## 2018-03-28   0.004468819    0.07859135    0.3461264
## 2018-04-04  -0.009730686   -0.01327567    0.3503608
## 2018-04-11   0.051905942    0.02178238    0.3495487
```