

# Portfolio Performance

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```
# library(alphavantage)
# alphavantage_key <- "SOOVBPKYDOQUGMSF"
# av_api_key(alphavantage_key)
```

## Section 1 Load Data from Alphavantage

```
# fetch_stock_data <- function(symbol) {
#   tryCatch({
#     df <- av_get(symbol, av_fun = "TIME_SERIES_DAILY")
#     df <- df %>%
#       slice(1:100)
#     return(df)
#   }, error = function(e) {
#     # If there's an error, print a message and return NULL
#     stop(paste0("Error fetching data for ", symbol, ": ", e$message))
#   })
# }
#
# stocks <- c("GS", "PG", "MRK", "LRCX", "SPY")
# # GS: Goldman Sachs
# # PG: Procter Gamble
# # MRK: Merck
# # LRCX: Lam's Research Lab
#
# stock_data_list <- lapply(stocks, fetch_stock_data)
```

## Section 2 Save in .rds format in Local Directory

```
# # Save the data into the /data directory as .rds files
# dir.create("./data", recursive = TRUE, showWarnings = FALSE) # Create directory if not exists
# for (i in seq_along(stocks)) {
#   if (!is.null(stock_data_list[[i]])) {
#     saveRDS(stock_data_list[[i]], file = paste0("./data/", stocks[i], ".rds"))
#   } else {
#     message(paste("No data to save for", stocks[i]))
#   }
# }
# }
```

## Section 3 Load Data from Local Directory

```
load_stock_data <- function(symbol) {  
  file_path <- paste0("./data/", symbol, ".rds")  
  readRDS(file_path)  
}  
  
# Load all the stock data from the saved files  
GS_data <- load_stock_data("GS")  
PG_data <- load_stock_data("PG")  
MRK_data <- load_stock_data("MRK")  
LRCX_data <- load_stock_data("LRCX")  
SPY_data <- load_stock_data("SPY")
```

## Section 4 Design the Portfolio

```
total_cash <- 1e6  
cash_reserve <- 0.05 * total_cash  
investable_cash <- total_cash - cash_reserve  
  
# Get the closing price on day 1 for each stock  
get_first_day_close <- function(stock_data) {  
  return(as.numeric(stock_data$close[1]))  
}  
  
# Closing prices for the 4 stocks  
first_day_prices <- c(  
  GS = get_first_day_close(GS_data),  
  PG = get_first_day_close(PG_data),  
  MRK = get_first_day_close(MRK_data),  
  LRCX = get_first_day_close(LRCX_data)  
)  
  
equal_allocation_amount <- investable_cash / 4  
shares_to_buy <- floor(equal_allocation_amount / first_day_prices)  
  
cat("Actual total investment amount:\n", sum(shares_to_buy*first_day_prices), "\n")  
## Actual total investment amount:  
## 949064.3  
cat("Portfolio:\n")  
## Portfolio:  
shares_to_buy  
## GS PG MRK LRCX  
## 504 1410 1816 246  
cat("First Day Close Prices:\n")  
## First Day Close Prices:  
first_day_prices  
## GS PG MRK LRCX  
## 470.41 168.35 130.76 964.00
```

## Section 5 Performance Report

### 5.1 Numerical Indexes

```

stock_data_list <- list(GS_data,PG_data,MRK_data,LRCX_data,SPY_data)
stocks <- c("GS", "PG", "MRK", "LRCX", "SPY")

valuation_df <- data.frame(timestamp = GS_data$timestamp)

# Calculate daily valuation and returns
for (i in seq_along(stocks)) {
  # Calculate daily valuation for each stock
  if(stocks[i]!='SPY'){
    stock_prices <- stock_data_list[[i]]$close
    valuation_df[paste(stocks[i], "valuation", sep = "_")] <- shares_to_buy[i] * stock_prices
  }
}
valuation_df

```

|       | timestamp  | GS_valuation | PG_valuation | MRK_valuation | LRCX_valuation |
|-------|------------|--------------|--------------|---------------|----------------|
| ## 1  | 2024-05-21 | 237086.6     | 237373.5     | 237460.2      | 237144.00      |
| ## 2  | 2024-05-22 | 233039.5     | 236612.1     | 238077.6      | 237579.42      |
| ## 3  | 2024-05-23 | 230907.6     | 233340.9     | 238059.4      | 235699.98      |
| ## 4  | 2024-05-24 | 232434.7     | 233115.3     | 235153.8      | 238760.22      |
| ## 5  | 2024-05-28 | 231744.2     | 229985.1     | 228979.4      | 238929.96      |
| ## 6  | 2024-05-29 | 230413.7     | 227926.5     | 228634.4      | 234497.04      |
| ## 7  | 2024-05-30 | 226915.9     | 229237.8     | 226146.5      | 233872.20      |
| ## 8  | 2024-05-31 | 230086.1     | 232001.4     | 227980.6      | 229380.24      |
| ## 9  | 2024-06-03 | 229309.9     | 232156.5     | 233210.7      | 230164.98      |
| ## 10 | 2024-06-04 | 229471.2     | 235484.1     | 233737.4      | 226991.58      |
| ## 11 | 2024-06-05 | 232686.7     | 234130.5     | 235081.2      | 239043.12      |
| ## 12 | 2024-06-06 | 230882.4     | 237542.7     | 237024.3      | 236698.74      |
| ## 13 | 2024-06-07 | 229274.6     | 235554.6     | 237296.7      | 236829.12      |
| ## 14 | 2024-06-10 | 228589.2     | 235963.5     | 238785.8      | 246755.22      |
| ## 15 | 2024-06-11 | 223912.1     | 236146.8     | 239421.4      | 245938.50      |
| ## 16 | 2024-06-12 | 226144.8     | 232903.8     | 236443.2      | 255256.98      |
| ## 17 | 2024-06-13 | 224960.4     | 234638.1     | 234935.9      | 255471.00      |
| ## 18 | 2024-06-14 | 225015.8     | 235173.9     | 235135.7      | 254851.08      |
| ## 19 | 2024-06-17 | 226890.7     | 236175.0     | 231540.0      | 263638.20      |
| ## 20 | 2024-06-18 | 230544.7     | 237669.6     | 232429.8      | 268036.68      |
| ## 21 | 2024-06-20 | 230857.2     | 236414.7     | 235480.7      | 261082.26      |
| ## 22 | 2024-06-21 | 226890.7     | 237246.6     | 237387.5      | 258386.10      |
| ## 23 | 2024-06-24 | 232893.4     | 237514.5     | 241455.4      | 252007.32      |
| ## 24 | 2024-06-25 | 230519.5     | 235258.5     | 241382.7      | 259013.40      |
| ## 25 | 2024-06-26 | 229753.4     | 236104.5     | 238804.0      | 259716.96      |
| ## 26 | 2024-06-27 | 224763.8     | 234934.2     | 235753.1      | 259734.18      |
| ## 27 | 2024-06-28 | 227969.3     | 232537.2     | 224820.8      | 261953.10      |
| ## 28 | 2024-07-01 | 233684.6     | 229435.2     | 232266.4      | 260914.98      |
| ## 29 | 2024-07-02 | 234667.4     | 231099.0     | 231939.5      | 263913.72      |
| ## 30 | 2024-07-03 | 235831.7     | 231000.3     | 228543.6      | 266354.04      |
| ## 31 | 2024-07-05 | 234234.0     | 232946.1     | 229633.2      | 267598.80      |
| ## 32 | 2024-07-08 | 234269.3     | 234793.2     | 228416.5      | 270996.06      |
| ## 33 | 2024-07-09 | 238306.3     | 233580.6     | 228888.6      | 273687.30      |
| ## 34 | 2024-07-10 | 241360.6     | 235188.0     | 231176.8      | 277315.80      |
| ## 35 | 2024-07-11 | 241531.9     | 233411.4     | 234209.5      | 260745.24      |
| ## 36 | 2024-07-12 | 241859.5     | 234920.1     | 232012.2      | 263175.72      |
| ## 37 | 2024-07-15 | 248083.9     | 232057.8     | 232665.9      | 263001.06      |

|       |            |          |          |          |           |
|-------|------------|----------|----------|----------|-----------|
| ## 38 | 2024-07-16 | 253522.1 | 235399.5 | 227799.0 | 264693.54 |
| ## 39 | 2024-07-17 | 253098.7 | 238910.4 | 228616.2 | 238049.28 |
| ## 40 | 2024-07-18 | 245049.8 | 237500.4 | 225638.0 | 234339.60 |
| ## 41 | 2024-07-19 | 244404.7 | 236823.6 | 228398.3 | 225609.06 |
| ## 42 | 2024-07-22 | 245468.2 | 237232.5 | 228253.0 | 240356.76 |
| ## 43 | 2024-07-23 | 248043.6 | 234934.2 | 225874.1 | 236083.74 |
| ## 44 | 2024-07-24 | 245296.8 | 236880.0 | 228670.7 | 223828.02 |
| ## 45 | 2024-07-25 | 247821.8 | 235329.0 | 228543.6 | 217493.52 |
| ## 46 | 2024-07-26 | 251511.1 | 238445.1 | 227472.2 | 220081.44 |
| ## 47 | 2024-07-29 | 248330.9 | 239601.3 | 232048.5 | 219515.64 |
| ## 48 | 2024-07-30 | 254857.7 | 227997.0 | 209294.0 | 210295.56 |
| ## 49 | 2024-07-31 | 256551.1 | 226671.6 | 205444.1 | 226625.04 |
| ## 50 | 2024-08-01 | 252060.5 | 233622.9 | 206697.1 | 204261.18 |
| ## 51 | 2024-08-02 | 237202.6 | 239812.8 | 209203.2 | 187698.00 |
| ## 52 | 2024-08-05 | 231346.1 | 236964.6 | 203955.0 | 189515.94 |
| ## 53 | 2024-08-06 | 236990.9 | 237006.9 | 201848.4 | 189461.82 |
| ## 54 | 2024-08-07 | 238397.0 | 239728.2 | 204281.8 | 184020.30 |
| ## 55 | 2024-08-08 | 244828.1 | 240926.7 | 206878.7 | 196585.98 |
| ## 56 | 2024-08-09 | 247091.0 | 240461.4 | 208022.8 | 198743.40 |
| ## 57 | 2024-08-12 | 244692.0 | 235202.1 | 206079.7 | 199478.94 |
| ## 58 | 2024-08-13 | 247937.8 | 235878.9 | 207732.2 | 206826.96 |
| ## 59 | 2024-08-14 | 251344.8 | 238008.0 | 206261.3 | 207951.18 |
| ## 60 | 2024-08-15 | 251506.1 | 236767.2 | 205771.0 | 218964.60 |
| ## 61 | 2024-08-16 | 254147.0 | 236724.9 | 206424.7 | 214300.44 |
| ## 62 | 2024-08-19 | 254358.7 | 237472.2 | 207786.7 | 216794.88 |
| ## 63 | 2024-08-20 | 250659.4 | 240278.1 | 209094.2 | 212263.56 |
| ## 64 | 2024-08-21 | 250215.8 | 239925.6 | 210710.5 | 214839.18 |
| ## 65 | 2024-08-22 | 250866.0 | 239911.5 | 211654.8 | 205587.12 |
| ## 66 | 2024-08-23 | 256747.7 | 238529.7 | 211745.6 | 208453.02 |
| ## 67 | 2024-08-26 | 255966.5 | 240193.5 | 211146.3 | 201451.86 |
| ## 68 | 2024-08-27 | 255659.0 | 238642.5 | 211564.0 | 201828.24 |
| ## 69 | 2024-08-28 | 253678.3 | 238374.6 | 213198.4 | 198057.06 |
| ## 70 | 2024-08-29 | 257090.4 | 239742.3 | 213307.4 | 196140.72 |
| ## 71 | 2024-08-30 | 257166.0 | 241871.4 | 215105.2 | 201968.46 |
| ## 72 | 2024-09-03 | 245679.8 | 246073.2 | 211709.3 | 188367.12 |
| ## 73 | 2024-09-04 | 247282.6 | 248019.0 | 210292.8 | 188052.24 |
| ## 74 | 2024-09-05 | 245891.5 | 247412.7 | 215359.4 | 185956.32 |
| ## 75 | 2024-09-06 | 241723.4 | 247581.9 | 213997.4 | 180522.18 |
| ## 76 | 2024-09-09 | 246239.3 | 248244.6 | 209584.6 | 180640.26 |
| ## 77 | 2024-09-10 | 235433.5 | 250683.9 | 209439.3 | 179963.76 |
| ## 78 | 2024-09-11 | 237469.7 | 245227.2 | 208313.4 | 188645.10 |
| ## 79 | 2024-09-12 | 238926.2 | 244592.7 | 209294.0 | 183953.88 |
| ## 80 | 2024-09-13 | 241411.0 | 245452.8 | 210401.8 | 189351.12 |
| ## 81 | 2024-09-16 | 244520.6 | 249908.4 | 214215.4 | 186583.62 |
| ## 82 | 2024-09-17 | 244636.6 | 247990.8 | 214814.6 | 188445.84 |
| ## 83 | 2024-09-18 | 244228.3 | 245227.2 | 215450.2 | 185944.02 |
| ## 84 | 2024-09-19 | 253930.3 | 241871.4 | 212889.7 | 194111.22 |
| ## 85 | 2024-09-20 | 251208.7 | 245650.2 | 212780.7 | 190204.74 |
| ## 86 | 2024-09-23 | 250694.6 | 245015.7 | 209984.1 | 192883.68 |
| ## 87 | 2024-09-24 | 251002.1 | 244268.4 | 208767.4 | 194600.76 |
| ## 88 | 2024-09-25 | 247534.6 | 242886.6 | 208349.7 | 197722.50 |
| ## 89 | 2024-09-26 | 250447.7 | 244226.1 | 205371.4 | 208485.00 |
| ## 90 | 2024-09-27 | 251249.0 | 244705.5 | 206461.0 | 203471.52 |

|        |            |          |          |          |           |
|--------|------------|----------|----------|----------|-----------|
| ## 91  | 2024-09-30 | 249535.4 | 244212.0 | 206225.0 | 200755.68 |
| ## 92  | 2024-10-01 | 247045.7 | 243986.4 | 208367.8 | 196155.48 |
| ## 93  | 2024-10-02 | 247963.0 | 242407.2 | 203537.3 | 200266.14 |
| ## 94  | 2024-10-03 | 244994.4 | 239869.2 | 200086.9 | 19953.06  |
| ## 95  | 2024-10-04 | 249560.6 | 238120.8 | 199342.3 | 20058.84  |
| ## 96  | 2024-10-07 | 249288.5 | 235639.2 | 197199.4 | 19830.06  |
| ## 97  | 2024-10-08 | 250271.3 | 237105.6 | 197072.3 | 19928.46  |
| ## 98  | 2024-10-09 | 254610.7 | 238670.7 | 200250.3 | 20383.56  |
| ## 99  | 2024-10-10 | 253874.9 | 238219.5 | 198670.4 | 20186.76  |
| ## 100 | 2024-10-11 | 260215.2 | 241236.9 | 199269.7 | 20390.94  |

```
# Calculate total portfolio valuation as a new column in the valuation_df
valuation_df$Total_Valuation <- rowSums(valuation_df[, grepl("valuation", colnames(valuation_df))], na.rm=T)
valuation_df
```

| ##    | timestamp  | GS_valuation | PG_valuation | MRK_valuation | LRCX_valuation |
|-------|------------|--------------|--------------|---------------|----------------|
| ## 1  | 2024-05-21 | 237086.6     | 237373.5     | 237460.2      | 237144.00      |
| ## 2  | 2024-05-22 | 233039.5     | 236612.1     | 238077.6      | 237579.42      |
| ## 3  | 2024-05-23 | 230907.6     | 233340.9     | 238059.4      | 235699.98      |
| ## 4  | 2024-05-24 | 232434.7     | 233115.3     | 235153.8      | 238760.22      |
| ## 5  | 2024-05-28 | 231744.2     | 229985.1     | 228979.4      | 238929.96      |
| ## 6  | 2024-05-29 | 230413.7     | 227926.5     | 228634.4      | 234497.04      |
| ## 7  | 2024-05-30 | 226915.9     | 229237.8     | 226146.5      | 233872.20      |
| ## 8  | 2024-05-31 | 230086.1     | 232001.4     | 227980.6      | 229380.24      |
| ## 9  | 2024-06-03 | 229309.9     | 232156.5     | 233210.7      | 230164.98      |
| ## 10 | 2024-06-04 | 229471.2     | 235484.1     | 233737.4      | 226991.58      |
| ## 11 | 2024-06-05 | 232686.7     | 234130.5     | 235081.2      | 239043.12      |
| ## 12 | 2024-06-06 | 230882.4     | 237542.7     | 237024.3      | 236698.74      |
| ## 13 | 2024-06-07 | 229274.6     | 235554.6     | 237296.7      | 236829.12      |
| ## 14 | 2024-06-10 | 228589.2     | 235963.5     | 238785.8      | 246755.22      |
| ## 15 | 2024-06-11 | 223912.1     | 236146.8     | 239421.4      | 245938.50      |
| ## 16 | 2024-06-12 | 226144.8     | 232903.8     | 236443.2      | 255256.98      |
| ## 17 | 2024-06-13 | 224960.4     | 234638.1     | 234935.9      | 255471.00      |
| ## 18 | 2024-06-14 | 225015.8     | 235173.9     | 235135.7      | 254851.08      |
| ## 19 | 2024-06-17 | 226890.7     | 236175.0     | 231540.0      | 263638.20      |
| ## 20 | 2024-06-18 | 230544.7     | 237669.6     | 232429.8      | 268036.68      |
| ## 21 | 2024-06-20 | 230857.2     | 236414.7     | 235480.7      | 261082.26      |
| ## 22 | 2024-06-21 | 226890.7     | 237246.6     | 237387.5      | 258386.10      |
| ## 23 | 2024-06-24 | 232893.4     | 237514.5     | 241455.4      | 252007.32      |
| ## 24 | 2024-06-25 | 230519.5     | 235258.5     | 241382.7      | 259013.40      |
| ## 25 | 2024-06-26 | 229753.4     | 236104.5     | 238804.0      | 259716.96      |
| ## 26 | 2024-06-27 | 224763.8     | 234934.2     | 235753.1      | 259734.18      |
| ## 27 | 2024-06-28 | 227969.3     | 232537.2     | 224820.8      | 261953.10      |
| ## 28 | 2024-07-01 | 233684.6     | 229435.2     | 232266.4      | 260914.98      |
| ## 29 | 2024-07-02 | 234667.4     | 231099.0     | 231939.5      | 263913.72      |
| ## 30 | 2024-07-03 | 235831.7     | 231000.3     | 228543.6      | 266354.04      |
| ## 31 | 2024-07-05 | 234234.0     | 232946.1     | 229633.2      | 267598.80      |
| ## 32 | 2024-07-08 | 234269.3     | 234793.2     | 228416.5      | 270996.06      |
| ## 33 | 2024-07-09 | 238306.3     | 233580.6     | 228888.6      | 273687.30      |
| ## 34 | 2024-07-10 | 241360.6     | 235188.0     | 231176.8      | 277315.80      |
| ## 35 | 2024-07-11 | 241531.9     | 233411.4     | 234209.5      | 260745.24      |
| ## 36 | 2024-07-12 | 241859.5     | 234920.1     | 232012.2      | 263175.72      |
| ## 37 | 2024-07-15 | 248083.9     | 232057.8     | 232665.9      | 263001.06      |
| ## 38 | 2024-07-16 | 253522.1     | 235399.5     | 227799.0      | 264693.54      |

|       |            |          |          |          |           |
|-------|------------|----------|----------|----------|-----------|
| ## 39 | 2024-07-17 | 253098.7 | 238910.4 | 228616.2 | 238049.28 |
| ## 40 | 2024-07-18 | 245049.8 | 237500.4 | 225638.0 | 234339.60 |
| ## 41 | 2024-07-19 | 244404.7 | 236823.6 | 228398.3 | 225609.06 |
| ## 42 | 2024-07-22 | 245468.2 | 237232.5 | 228253.0 | 240356.76 |
| ## 43 | 2024-07-23 | 248043.6 | 234934.2 | 225874.1 | 236083.74 |
| ## 44 | 2024-07-24 | 245296.8 | 236880.0 | 228670.7 | 223828.02 |
| ## 45 | 2024-07-25 | 247821.8 | 235329.0 | 228543.6 | 217493.52 |
| ## 46 | 2024-07-26 | 251511.1 | 238445.1 | 227472.2 | 220081.44 |
| ## 47 | 2024-07-29 | 248330.9 | 239601.3 | 232048.5 | 219515.64 |
| ## 48 | 2024-07-30 | 254857.7 | 227997.0 | 209294.0 | 210295.56 |
| ## 49 | 2024-07-31 | 256551.1 | 226671.6 | 205444.1 | 226625.04 |
| ## 50 | 2024-08-01 | 252060.5 | 233622.9 | 206697.1 | 204261.18 |
| ## 51 | 2024-08-02 | 237202.6 | 239812.8 | 209203.2 | 187698.00 |
| ## 52 | 2024-08-05 | 231346.1 | 236964.6 | 203955.0 | 189515.94 |
| ## 53 | 2024-08-06 | 236990.9 | 237006.9 | 201848.4 | 189461.82 |
| ## 54 | 2024-08-07 | 238397.0 | 239728.2 | 204281.8 | 184020.30 |
| ## 55 | 2024-08-08 | 244828.1 | 240926.7 | 206878.7 | 196585.98 |
| ## 56 | 2024-08-09 | 247091.0 | 240461.4 | 208022.8 | 198743.40 |
| ## 57 | 2024-08-12 | 244692.0 | 235202.1 | 206079.7 | 199478.94 |
| ## 58 | 2024-08-13 | 247937.8 | 235878.9 | 207732.2 | 206826.96 |
| ## 59 | 2024-08-14 | 251344.8 | 238008.0 | 206261.3 | 207951.18 |
| ## 60 | 2024-08-15 | 251506.1 | 236767.2 | 205771.0 | 218964.60 |
| ## 61 | 2024-08-16 | 254147.0 | 236724.9 | 206424.7 | 214300.44 |
| ## 62 | 2024-08-19 | 254358.7 | 237472.2 | 207786.7 | 216794.88 |
| ## 63 | 2024-08-20 | 250659.4 | 240278.1 | 209094.2 | 212263.56 |
| ## 64 | 2024-08-21 | 250215.8 | 239925.6 | 210710.5 | 214839.18 |
| ## 65 | 2024-08-22 | 250866.0 | 239911.5 | 211654.8 | 205587.12 |
| ## 66 | 2024-08-23 | 256747.7 | 238529.7 | 211745.6 | 208453.02 |
| ## 67 | 2024-08-26 | 255966.5 | 240193.5 | 211146.3 | 201451.86 |
| ## 68 | 2024-08-27 | 255659.0 | 238642.5 | 211564.0 | 201828.24 |
| ## 69 | 2024-08-28 | 253678.3 | 238374.6 | 213198.4 | 198057.06 |
| ## 70 | 2024-08-29 | 257090.4 | 239742.3 | 213307.4 | 196140.72 |
| ## 71 | 2024-08-30 | 257166.0 | 241871.4 | 215105.2 | 201968.46 |
| ## 72 | 2024-09-03 | 245679.8 | 246073.2 | 211709.3 | 188367.12 |
| ## 73 | 2024-09-04 | 247282.6 | 248019.0 | 210292.8 | 188052.24 |
| ## 74 | 2024-09-05 | 245891.5 | 247412.7 | 215359.4 | 185956.32 |
| ## 75 | 2024-09-06 | 241723.4 | 247581.9 | 213997.4 | 180522.18 |
| ## 76 | 2024-09-09 | 246239.3 | 248244.6 | 209584.6 | 180640.26 |
| ## 77 | 2024-09-10 | 235433.5 | 250683.9 | 209439.3 | 179963.76 |
| ## 78 | 2024-09-11 | 237469.7 | 245227.2 | 208313.4 | 188645.10 |
| ## 79 | 2024-09-12 | 238926.2 | 244592.7 | 209294.0 | 183953.88 |
| ## 80 | 2024-09-13 | 241411.0 | 245452.8 | 210401.8 | 189351.12 |
| ## 81 | 2024-09-16 | 244520.6 | 249908.4 | 214215.4 | 186583.62 |
| ## 82 | 2024-09-17 | 244636.6 | 247990.8 | 214814.6 | 188445.84 |
| ## 83 | 2024-09-18 | 244228.3 | 245227.2 | 215450.2 | 185944.02 |
| ## 84 | 2024-09-19 | 253930.3 | 241871.4 | 212889.7 | 194111.22 |
| ## 85 | 2024-09-20 | 251208.7 | 245650.2 | 212780.7 | 190204.74 |
| ## 86 | 2024-09-23 | 250694.6 | 245015.7 | 209984.1 | 192883.68 |
| ## 87 | 2024-09-24 | 251002.1 | 244268.4 | 208767.4 | 194600.76 |
| ## 88 | 2024-09-25 | 247534.6 | 242886.6 | 208349.7 | 197722.50 |
| ## 89 | 2024-09-26 | 250447.7 | 244226.1 | 205371.4 | 208485.00 |
| ## 90 | 2024-09-27 | 251249.0 | 244705.5 | 206461.0 | 203471.52 |
| ## 91 | 2024-09-30 | 249535.4 | 244212.0 | 206225.0 | 200755.68 |

|        |                 |          |          |          |           |
|--------|-----------------|----------|----------|----------|-----------|
| ## 92  | 2024-10-01      | 247045.7 | 243986.4 | 208367.8 | 196155.48 |
| ## 93  | 2024-10-02      | 247963.0 | 242407.2 | 203537.3 | 200266.14 |
| ## 94  | 2024-10-03      | 244994.4 | 239869.2 | 200086.9 | 19953.06  |
| ## 95  | 2024-10-04      | 249560.6 | 238120.8 | 199342.3 | 20058.84  |
| ## 96  | 2024-10-07      | 249288.5 | 235639.2 | 197199.4 | 19830.06  |
| ## 97  | 2024-10-08      | 250271.3 | 237105.6 | 197072.3 | 19928.46  |
| ## 98  | 2024-10-09      | 254610.7 | 238670.7 | 200250.3 | 20383.56  |
| ## 99  | 2024-10-10      | 253874.9 | 238219.5 | 198670.4 | 20186.76  |
| ## 100 | 2024-10-11      | 260215.2 | 241236.9 | 199269.7 | 20390.94  |
| ##     | Total_Valuation |          |          |          |           |
| ## 1   |                 | 949064.3 |          |          |           |
| ## 2   |                 | 945308.6 |          |          |           |
| ## 3   |                 | 938007.9 |          |          |           |
| ## 4   |                 | 939464.1 |          |          |           |
| ## 5   |                 | 929638.7 |          |          |           |
| ## 6   |                 | 921471.6 |          |          |           |
| ## 7   |                 | 916172.4 |          |          |           |
| ## 8   |                 | 919448.4 |          |          |           |
| ## 9   |                 | 924842.1 |          |          |           |
| ## 10  |                 | 925684.2 |          |          |           |
| ## 11  |                 | 940941.5 |          |          |           |
| ## 12  |                 | 942148.2 |          |          |           |
| ## 13  |                 | 938955.1 |          |          |           |
| ## 14  |                 | 950093.8 |          |          |           |
| ## 15  |                 | 945418.8 |          |          |           |
| ## 16  |                 | 950748.8 |          |          |           |
| ## 17  |                 | 950005.4 |          |          |           |
| ## 18  |                 | 950176.5 |          |          |           |
| ## 19  |                 | 958243.9 |          |          |           |
| ## 20  |                 | 968680.8 |          |          |           |
| ## 21  |                 | 963834.9 |          |          |           |
| ## 22  |                 | 959910.9 |          |          |           |
| ## 23  |                 | 963870.5 |          |          |           |
| ## 24  |                 | 966174.1 |          |          |           |
| ## 25  |                 | 964378.9 |          |          |           |
| ## 26  |                 | 955185.3 |          |          |           |
| ## 27  |                 | 947280.4 |          |          |           |
| ## 28  |                 | 956301.2 |          |          |           |
| ## 29  |                 | 961619.7 |          |          |           |
| ## 30  |                 | 961729.6 |          |          |           |
| ## 31  |                 | 964412.1 |          |          |           |
| ## 32  |                 | 968475.0 |          |          |           |
| ## 33  |                 | 974462.9 |          |          |           |
| ## 34  |                 | 985041.2 |          |          |           |
| ## 35  |                 | 969898.1 |          |          |           |
| ## 36  |                 | 971967.5 |          |          |           |
| ## 37  |                 | 975808.7 |          |          |           |
| ## 38  |                 | 981414.2 |          |          |           |
| ## 39  |                 | 958674.6 |          |          |           |
| ## 40  |                 | 942527.8 |          |          |           |
| ## 41  |                 | 935235.7 |          |          |           |
| ## 42  |                 | 951310.5 |          |          |           |
| ## 43  |                 | 944935.6 |          |          |           |

|       |          |
|-------|----------|
| ## 44 | 934675.5 |
| ## 45 | 929188.0 |
| ## 46 | 937509.8 |
| ## 47 | 939496.3 |
| ## 48 | 902444.2 |
| ## 49 | 915291.8 |
| ## 50 | 896641.7 |
| ## 51 | 873916.6 |
| ## 52 | 861781.6 |
| ## 53 | 865308.0 |
| ## 54 | 866427.4 |
| ## 55 | 889219.5 |
| ## 56 | 894318.6 |
| ## 57 | 885452.7 |
| ## 58 | 898375.9 |
| ## 59 | 903565.3 |
| ## 60 | 913008.8 |
| ## 61 | 911597.1 |
| ## 62 | 916412.5 |
| ## 63 | 912295.3 |
| ## 64 | 915691.1 |
| ## 65 | 908019.4 |
| ## 66 | 915476.0 |
| ## 67 | 908758.2 |
| ## 68 | 907693.8 |
| ## 69 | 903308.4 |
| ## 70 | 906280.8 |
| ## 71 | 916111.1 |
| ## 72 | 891829.4 |
| ## 73 | 893646.6 |
| ## 74 | 894620.0 |
| ## 75 | 883825.0 |
| ## 76 | 884708.7 |
| ## 77 | 875520.5 |
| ## 78 | 879655.3 |
| ## 79 | 876766.8 |
| ## 80 | 886616.6 |
| ## 81 | 895228.0 |
| ## 82 | 895887.8 |
| ## 83 | 890849.8 |
| ## 84 | 902802.6 |
| ## 85 | 899844.4 |
| ## 86 | 898578.1 |
| ## 87 | 898638.6 |
| ## 88 | 896493.3 |
| ## 89 | 908530.2 |
| ## 90 | 905887.1 |
| ## 91 | 900728.1 |
| ## 92 | 895555.4 |
| ## 93 | 894173.6 |
| ## 94 | 704903.5 |
| ## 95 | 707082.6 |
| ## 96 | 701957.2 |



```
## 97      704377.7
## 98      713915.3
## 99      710951.5
## 100     721112.7
```

```
# Calculate total daily portfolio value
```

```
valuation_df$Daily_Return <- c(NA, diff(valuation_df$Total_Valuation) / head(valuation_df$Total_Valuation, n=1))
valuation_df
```

| ##    | timestamp  | GS_valuation | PG_valuation | MRK_valuation | LRCX_valuation |
|-------|------------|--------------|--------------|---------------|----------------|
| ## 1  | 2024-05-21 | 237086.6     | 237373.5     | 237460.2      | 237144.00      |
| ## 2  | 2024-05-22 | 233039.5     | 236612.1     | 238077.6      | 237579.42      |
| ## 3  | 2024-05-23 | 230907.6     | 233340.9     | 238059.4      | 235699.98      |
| ## 4  | 2024-05-24 | 232434.7     | 233115.3     | 235153.8      | 238760.22      |
| ## 5  | 2024-05-28 | 231744.2     | 229985.1     | 228979.4      | 238929.96      |
| ## 6  | 2024-05-29 | 230413.7     | 227926.5     | 228634.4      | 234497.04      |
| ## 7  | 2024-05-30 | 226915.9     | 229237.8     | 226146.5      | 233872.20      |
| ## 8  | 2024-05-31 | 230086.1     | 232001.4     | 227980.6      | 229380.24      |
| ## 9  | 2024-06-03 | 229309.9     | 232156.5     | 233210.7      | 230164.98      |
| ## 10 | 2024-06-04 | 229471.2     | 235484.1     | 233737.4      | 226991.58      |
| ## 11 | 2024-06-05 | 232686.7     | 234130.5     | 235081.2      | 239043.12      |
| ## 12 | 2024-06-06 | 230882.4     | 237542.7     | 237024.3      | 236698.74      |
| ## 13 | 2024-06-07 | 229274.6     | 235554.6     | 237296.7      | 236829.12      |
| ## 14 | 2024-06-10 | 228589.2     | 235963.5     | 238785.8      | 246755.22      |
| ## 15 | 2024-06-11 | 223912.1     | 236146.8     | 239421.4      | 245938.50      |
| ## 16 | 2024-06-12 | 226144.8     | 232903.8     | 236443.2      | 255256.98      |
| ## 17 | 2024-06-13 | 224960.4     | 234638.1     | 234935.9      | 255471.00      |
| ## 18 | 2024-06-14 | 225015.8     | 235173.9     | 235135.7      | 254851.08      |
| ## 19 | 2024-06-17 | 226890.7     | 236175.0     | 231540.0      | 263638.20      |
| ## 20 | 2024-06-18 | 230544.7     | 237669.6     | 232429.8      | 268036.68      |
| ## 21 | 2024-06-20 | 230857.2     | 236414.7     | 235480.7      | 261082.26      |
| ## 22 | 2024-06-21 | 226890.7     | 237246.6     | 237387.5      | 258386.10      |
| ## 23 | 2024-06-24 | 232893.4     | 237514.5     | 241455.4      | 252007.32      |
| ## 24 | 2024-06-25 | 230519.5     | 235258.5     | 241382.7      | 259013.40      |
| ## 25 | 2024-06-26 | 229753.4     | 236104.5     | 238804.0      | 259716.96      |
| ## 26 | 2024-06-27 | 224763.8     | 234934.2     | 235753.1      | 259734.18      |
| ## 27 | 2024-06-28 | 227969.3     | 232537.2     | 224820.8      | 261953.10      |
| ## 28 | 2024-07-01 | 233684.6     | 229435.2     | 232266.4      | 260914.98      |
| ## 29 | 2024-07-02 | 234667.4     | 231099.0     | 231939.5      | 263913.72      |
| ## 30 | 2024-07-03 | 235831.7     | 231000.3     | 228543.6      | 266354.04      |
| ## 31 | 2024-07-05 | 234234.0     | 232946.1     | 229633.2      | 267598.80      |
| ## 32 | 2024-07-08 | 234269.3     | 234793.2     | 228416.5      | 270996.06      |
| ## 33 | 2024-07-09 | 238306.3     | 233580.6     | 228888.6      | 273687.30      |
| ## 34 | 2024-07-10 | 241360.6     | 235188.0     | 231176.8      | 277315.80      |
| ## 35 | 2024-07-11 | 241531.9     | 233411.4     | 234209.5      | 260745.24      |
| ## 36 | 2024-07-12 | 241859.5     | 234920.1     | 232012.2      | 263175.72      |
| ## 37 | 2024-07-15 | 248083.9     | 232057.8     | 232665.9      | 263001.06      |
| ## 38 | 2024-07-16 | 253522.1     | 235399.5     | 227799.0      | 264693.54      |
| ## 39 | 2024-07-17 | 253098.7     | 238910.4     | 228616.2      | 238049.28      |
| ## 40 | 2024-07-18 | 245049.8     | 237500.4     | 225638.0      | 234339.60      |
| ## 41 | 2024-07-19 | 244404.7     | 236823.6     | 228398.3      | 225609.06      |
| ## 42 | 2024-07-22 | 245468.2     | 237232.5     | 228253.0      | 240356.76      |
| ## 43 | 2024-07-23 | 248043.6     | 234934.2     | 225874.1      | 236083.74      |
| ## 44 | 2024-07-24 | 245296.8     | 236880.0     | 228670.7      | 223828.02      |

|       |            |          |          |          |           |
|-------|------------|----------|----------|----------|-----------|
| ## 45 | 2024-07-25 | 247821.8 | 235329.0 | 228543.6 | 217493.52 |
| ## 46 | 2024-07-26 | 251511.1 | 238445.1 | 227472.2 | 220081.44 |
| ## 47 | 2024-07-29 | 248330.9 | 239601.3 | 232048.5 | 219515.64 |
| ## 48 | 2024-07-30 | 254857.7 | 227997.0 | 209294.0 | 210295.56 |
| ## 49 | 2024-07-31 | 256551.1 | 226671.6 | 205444.1 | 226625.04 |
| ## 50 | 2024-08-01 | 252060.5 | 233622.9 | 206697.1 | 204261.18 |
| ## 51 | 2024-08-02 | 237202.6 | 239812.8 | 209203.2 | 187698.00 |
| ## 52 | 2024-08-05 | 231346.1 | 236964.6 | 203955.0 | 189515.94 |
| ## 53 | 2024-08-06 | 236990.9 | 237006.9 | 201848.4 | 189461.82 |
| ## 54 | 2024-08-07 | 238397.0 | 239728.2 | 204281.8 | 184020.30 |
| ## 55 | 2024-08-08 | 244828.1 | 240926.7 | 206878.7 | 196585.98 |
| ## 56 | 2024-08-09 | 247091.0 | 240461.4 | 208022.8 | 198743.40 |
| ## 57 | 2024-08-12 | 244692.0 | 235202.1 | 206079.7 | 199478.94 |
| ## 58 | 2024-08-13 | 247937.8 | 235878.9 | 207732.2 | 206826.96 |
| ## 59 | 2024-08-14 | 251344.8 | 238008.0 | 206261.3 | 207951.18 |
| ## 60 | 2024-08-15 | 251506.1 | 236767.2 | 205771.0 | 218964.60 |
| ## 61 | 2024-08-16 | 254147.0 | 236724.9 | 206424.7 | 214300.44 |
| ## 62 | 2024-08-19 | 254358.7 | 237472.2 | 207786.7 | 216794.88 |
| ## 63 | 2024-08-20 | 250659.4 | 240278.1 | 209094.2 | 212263.56 |
| ## 64 | 2024-08-21 | 250215.8 | 239925.6 | 210710.5 | 214839.18 |
| ## 65 | 2024-08-22 | 250866.0 | 239911.5 | 211654.8 | 205587.12 |
| ## 66 | 2024-08-23 | 256747.7 | 238529.7 | 211745.6 | 208453.02 |
| ## 67 | 2024-08-26 | 255966.5 | 240193.5 | 211146.3 | 201451.86 |
| ## 68 | 2024-08-27 | 255659.0 | 238642.5 | 211564.0 | 201828.24 |
| ## 69 | 2024-08-28 | 253678.3 | 238374.6 | 213198.4 | 198057.06 |
| ## 70 | 2024-08-29 | 257090.4 | 239742.3 | 213307.4 | 196140.72 |
| ## 71 | 2024-08-30 | 257166.0 | 241871.4 | 215105.2 | 201968.46 |
| ## 72 | 2024-09-03 | 245679.8 | 246073.2 | 211709.3 | 188367.12 |
| ## 73 | 2024-09-04 | 247282.6 | 248019.0 | 210292.8 | 188052.24 |
| ## 74 | 2024-09-05 | 245891.5 | 247412.7 | 215359.4 | 185956.32 |
| ## 75 | 2024-09-06 | 241723.4 | 247581.9 | 213997.4 | 180522.18 |
| ## 76 | 2024-09-09 | 246239.3 | 248244.6 | 209584.6 | 180640.26 |
| ## 77 | 2024-09-10 | 235433.5 | 250683.9 | 209439.3 | 179963.76 |
| ## 78 | 2024-09-11 | 237469.7 | 245227.2 | 208313.4 | 188645.10 |
| ## 79 | 2024-09-12 | 238926.2 | 244592.7 | 209294.0 | 183953.88 |
| ## 80 | 2024-09-13 | 241411.0 | 245452.8 | 210401.8 | 189351.12 |
| ## 81 | 2024-09-16 | 244520.6 | 249908.4 | 214215.4 | 186583.62 |
| ## 82 | 2024-09-17 | 244636.6 | 247990.8 | 214814.6 | 188445.84 |
| ## 83 | 2024-09-18 | 244228.3 | 245227.2 | 215450.2 | 185944.02 |
| ## 84 | 2024-09-19 | 253930.3 | 241871.4 | 212889.7 | 194111.22 |
| ## 85 | 2024-09-20 | 251208.7 | 245650.2 | 212780.7 | 190204.74 |
| ## 86 | 2024-09-23 | 250694.6 | 245015.7 | 209984.1 | 192883.68 |
| ## 87 | 2024-09-24 | 251002.1 | 244268.4 | 208767.4 | 194600.76 |
| ## 88 | 2024-09-25 | 247534.6 | 242886.6 | 208349.7 | 197722.50 |
| ## 89 | 2024-09-26 | 250447.7 | 244226.1 | 205371.4 | 208485.00 |
| ## 90 | 2024-09-27 | 251249.0 | 244705.5 | 206461.0 | 203471.52 |
| ## 91 | 2024-09-30 | 249535.4 | 244212.0 | 206225.0 | 200755.68 |
| ## 92 | 2024-10-01 | 247045.7 | 243986.4 | 208367.8 | 196155.48 |
| ## 93 | 2024-10-02 | 247963.0 | 242407.2 | 203537.3 | 200266.14 |
| ## 94 | 2024-10-03 | 244994.4 | 239869.2 | 200086.9 | 19953.06  |
| ## 95 | 2024-10-04 | 249560.6 | 238120.8 | 199342.3 | 20058.84  |
| ## 96 | 2024-10-07 | 249288.5 | 235639.2 | 197199.4 | 19830.06  |
| ## 97 | 2024-10-08 | 250271.3 | 237105.6 | 197072.3 | 19928.46  |

|        |                 |               |          |          |          |
|--------|-----------------|---------------|----------|----------|----------|
| ## 98  | 2024-10-09      | 254610.7      | 238670.7 | 200250.3 | 20383.56 |
| ## 99  | 2024-10-10      | 253874.9      | 238219.5 | 198670.4 | 20186.76 |
| ## 100 | 2024-10-11      | 260215.2      | 241236.9 | 199269.7 | 20390.94 |
| ##     | Total_Valuation | Daily_Return  |          |          |          |
| ## 1   | 949064.3        | NA            |          |          |          |
| ## 2   | 945308.6        | -3.957224e-03 |          |          |          |
| ## 3   | 938007.9        | -7.723107e-03 |          |          |          |
| ## 4   | 939464.1        | 1.552396e-03  |          |          |          |
| ## 5   | 929638.7        | -1.045845e-02 |          |          |          |
| ## 6   | 921471.6        | -8.785262e-03 |          |          |          |
| ## 7   | 916172.4        | -5.750823e-03 |          |          |          |
| ## 8   | 919448.4        | 3.575703e-03  |          |          |          |
| ## 9   | 924842.1        | 5.866300e-03  |          |          |          |
| ## 10  | 925684.2        | 9.105554e-04  |          |          |          |
| ## 11  | 940941.5        | 1.648219e-02  |          |          |          |
| ## 12  | 942148.2        | 1.282354e-03  |          |          |          |
| ## 13  | 938955.1        | -3.389148e-03 |          |          |          |
| ## 14  | 950093.8        | 1.186285e-02  |          |          |          |
| ## 15  | 945418.8        | -4.920504e-03 |          |          |          |
| ## 16  | 950748.8        | 5.637671e-03  |          |          |          |
| ## 17  | 950005.4        | -7.818680e-04 |          |          |          |
| ## 18  | 950176.5        | 1.800832e-04  |          |          |          |
| ## 19  | 958243.9        | 8.490444e-03  |          |          |          |
| ## 20  | 968680.8        | 1.089172e-02  |          |          |          |
| ## 21  | 963834.9        | -5.002638e-03 |          |          |          |
| ## 22  | 959910.9        | -4.071175e-03 |          |          |          |
| ## 23  | 963870.5        | 4.124966e-03  |          |          |          |
| ## 24  | 966174.1        | 2.389948e-03  |          |          |          |
| ## 25  | 964378.9        | -1.858092e-03 |          |          |          |
| ## 26  | 955185.3        | -9.533141e-03 |          |          |          |
| ## 27  | 947280.4        | -8.275839e-03 |          |          |          |
| ## 28  | 956301.2        | 9.522883e-03  |          |          |          |
| ## 29  | 961619.7        | 5.561490e-03  |          |          |          |
| ## 30  | 961729.6        | 1.143279e-04  |          |          |          |
| ## 31  | 964412.1        | 2.789225e-03  |          |          |          |
| ## 32  | 968475.0        | 4.212846e-03  |          |          |          |
| ## 33  | 974462.9        | 6.182751e-03  |          |          |          |
| ## 34  | 985041.2        | 1.085552e-02  |          |          |          |
| ## 35  | 969898.1        | -1.537304e-02 |          |          |          |
| ## 36  | 971967.5        | 2.133647e-03  |          |          |          |
| ## 37  | 975808.7        | 3.951984e-03  |          |          |          |
| ## 38  | 981414.2        | 5.744425e-03  |          |          |          |
| ## 39  | 958674.6        | -2.317016e-02 |          |          |          |
| ## 40  | 942527.8        | -1.684284e-02 |          |          |          |
| ## 41  | 935235.7        | -7.736790e-03 |          |          |          |
| ## 42  | 951310.5        | 1.718792e-02  |          |          |          |
| ## 43  | 944935.6        | -6.701114e-03 |          |          |          |
| ## 44  | 934675.5        | -1.085797e-02 |          |          |          |
| ## 45  | 929188.0        | -5.871107e-03 |          |          |          |
| ## 46  | 937509.8        | 8.956057e-03  |          |          |          |
| ## 47  | 939496.3        | 2.118890e-03  |          |          |          |
| ## 48  | 902444.2        | -3.943822e-02 |          |          |          |
| ## 49  | 915291.8        | 1.423645e-02  |          |          |          |

|        |          |               |
|--------|----------|---------------|
| ## 50  | 896641.7 | -2.037619e-02 |
| ## 51  | 873916.6 | -2.534471e-02 |
| ## 52  | 861781.6 | -1.388574e-02 |
| ## 53  | 865308.0 | 4.092011e-03  |
| ## 54  | 866427.4 | 1.293620e-03  |
| ## 55  | 889219.5 | 2.630584e-02  |
| ## 56  | 894318.6 | 5.734422e-03  |
| ## 57  | 885452.7 | -9.913603e-03 |
| ## 58  | 898375.9 | 1.459495e-02  |
| ## 59  | 903565.3 | 5.776424e-03  |
| ## 60  | 913008.8 | 1.045146e-02  |
| ## 61  | 911597.1 | -1.546250e-03 |
| ## 62  | 916412.5 | 5.282399e-03  |
| ## 63  | 912295.3 | -4.492802e-03 |
| ## 64  | 915691.1 | 3.722304e-03  |
| ## 65  | 908019.4 | -8.378022e-03 |
| ## 66  | 915476.0 | 8.211917e-03  |
| ## 67  | 908758.2 | -7.338084e-03 |
| ## 68  | 907693.8 | -1.171247e-03 |
| ## 69  | 903308.4 | -4.831365e-03 |
| ## 70  | 906280.8 | 3.290571e-03  |
| ## 71  | 916111.1 | 1.084684e-02  |
| ## 72  | 891829.4 | -2.650511e-02 |
| ## 73  | 893646.6 | 2.037564e-03  |
| ## 74  | 894620.0 | 1.089223e-03  |
| ## 75  | 883825.0 | -1.206660e-02 |
| ## 76  | 884708.7 | 9.999039e-04  |
| ## 77  | 875520.5 | -1.038561e-02 |
| ## 78  | 879655.3 | 4.722768e-03  |
| ## 79  | 876766.8 | -3.283695e-03 |
| ## 80  | 886616.6 | 1.123425e-02  |
| ## 81  | 895228.0 | 9.712631e-03  |
| ## 82  | 895887.8 | 7.370413e-04  |
| ## 83  | 890849.8 | -5.623539e-03 |
| ## 84  | 902802.6 | 1.341735e-02  |
| ## 85  | 899844.4 | -3.276730e-03 |
| ## 86  | 898578.1 | -1.407221e-03 |
| ## 87  | 898638.6 | 6.732859e-05  |
| ## 88  | 896493.3 | -2.387233e-03 |
| ## 89  | 908530.2 | 1.342663e-02  |
| ## 90  | 905887.1 | -2.909226e-03 |
| ## 91  | 900728.1 | -5.694992e-03 |
| ## 92  | 895555.4 | -5.742776e-03 |
| ## 93  | 894173.6 | -1.542975e-03 |
| ## 94  | 704903.5 | -2.116704e-01 |
| ## 95  | 707082.6 | 3.091288e-03  |
| ## 96  | 701957.2 | -7.248686e-03 |
| ## 97  | 704377.7 | 3.448188e-03  |
| ## 98  | 713915.3 | 1.354052e-02  |
| ## 99  | 710951.5 | -4.151417e-03 |
| ## 100 | 721112.7 | 1.429237e-02  |

### 5.1.1 Daily Valuation and Return

```

# Function to calculate maximum drawdown
calculate_max_drawdown <- function(values) {
  peak <- cummax(values)
  drawdown <- (peak - values) / peak
  max(drawdown, na.rm = TRUE)
}

# Calculate maximum drawdown for the portfolio
max_drawdown_portfolio <- calculate_max_drawdown(valuation_df$Total_Valuation)

# Calculate maximum drawdown for SPY
spy_prices <- stock_data_list[[5]]$close
max_drawdown_spy <- calculate_max_drawdown(spy_prices)

# Print the maximum drawdowns
cat("Maximum Drawdown for Portfolio: ", max_drawdown_portfolio * 100, "%\n")
## Maximum Drawdown for Portfolio: 28.73829 %
cat("Maximum Drawdown for SPY: ", max_drawdown_spy * 100, "%\n")
## Maximum Drawdown for SPY: 8.405623 %

```

### 5.1.2 Maximum Drawdown

```

risk_free_rate <- 0.05 / 365

average_daily_return_portfolio <- mean(valuation_df$Daily_Return, na.rm = TRUE)

std_dev_portfolio <- sd(valuation_df$Daily_Return, na.rm = TRUE)

# Calculate the Sharpe ratio for the portfolio
sharpe_ratio_portfolio <- (average_daily_return_portfolio - risk_free_rate) / std_dev_portfolio

# Calculate average daily return for SPY
average_daily_return_spy <- mean(diff(spy_prices) / head(spy_prices, -1), na.rm = TRUE)

# Calculate the standard deviation of SPY returns
std_dev_spy <- sd(diff(spy_prices) / head(spy_prices, -1), na.rm = TRUE)

# Calculate the Sharpe ratio for SPY
sharpe_ratio_spy <- (average_daily_return_spy - risk_free_rate) / std_dev_spy

# Print the Sharpe Ratios
cat("Sharpe Ratio for Portfolio: ", sharpe_ratio_portfolio, "\n")
## Sharpe Ratio for Portfolio: -0.110285
cat("Sharpe Ratio for SPY: ", sharpe_ratio_spy, "\n")
## Sharpe Ratio for SPY: 0.09047136

```

### 5.1.3 Sharpe Ratio

## 5.2 Visualizations

```

SPY_daily_return <- c(NA, diff(spy_prices) / head(spy_prices, -1))

# Add SPY daily returns to the valuation_df
valuation_df$SPY_Daily_Return <- SPY_daily_return

# Calculate the daily return difference
valuation_df$Return_Difference <- valuation_df$Daily_Return - valuation_df$SPY_Daily_Return
valuation_df

```

|       | timestamp  | GS_valuation | PG_valuation | MRK_valuation | LRCX_valuation |
|-------|------------|--------------|--------------|---------------|----------------|
| ## 1  | 2024-05-21 | 237086.6     | 237373.5     | 237460.2      | 237144.00      |
| ## 2  | 2024-05-22 | 233039.5     | 236612.1     | 238077.6      | 237579.42      |
| ## 3  | 2024-05-23 | 230907.6     | 233340.9     | 238059.4      | 235699.98      |
| ## 4  | 2024-05-24 | 232434.7     | 233115.3     | 235153.8      | 238760.22      |
| ## 5  | 2024-05-28 | 231744.2     | 229985.1     | 228979.4      | 238929.96      |
| ## 6  | 2024-05-29 | 230413.7     | 227926.5     | 228634.4      | 234497.04      |
| ## 7  | 2024-05-30 | 226915.9     | 229237.8     | 226146.5      | 233872.20      |
| ## 8  | 2024-05-31 | 230086.1     | 232001.4     | 227980.6      | 229380.24      |
| ## 9  | 2024-06-03 | 229309.9     | 232156.5     | 233210.7      | 230164.98      |
| ## 10 | 2024-06-04 | 229471.2     | 235484.1     | 233737.4      | 226991.58      |
| ## 11 | 2024-06-05 | 232686.7     | 234130.5     | 235081.2      | 239043.12      |
| ## 12 | 2024-06-06 | 230882.4     | 237542.7     | 237024.3      | 236698.74      |
| ## 13 | 2024-06-07 | 229274.6     | 235554.6     | 237296.7      | 236829.12      |
| ## 14 | 2024-06-10 | 228589.2     | 235963.5     | 238785.8      | 246755.22      |
| ## 15 | 2024-06-11 | 223912.1     | 236146.8     | 239421.4      | 245938.50      |
| ## 16 | 2024-06-12 | 226144.8     | 232903.8     | 236443.2      | 255256.98      |
| ## 17 | 2024-06-13 | 224960.4     | 234638.1     | 234935.9      | 255471.00      |
| ## 18 | 2024-06-14 | 225015.8     | 235173.9     | 235135.7      | 254851.08      |
| ## 19 | 2024-06-17 | 226890.7     | 236175.0     | 231540.0      | 263638.20      |
| ## 20 | 2024-06-18 | 230544.7     | 237669.6     | 232429.8      | 268036.68      |
| ## 21 | 2024-06-20 | 230857.2     | 236414.7     | 235480.7      | 261082.26      |
| ## 22 | 2024-06-21 | 226890.7     | 237246.6     | 237387.5      | 258386.10      |
| ## 23 | 2024-06-24 | 232893.4     | 237514.5     | 241455.4      | 252007.32      |
| ## 24 | 2024-06-25 | 230519.5     | 235258.5     | 241382.7      | 259013.40      |
| ## 25 | 2024-06-26 | 229753.4     | 236104.5     | 238804.0      | 259716.96      |
| ## 26 | 2024-06-27 | 224763.8     | 234934.2     | 235753.1      | 259734.18      |
| ## 27 | 2024-06-28 | 227969.3     | 232537.2     | 224820.8      | 261953.10      |
| ## 28 | 2024-07-01 | 233684.6     | 229435.2     | 232266.4      | 260914.98      |
| ## 29 | 2024-07-02 | 234667.4     | 231099.0     | 231939.5      | 263913.72      |
| ## 30 | 2024-07-03 | 235831.7     | 231000.3     | 228543.6      | 266354.04      |
| ## 31 | 2024-07-05 | 234234.0     | 232946.1     | 229633.2      | 267598.80      |
| ## 32 | 2024-07-08 | 234269.3     | 234793.2     | 228416.5      | 270996.06      |
| ## 33 | 2024-07-09 | 238306.3     | 233580.6     | 228888.6      | 273687.30      |
| ## 34 | 2024-07-10 | 241360.6     | 235188.0     | 231176.8      | 277315.80      |
| ## 35 | 2024-07-11 | 241531.9     | 233411.4     | 234209.5      | 260745.24      |
| ## 36 | 2024-07-12 | 241859.5     | 234920.1     | 232012.2      | 263175.72      |
| ## 37 | 2024-07-15 | 248083.9     | 232057.8     | 232665.9      | 263001.06      |
| ## 38 | 2024-07-16 | 253522.1     | 235399.5     | 227799.0      | 264693.54      |
| ## 39 | 2024-07-17 | 253098.7     | 238910.4     | 228616.2      | 238049.28      |
| ## 40 | 2024-07-18 | 245049.8     | 237500.4     | 225638.0      | 234339.60      |
| ## 41 | 2024-07-19 | 244404.7     | 236823.6     | 228398.3      | 225609.06      |
| ## 42 | 2024-07-22 | 245468.2     | 237232.5     | 228253.0      | 240356.76      |
| ## 43 | 2024-07-23 | 248043.6     | 234934.2     | 225874.1      | 236083.74      |
| ## 44 | 2024-07-24 | 245296.8     | 236880.0     | 228670.7      | 223828.02      |

|       |            |          |          |          |           |
|-------|------------|----------|----------|----------|-----------|
| ## 45 | 2024-07-25 | 247821.8 | 235329.0 | 228543.6 | 217493.52 |
| ## 46 | 2024-07-26 | 251511.1 | 238445.1 | 227472.2 | 220081.44 |
| ## 47 | 2024-07-29 | 248330.9 | 239601.3 | 232048.5 | 219515.64 |
| ## 48 | 2024-07-30 | 254857.7 | 227997.0 | 209294.0 | 210295.56 |
| ## 49 | 2024-07-31 | 256551.1 | 226671.6 | 205444.1 | 226625.04 |
| ## 50 | 2024-08-01 | 252060.5 | 233622.9 | 206697.1 | 204261.18 |
| ## 51 | 2024-08-02 | 237202.6 | 239812.8 | 209203.2 | 187698.00 |
| ## 52 | 2024-08-05 | 231346.1 | 236964.6 | 203955.0 | 189515.94 |
| ## 53 | 2024-08-06 | 236990.9 | 237006.9 | 201848.4 | 189461.82 |
| ## 54 | 2024-08-07 | 238397.0 | 239728.2 | 204281.8 | 184020.30 |
| ## 55 | 2024-08-08 | 244828.1 | 240926.7 | 206878.7 | 196585.98 |
| ## 56 | 2024-08-09 | 247091.0 | 240461.4 | 208022.8 | 198743.40 |
| ## 57 | 2024-08-12 | 244692.0 | 235202.1 | 206079.7 | 199478.94 |
| ## 58 | 2024-08-13 | 247937.8 | 235878.9 | 207732.2 | 206826.96 |
| ## 59 | 2024-08-14 | 251344.8 | 238008.0 | 206261.3 | 207951.18 |
| ## 60 | 2024-08-15 | 251506.1 | 236767.2 | 205771.0 | 218964.60 |
| ## 61 | 2024-08-16 | 254147.0 | 236724.9 | 206424.7 | 214300.44 |
| ## 62 | 2024-08-19 | 254358.7 | 237472.2 | 207786.7 | 216794.88 |
| ## 63 | 2024-08-20 | 250659.4 | 240278.1 | 209094.2 | 212263.56 |
| ## 64 | 2024-08-21 | 250215.8 | 239925.6 | 210710.5 | 214839.18 |
| ## 65 | 2024-08-22 | 250866.0 | 239911.5 | 211654.8 | 205587.12 |
| ## 66 | 2024-08-23 | 256747.7 | 238529.7 | 211745.6 | 208453.02 |
| ## 67 | 2024-08-26 | 255966.5 | 240193.5 | 211146.3 | 201451.86 |
| ## 68 | 2024-08-27 | 255659.0 | 238642.5 | 211564.0 | 201828.24 |
| ## 69 | 2024-08-28 | 253678.3 | 238374.6 | 213198.4 | 198057.06 |
| ## 70 | 2024-08-29 | 257090.4 | 239742.3 | 213307.4 | 196140.72 |
| ## 71 | 2024-08-30 | 257166.0 | 241871.4 | 215105.2 | 201968.46 |
| ## 72 | 2024-09-03 | 245679.8 | 246073.2 | 211709.3 | 188367.12 |
| ## 73 | 2024-09-04 | 247282.6 | 248019.0 | 210292.8 | 188052.24 |
| ## 74 | 2024-09-05 | 245891.5 | 247412.7 | 215359.4 | 185956.32 |
| ## 75 | 2024-09-06 | 241723.4 | 247581.9 | 213997.4 | 180522.18 |
| ## 76 | 2024-09-09 | 246239.3 | 248244.6 | 209584.6 | 180640.26 |
| ## 77 | 2024-09-10 | 235433.5 | 250683.9 | 209439.3 | 179963.76 |
| ## 78 | 2024-09-11 | 237469.7 | 245227.2 | 208313.4 | 188645.10 |
| ## 79 | 2024-09-12 | 238926.2 | 244592.7 | 209294.0 | 183953.88 |
| ## 80 | 2024-09-13 | 241411.0 | 245452.8 | 210401.8 | 189351.12 |
| ## 81 | 2024-09-16 | 244520.6 | 249908.4 | 214215.4 | 186583.62 |
| ## 82 | 2024-09-17 | 244636.6 | 247990.8 | 214814.6 | 188445.84 |
| ## 83 | 2024-09-18 | 244228.3 | 245227.2 | 215450.2 | 185944.02 |
| ## 84 | 2024-09-19 | 253930.3 | 241871.4 | 212889.7 | 194111.22 |
| ## 85 | 2024-09-20 | 251208.7 | 245650.2 | 212780.7 | 190204.74 |
| ## 86 | 2024-09-23 | 250694.6 | 245015.7 | 209984.1 | 192883.68 |
| ## 87 | 2024-09-24 | 251002.1 | 244268.4 | 208767.4 | 194600.76 |
| ## 88 | 2024-09-25 | 247534.6 | 242886.6 | 208349.7 | 197722.50 |
| ## 89 | 2024-09-26 | 250447.7 | 244226.1 | 205371.4 | 208485.00 |
| ## 90 | 2024-09-27 | 251249.0 | 244705.5 | 206461.0 | 203471.52 |
| ## 91 | 2024-09-30 | 249535.4 | 244212.0 | 206225.0 | 200755.68 |
| ## 92 | 2024-10-01 | 247045.7 | 243986.4 | 208367.8 | 196155.48 |
| ## 93 | 2024-10-02 | 247963.0 | 242407.2 | 203537.3 | 200266.14 |
| ## 94 | 2024-10-03 | 244994.4 | 239869.2 | 200086.9 | 19953.06  |
| ## 95 | 2024-10-04 | 249560.6 | 238120.8 | 199342.3 | 20058.84  |
| ## 96 | 2024-10-07 | 249288.5 | 235639.2 | 197199.4 | 19830.06  |
| ## 97 | 2024-10-08 | 250271.3 | 237105.6 | 197072.3 | 19928.46  |



|        |                 |               |                  |                   |          |
|--------|-----------------|---------------|------------------|-------------------|----------|
| ## 98  | 2024-10-09      | 254610.7      | 238670.7         | 200250.3          | 20383.56 |
| ## 99  | 2024-10-10      | 253874.9      | 238219.5         | 198670.4          | 20186.76 |
| ## 100 | 2024-10-11      | 260215.2      | 241236.9         | 199269.7          | 20390.94 |
| ##     | Total_Valuation | Daily_Return  | SPY_Daily_Return | Return_Difference |          |
| ## 1   | 949064.3        | NA            | NA               | NA                |          |
| ## 2   | 945308.6        | -3.957224e-03 | -2.879404e-03    | -0.0010778202     |          |
| ## 3   | 938007.9        | -7.723107e-03 | -7.304230e-03    | -0.0004188776     |          |
| ## 4   | 939464.1        | 1.552396e-03  | 6.616473e-03     | -0.0050640765     |          |
| ## 5   | 929638.7        | -1.045845e-02 | 6.988516e-04     | -0.0111573036     |          |
| ## 6   | 921471.6        | -8.785262e-03 | -7.002510e-03    | -0.0017827518     |          |
| ## 7   | 916172.4        | -5.750823e-03 | -6.633720e-03    | 0.0008828970      |          |
| ## 8   | 919448.4        | 3.575703e-03  | 9.108130e-03     | -0.0055324278     |          |
| ## 9   | 924842.1        | 5.866300e-03  | 8.153668e-04     | 0.0050509333      |          |
| ## 10  | 925684.2        | 9.105554e-04  | 1.117848e-03     | -0.0002072923     |          |
| ## 11  | 940941.5        | 1.648219e-02  | 1.188516e-02     | 0.0045970256      |          |
| ## 12  | 942148.2        | 1.282354e-03  | -1.870313e-05    | 0.0013010570      |          |
| ## 13  | 938955.1        | -3.389148e-03 | -1.215726e-03    | -0.0021734226     |          |
| ## 14  | 950093.8        | 1.186285e-02  | 3.089830e-03     | 0.0087730167      |          |
| ## 15  | 945418.8        | -4.920504e-03 | 2.408244e-03     | -0.0073287479     |          |
| ## 16  | 950748.8        | 5.637671e-03  | 8.213055e-03     | -0.0025753845     |          |
| ## 17  | 950005.4        | -7.818680e-04 | 2.013448e-03     | -0.0027953156     |          |
| ## 18  | 950176.5        | 1.800832e-04  | 6.083510e-04     | -0.0004282678     |          |
| ## 19  | 958243.9        | 8.490444e-03  | 7.959026e-03     | 0.0005314179      |          |
| ## 20  | 968680.8        | 1.089172e-02  | 2.540669e-03     | 0.0083510464      |          |
| ## 21  | 963834.9        | -5.002638e-03 | -2.716549e-03    | -0.0022860894     |          |
| ## 22  | 959910.9        | -4.071175e-03 | -4.552102e-03    | 0.0004809279      |          |
| ## 23  | 963870.5        | 4.124966e-03  | -3.250629e-03    | 0.0073755950      |          |
| ## 24  | 966174.1        | 2.389948e-03  | 3.850831e-03     | -0.0014608835     |          |
| ## 25  | 964378.9        | -1.858092e-03 | 1.248096e-03     | -0.0031061873     |          |
| ## 26  | 955185.3        | -9.533141e-03 | 1.576506e-03     | -0.0111096474     |          |
| ## 27  | 947280.4        | -8.275839e-03 | -3.935062e-03    | -0.0043407766     |          |
| ## 28  | 956301.2        | 9.522883e-03  | 2.057991e-03     | 0.0074648915      |          |
| ## 29  | 961619.7        | 5.561490e-03  | 6.729747e-03     | -0.0011682562     |          |
| ## 30  | 961729.6        | 1.143279e-04  | 4.462578e-03     | -0.0043482502     |          |
| ## 31  | 964412.1        | 2.789225e-03  | 5.766511e-03     | -0.0029772860     |          |
| ## 32  | 968475.0        | 4.212846e-03  | 1.153902e-03     | 0.0030589447      |          |
| ## 33  | 974462.9        | 6.182751e-03  | 9.724824e-04     | 0.0052102688      |          |
| ## 34  | 985041.2        | 1.085552e-02  | 9.895290e-03     | 0.0009602291      |          |
| ## 35  | 969898.1        | -1.537304e-02 | -8.622533e-03    | -0.0067505103     |          |
| ## 36  | 971967.5        | 2.133647e-03  | 6.307504e-03     | -0.0041738574     |          |
| ## 37  | 975808.7        | 3.951984e-03  | 2.750049e-03     | 0.0012019349      |          |
| ## 38  | 981414.2        | 5.744425e-03  | 5.930226e-03     | -0.0001858012     |          |
| ## 39  | 958674.6        | -2.317016e-02 | -1.402117e-02    | -0.0091489834     |          |
| ## 40  | 942527.8        | -1.684284e-02 | -7.684849e-03    | -0.0091579869     |          |
| ## 41  | 935235.7        | -7.736790e-03 | -6.640611e-03    | -0.0010961792     |          |
| ## 42  | 951310.5        | 1.718792e-02  | 1.030984e-02     | 0.0068780821      |          |
| ## 43  | 944935.6        | -6.701114e-03 | -1.568557e-03    | -0.0051325574     |          |
| ## 44  | 934675.5        | -1.085797e-02 | -2.266243e-02    | 0.0118044619      |          |
| ## 45  | 929188.0        | -5.871107e-03 | -5.210354e-03    | -0.0006607527     |          |
| ## 46  | 937509.8        | 8.956057e-03  | 1.119964e-02     | -0.0022435868     |          |
| ## 47  | 939496.3        | 2.118890e-03  | 5.877599e-04     | 0.0015311299      |          |
| ## 48  | 902444.2        | -3.943822e-02 | -5.066451e-03    | -0.0343717668     |          |
| ## 49  | 915291.8        | 1.423645e-02  | 1.625461e-02     | -0.0020181651     |          |

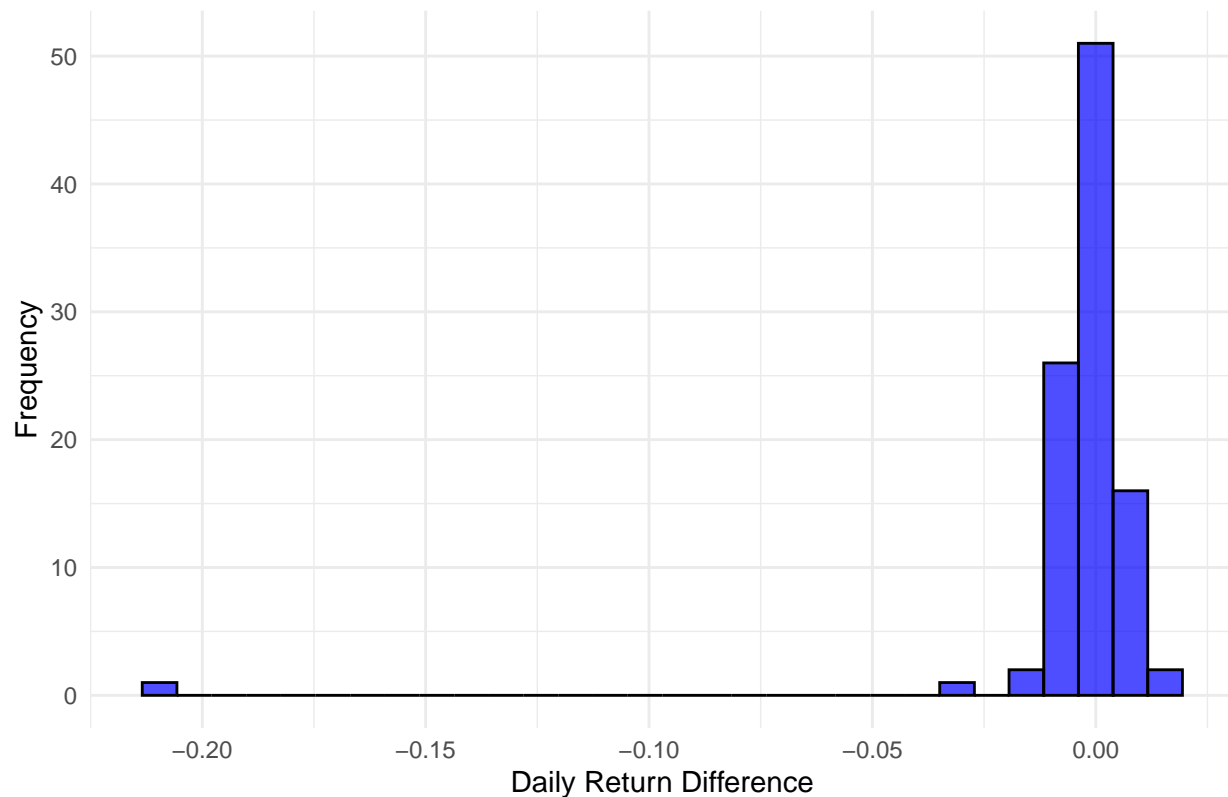


|        |          |               |               |               |
|--------|----------|---------------|---------------|---------------|
| ## 50  | 896641.7 | -2.037619e-02 | -1.416096e-02 | -0.0062152266 |
| ## 51  | 873916.6 | -2.534471e-02 | -1.861844e-02 | -0.0067262646 |
| ## 52  | 861781.6 | -1.388574e-02 | -2.912366e-02 | 0.0152379208  |
| ## 53  | 865308.0 | 4.092011e-03  | 9.219529e-03  | -0.0051275178 |
| ## 54  | 866427.4 | 1.293620e-03  | -6.683903e-03 | 0.0079775234  |
| ## 55  | 889219.5 | 2.630584e-02  | 2.311726e-02  | 0.0031885762  |
| ## 56  | 894318.6 | 5.734422e-03  | 4.409686e-03  | 0.0013247360  |
| ## 57  | 885452.7 | -9.913603e-03 | 5.253382e-04  | -0.0104389412 |
| ## 58  | 898375.9 | 1.459495e-02  | 1.644570e-02  | -0.0018507509 |
| ## 59  | 903565.3 | 5.776424e-03  | 3.154749e-03  | 0.0026216754  |
| ## 60  | 913008.8 | 1.045146e-02  | 1.714023e-02  | -0.0066887656 |
| ## 61  | 911597.1 | -1.546250e-03 | 2.242031e-03  | -0.0037882809 |
| ## 62  | 916412.5 | 5.282399e-03  | 9.561437e-03  | -0.0042790373 |
| ## 63  | 912295.3 | -4.492802e-03 | -1.626132e-03 | -0.0028666695 |
| ## 64  | 915691.1 | 3.722304e-03  | 3.436549e-03  | 0.0002857545  |
| ## 65  | 908019.4 | -8.378022e-03 | -7.848453e-03 | -0.0005295683 |
| ## 66  | 915476.0 | 8.211917e-03  | 1.062529e-02  | -0.0024133753 |
| ## 67  | 908758.2 | -7.338084e-03 | -2.383790e-03 | -0.0049542940 |
| ## 68  | 907693.8 | -1.171247e-03 | 1.373063e-03  | -0.0025443097 |
| ## 69  | 903308.4 | -4.831365e-03 | -5.805257e-03 | 0.0009738917  |
| ## 70  | 906280.8 | 3.290571e-03  | 8.955759e-05  | 0.0032010130  |
| ## 71  | 916111.1 | 1.084684e-02  | 9.545984e-03  | 0.0013008534  |
| ## 72  | 891829.4 | -2.650511e-02 | -2.057905e-02 | -0.0059260532 |
| ## 73  | 893646.6 | 2.037564e-03  | -2.046805e-03 | 0.0040843693  |
| ## 74  | 894620.0 | 1.089223e-03  | -2.432163e-03 | 0.0035213851  |
| ## 75  | 883825.0 | -1.206660e-02 | -1.683012e-02 | 0.0047635175  |
| ## 76  | 884708.7 | 9.999039e-04  | 1.119624e-02  | -0.0101963357 |
| ## 77  | 875520.5 | -1.038561e-02 | 4.355704e-03  | -0.0147413141 |
| ## 78  | 879655.3 | 4.722768e-03  | 1.025893e-02  | -0.0055361653 |
| ## 79  | 876766.8 | -3.283695e-03 | 8.423217e-03  | -0.0117069122 |
| ## 80  | 886616.6 | 1.123425e-02  | 5.222773e-03  | 0.0060114800  |
| ## 81  | 895228.0 | 9.712631e-03  | 1.476842e-03  | 0.0082357887  |
| ## 82  | 895887.8 | 7.370413e-04  | 4.086419e-04  | 0.0003283994  |
| ## 83  | 890849.8 | -5.623539e-03 | -2.965883e-03 | -0.0026576553 |
| ## 84  | 902802.6 | 1.341735e-02  | 1.706448e-02  | -0.0036471354 |
| ## 85  | 899844.4 | -3.276730e-03 | -4.781253e-03 | 0.0015045238  |
| ## 86  | 898578.1 | -1.407221e-03 | 2.498900e-03  | -0.0039061212 |
| ## 87  | 898638.6 | 6.732859e-05  | 2.861306e-03  | -0.0027939771 |
| ## 88  | 896493.3 | -2.387233e-03 | -2.205496e-03 | -0.0001817371 |
| ## 89  | 908530.2 | 1.342663e-02  | 3.964634e-03  | 0.0094619911  |
| ## 90  | 905887.1 | -2.909226e-03 | -1.450288e-03 | -0.0014589380 |
| ## 91  | 900728.1 | -5.694992e-03 | 4.007209e-03  | -0.0097022017 |
| ## 92  | 895555.4 | -5.742776e-03 | -8.958450e-03 | 0.0032156731  |
| ## 93  | 894173.6 | -1.542975e-03 | 4.220745e-04  | -0.0019650500 |
| ## 94  | 704903.5 | -2.116704e-01 | -1.828218e-03 | -0.2098421382 |
| ## 95  | 707082.6 | 3.091288e-03  | 9.087387e-03  | -0.0059960986 |
| ## 96  | 701957.2 | -7.248686e-03 | -9.040455e-03 | 0.0017917688  |
| ## 97  | 704377.7 | 3.448188e-03  | 9.457555e-03  | -0.0060093679 |
| ## 98  | 713915.3 | 1.354052e-02  | 6.926392e-03  | 0.0066141285  |
| ## 99  | 710951.5 | -4.151417e-03 | -1.750009e-03 | -0.0024014082 |
| ## 100 | 721112.7 | 1.429237e-02  | 5.988232e-03  | 0.0083041347  |

```
# Plot histogram of daily return differences
ggplot(valuation_df, aes(x = Return_Difference)) +
  geom_histogram(bins = 30, fill = "blue", color = "black", alpha = 0.7) +
  labs(title = "Histogram of Daily Return Differences (Portfolio - SPY)",
       x = "Daily Return Difference",
       y = "Frequency") +
  theme_minimal()
## Warning: Removed 1 row containing non-finite outside the scale range
## (`stat_bin()`).
```

### 5.2.1 Histogram of Daily Return of Portfolio minus Return of SPY

Histogram of Daily Return Differences (Portfolio – SPY)



```
# Identify the days with the largest and lowest returns
largest_return <- valuation_df[which.max(valuation_df$Return_Difference), ]
lowest_return <- valuation_df[which.min(valuation_df$Return_Difference), ]

cat("Day with Largest Return Difference:\n")
## Day with Largest Return Difference:
cat("Date:", format(largest_return$timestamp, "%Y-%m-%d"), "\n")
## Date: 2024-08-05
cat("Return Difference:", largest_return$Return_Difference, "\n")
## Return Difference: 0.01523792

cat("\nDay with Lowest Return Difference:\n")
##
## Day with Lowest Return Difference:
cat("Date:", format(lowest_return$timestamp, "%Y-%m-%d"), "\n")
```

```
## Date: 2024-10-03
cat("Return Difference:", lowest_return$Return_Difference, "\n")
## Return Difference: -0.2098421
```

**5.2.1.1 Largest Return Difference Date** A closer look at largest return difference day to compare each stock's return to SPY's return on that day

```
get_previous_index <- function(data_frame, current_index) {
  if (current_index == 1) return(NA) # No previous date for the first row
  for (i in (current_index - 1):1) {
    if (!is.na(data_frame$timestamp[i])) {
      return(i)
    }
  }
  return(NA)
}

largest_index <- which(valuation_df$timestamp == largest_return$timestamp)
previous_largest_index <- get_previous_index(valuation_df, largest_index)

for (stock in stocks[stocks != "SPY"]) {
  stock_val_today <- valuation_df[largest_index, paste0(stock, "_valuation")]
  stock_val_previous <- valuation_df[previous_largest_index, paste0(stock, "_valuation")]
  stock_return <- (stock_val_today / stock_val_previous) - 1

  spy_return <- largest_return$SPY_Daily_Return

  return_diff <- stock_return - spy_return

  cat(stock, "Return:", round(stock_return * 100, 2), "%", "\n")
  cat("Compared to SPY (SPY Return:", round(spy_return * 100, 2), "%)\n")
  cat("Difference:", round(return_diff * 100, 2), "%\n\n")
}

## GS Return: -2.47 %
## Compared to SPY (SPY Return: -2.91 %)
## Difference: 0.44 %
##
## PG Return: -1.19 %
## Compared to SPY (SPY Return: -2.91 %)
## Difference: 1.72 %
##
## MRK Return: -2.51 %
## Compared to SPY (SPY Return: -2.91 %)
## Difference: 0.4 %
##
## LRCX Return: 0.97 %
## Compared to SPY (SPY Return: -2.91 %)
## Difference: 3.88 %
```

Comment:

Apparently, stock of Lam Research Corporation outperforms the benchmark SPY by a large margin which is about 3.88%. The driving force behind the scene could be that the earning per share of Lam's Research Corporation beats market's expectation according to <https://www.sahmcapital.com/news/content/lam-research-full-year-2024-earnings-eps-beats-expectations-2024-08-05>. Additionally, the Q2 financial results of

LRCX was released around 31th July which could account for an upward trend of LRCX return.

**5.2.1.2 Least Return Difference Date** A closer look at least return difference day to compare each stock's return to SPY's return on that day

```
smallest_index <- which(valuation_df$timestamp == lowest_return$timestamp)
previous_smallest_index <- get_previous_index(valuation_df, smallest_index)

for (stock in stocks[stocks != "SPY"]) {
  stock_val_today <- valuation_df[smallest_index, paste0(stock, "_valuation")]
  stock_val_previous <- valuation_df[previous_smallest_index, paste0(stock, "_valuation")]
  stock_return <- (stock_val_today / stock_val_previous) - 1

  spy_return <- lowest_return$SPY_Daily_Return

  return_diff <- stock_return - spy_return

  cat(stock, "Return:", round(stock_return * 100, 2), "%", "\n")
  cat("Compared to SPY (SPY Return:", round(spy_return * 100, 2), "%)\n")
  cat("Difference:", round(return_diff * 100, 2), "%\n\n")
}

## GS Return: -1.2 %
## Compared to SPY (SPY Return: -0.18 %)
## Difference: -1.01 %
##
## PG Return: -1.05 %
## Compared to SPY (SPY Return: -0.18 %)
## Difference: -0.86 %
##
## MRK Return: -1.7 %
## Compared to SPY (SPY Return: -0.18 %)
## Difference: -1.51 %
##
## LRCX Return: -90.04 %
## Compared to SPY (SPY Return: -0.18 %)
## Difference: -89.85 %
```

Comment:

Well, the main driver is Lam Research Corporation again as it announced a significant change of capital structure on 02/10/2024 which is just one day before the least return difference observed. Lam Research Corporation implemented a **ten-for-one (10:1)** forward stock split and increasing its authorized shares of common stock tenfold. According to <https://www.investing.com/news/company-news/lam-research-enacts-10for1-stock-split-increases-authorized-shares-93CH-3646202>, Lam Research's recent stock split aligns with its strong market position and financial performance. According to InvestingPro data, the company boasts a substantial market capitalization of \$105.45 billion, reflecting its significant presence in the semiconductor industry. This move to increase accessibility to its shares comes at a time when Lam Research has demonstrated robust financial health and shareholder value.

```
initial_spy_price <- SPY_data$close[1]
spy_investment <- investable_cash

spy_fractional_shares <- spy_investment / initial_spy_price
```

```

spy_valuation <- SPY_data$close * spy_fractional_shares

valuation_df$SPY_Valuation <- spy_valuation
valuation_df

```

|       | timestamp  | GS_valuation | PG_valuation | MRK_valuation | LRCX_valuation |
|-------|------------|--------------|--------------|---------------|----------------|
| ## 1  | 2024-05-21 | 237086.6     | 237373.5     | 237460.2      | 237144.00      |
| ## 2  | 2024-05-22 | 233039.5     | 236612.1     | 238077.6      | 237579.42      |
| ## 3  | 2024-05-23 | 230907.6     | 233340.9     | 238059.4      | 235699.98      |
| ## 4  | 2024-05-24 | 232434.7     | 233115.3     | 235153.8      | 238760.22      |
| ## 5  | 2024-05-28 | 231744.2     | 229985.1     | 228979.4      | 238929.96      |
| ## 6  | 2024-05-29 | 230413.7     | 227926.5     | 228634.4      | 234497.04      |
| ## 7  | 2024-05-30 | 226915.9     | 229237.8     | 226146.5      | 233872.20      |
| ## 8  | 2024-05-31 | 230086.1     | 232001.4     | 227980.6      | 229380.24      |
| ## 9  | 2024-06-03 | 229309.9     | 232156.5     | 233210.7      | 230164.98      |
| ## 10 | 2024-06-04 | 229471.2     | 235484.1     | 233737.4      | 226991.58      |
| ## 11 | 2024-06-05 | 232686.7     | 234130.5     | 235081.2      | 239043.12      |
| ## 12 | 2024-06-06 | 230882.4     | 237542.7     | 237024.3      | 236698.74      |
| ## 13 | 2024-06-07 | 229274.6     | 235554.6     | 237296.7      | 236829.12      |
| ## 14 | 2024-06-10 | 228589.2     | 235963.5     | 238785.8      | 246755.22      |
| ## 15 | 2024-06-11 | 223912.1     | 236146.8     | 239421.4      | 245938.50      |
| ## 16 | 2024-06-12 | 226144.8     | 232903.8     | 236443.2      | 255256.98      |
| ## 17 | 2024-06-13 | 224960.4     | 234638.1     | 234935.9      | 255471.00      |
| ## 18 | 2024-06-14 | 225015.8     | 235173.9     | 235135.7      | 254851.08      |
| ## 19 | 2024-06-17 | 226890.7     | 236175.0     | 231540.0      | 263638.20      |
| ## 20 | 2024-06-18 | 230544.7     | 237669.6     | 232429.8      | 268036.68      |
| ## 21 | 2024-06-20 | 230857.2     | 236414.7     | 235480.7      | 261082.26      |
| ## 22 | 2024-06-21 | 226890.7     | 237246.6     | 237387.5      | 258386.10      |
| ## 23 | 2024-06-24 | 232893.4     | 237514.5     | 241455.4      | 252007.32      |
| ## 24 | 2024-06-25 | 230519.5     | 235258.5     | 241382.7      | 259013.40      |
| ## 25 | 2024-06-26 | 229753.4     | 236104.5     | 238804.0      | 259716.96      |
| ## 26 | 2024-06-27 | 224763.8     | 234934.2     | 235753.1      | 259734.18      |
| ## 27 | 2024-06-28 | 227969.3     | 232537.2     | 224820.8      | 261953.10      |
| ## 28 | 2024-07-01 | 233684.6     | 229435.2     | 232266.4      | 260914.98      |
| ## 29 | 2024-07-02 | 234667.4     | 231099.0     | 231939.5      | 263913.72      |
| ## 30 | 2024-07-03 | 235831.7     | 231000.3     | 228543.6      | 266354.04      |
| ## 31 | 2024-07-05 | 234234.0     | 232946.1     | 229633.2      | 267598.80      |
| ## 32 | 2024-07-08 | 234269.3     | 234793.2     | 228416.5      | 270996.06      |
| ## 33 | 2024-07-09 | 238306.3     | 233580.6     | 228888.6      | 273687.30      |
| ## 34 | 2024-07-10 | 241360.6     | 235188.0     | 231176.8      | 277315.80      |
| ## 35 | 2024-07-11 | 241531.9     | 233411.4     | 234209.5      | 260745.24      |
| ## 36 | 2024-07-12 | 241859.5     | 234920.1     | 232012.2      | 263175.72      |
| ## 37 | 2024-07-15 | 248083.9     | 232057.8     | 232665.9      | 263001.06      |
| ## 38 | 2024-07-16 | 253522.1     | 235399.5     | 227799.0      | 264693.54      |
| ## 39 | 2024-07-17 | 253098.7     | 238910.4     | 228616.2      | 238049.28      |
| ## 40 | 2024-07-18 | 245049.8     | 237500.4     | 225638.0      | 234339.60      |
| ## 41 | 2024-07-19 | 244404.7     | 236823.6     | 228398.3      | 225609.06      |
| ## 42 | 2024-07-22 | 245468.2     | 237232.5     | 228253.0      | 240356.76      |
| ## 43 | 2024-07-23 | 248043.6     | 234934.2     | 225874.1      | 236083.74      |
| ## 44 | 2024-07-24 | 245296.8     | 236880.0     | 228670.7      | 223828.02      |
| ## 45 | 2024-07-25 | 247821.8     | 235329.0     | 228543.6      | 217493.52      |
| ## 46 | 2024-07-26 | 251511.1     | 238445.1     | 227472.2      | 220081.44      |
| ## 47 | 2024-07-29 | 248330.9     | 239601.3     | 232048.5      | 219515.64      |
| ## 48 | 2024-07-30 | 254857.7     | 227997.0     | 209294.0      | 210295.56      |

|        |                 |              |                  |                   |           |
|--------|-----------------|--------------|------------------|-------------------|-----------|
| ## 49  | 2024-07-31      | 256551.1     | 226671.6         | 205444.1          | 226625.04 |
| ## 50  | 2024-08-01      | 252060.5     | 233622.9         | 206697.1          | 204261.18 |
| ## 51  | 2024-08-02      | 237202.6     | 239812.8         | 209203.2          | 187698.00 |
| ## 52  | 2024-08-05      | 231346.1     | 236964.6         | 203955.0          | 189515.94 |
| ## 53  | 2024-08-06      | 236990.9     | 237006.9         | 201848.4          | 189461.82 |
| ## 54  | 2024-08-07      | 238397.0     | 239728.2         | 204281.8          | 184020.30 |
| ## 55  | 2024-08-08      | 244828.1     | 240926.7         | 206878.7          | 196585.98 |
| ## 56  | 2024-08-09      | 247091.0     | 240461.4         | 208022.8          | 198743.40 |
| ## 57  | 2024-08-12      | 244692.0     | 235202.1         | 206079.7          | 199478.94 |
| ## 58  | 2024-08-13      | 247937.8     | 235878.9         | 207732.2          | 206826.96 |
| ## 59  | 2024-08-14      | 251344.8     | 238008.0         | 206261.3          | 207951.18 |
| ## 60  | 2024-08-15      | 251506.1     | 236767.2         | 205771.0          | 218964.60 |
| ## 61  | 2024-08-16      | 254147.0     | 236724.9         | 206424.7          | 214300.44 |
| ## 62  | 2024-08-19      | 254358.7     | 237472.2         | 207786.7          | 216794.88 |
| ## 63  | 2024-08-20      | 250659.4     | 240278.1         | 209094.2          | 212263.56 |
| ## 64  | 2024-08-21      | 250215.8     | 239925.6         | 210710.5          | 214839.18 |
| ## 65  | 2024-08-22      | 250866.0     | 239911.5         | 211654.8          | 205587.12 |
| ## 66  | 2024-08-23      | 256747.7     | 238529.7         | 211745.6          | 208453.02 |
| ## 67  | 2024-08-26      | 255966.5     | 240193.5         | 211146.3          | 201451.86 |
| ## 68  | 2024-08-27      | 255659.0     | 238642.5         | 211564.0          | 201828.24 |
| ## 69  | 2024-08-28      | 253678.3     | 238374.6         | 213198.4          | 198057.06 |
| ## 70  | 2024-08-29      | 257090.4     | 239742.3         | 213307.4          | 196140.72 |
| ## 71  | 2024-08-30      | 257166.0     | 241871.4         | 215105.2          | 201968.46 |
| ## 72  | 2024-09-03      | 245679.8     | 246073.2         | 211709.3          | 188367.12 |
| ## 73  | 2024-09-04      | 247282.6     | 248019.0         | 210292.8          | 188052.24 |
| ## 74  | 2024-09-05      | 245891.5     | 247412.7         | 215359.4          | 185956.32 |
| ## 75  | 2024-09-06      | 241723.4     | 247581.9         | 213997.4          | 180522.18 |
| ## 76  | 2024-09-09      | 246239.3     | 248244.6         | 209584.6          | 180640.26 |
| ## 77  | 2024-09-10      | 235433.5     | 250683.9         | 209439.3          | 179963.76 |
| ## 78  | 2024-09-11      | 237469.7     | 245227.2         | 208313.4          | 188645.10 |
| ## 79  | 2024-09-12      | 238926.2     | 244592.7         | 209294.0          | 183953.88 |
| ## 80  | 2024-09-13      | 241411.0     | 245452.8         | 210401.8          | 189351.12 |
| ## 81  | 2024-09-16      | 244520.6     | 249908.4         | 214215.4          | 186583.62 |
| ## 82  | 2024-09-17      | 244636.6     | 247990.8         | 214814.6          | 188445.84 |
| ## 83  | 2024-09-18      | 244228.3     | 245227.2         | 215450.2          | 185944.02 |
| ## 84  | 2024-09-19      | 253930.3     | 241871.4         | 212889.7          | 194111.22 |
| ## 85  | 2024-09-20      | 251208.7     | 245650.2         | 212780.7          | 190204.74 |
| ## 86  | 2024-09-23      | 250694.6     | 245015.7         | 209984.1          | 192883.68 |
| ## 87  | 2024-09-24      | 251002.1     | 244268.4         | 208767.4          | 194600.76 |
| ## 88  | 2024-09-25      | 247534.6     | 242886.6         | 208349.7          | 197722.50 |
| ## 89  | 2024-09-26      | 250447.7     | 244226.1         | 205371.4          | 208485.00 |
| ## 90  | 2024-09-27      | 251249.0     | 244705.5         | 206461.0          | 203471.52 |
| ## 91  | 2024-09-30      | 249535.4     | 244212.0         | 206225.0          | 200755.68 |
| ## 92  | 2024-10-01      | 247045.7     | 243986.4         | 208367.8          | 196155.48 |
| ## 93  | 2024-10-02      | 247963.0     | 242407.2         | 203537.3          | 200266.14 |
| ## 94  | 2024-10-03      | 244994.4     | 239869.2         | 200086.9          | 19953.06  |
| ## 95  | 2024-10-04      | 249560.6     | 238120.8         | 199342.3          | 20058.84  |
| ## 96  | 2024-10-07      | 249288.5     | 235639.2         | 197199.4          | 19830.06  |
| ## 97  | 2024-10-08      | 250271.3     | 237105.6         | 197072.3          | 19928.46  |
| ## 98  | 2024-10-09      | 254610.7     | 238670.7         | 200250.3          | 20383.56  |
| ## 99  | 2024-10-10      | 253874.9     | 238219.5         | 198670.4          | 20186.76  |
| ## 100 | 2024-10-11      | 260215.2     | 241236.9         | 199269.7          | 20390.94  |
| ##     | Total_Valuation | Daily_Return | SPY_Daily_Return | Return_Difference |           |

|       |          |               |               |               |
|-------|----------|---------------|---------------|---------------|
| ## 1  | 949064.3 | NA            | NA            | NA            |
| ## 2  | 945308.6 | -3.957224e-03 | -2.879404e-03 | -0.0010778202 |
| ## 3  | 938007.9 | -7.723107e-03 | -7.304230e-03 | -0.0004188776 |
| ## 4  | 939464.1 | 1.552396e-03  | 6.616473e-03  | -0.0050640765 |
| ## 5  | 929638.7 | -1.045845e-02 | 6.988516e-04  | -0.0111573036 |
| ## 6  | 921471.6 | -8.785262e-03 | -7.002510e-03 | -0.0017827518 |
| ## 7  | 916172.4 | -5.750823e-03 | -6.633720e-03 | 0.0008828970  |
| ## 8  | 919448.4 | 3.575703e-03  | 9.108130e-03  | -0.0055324278 |
| ## 9  | 924842.1 | 5.866300e-03  | 8.153668e-04  | 0.0050509333  |
| ## 10 | 925684.2 | 9.105554e-04  | 1.117848e-03  | -0.0002072923 |
| ## 11 | 940941.5 | 1.648219e-02  | 1.188516e-02  | 0.0045970256  |
| ## 12 | 942148.2 | 1.282354e-03  | -1.870313e-05 | 0.0013010570  |
| ## 13 | 938955.1 | -3.389148e-03 | -1.215726e-03 | -0.0021734226 |
| ## 14 | 950093.8 | 1.186285e-02  | 3.089830e-03  | 0.0087730167  |
| ## 15 | 945418.8 | -4.920504e-03 | 2.408244e-03  | -0.0073287479 |
| ## 16 | 950748.8 | 5.637671e-03  | 8.213055e-03  | -0.0025753845 |
| ## 17 | 950005.4 | -7.818680e-04 | 2.013448e-03  | -0.0027953156 |
| ## 18 | 950176.5 | 1.800832e-04  | 6.083510e-04  | -0.0004282678 |
| ## 19 | 958243.9 | 8.490444e-03  | 7.959026e-03  | 0.0005314179  |
| ## 20 | 968680.8 | 1.089172e-02  | 2.540669e-03  | 0.0083510464  |
| ## 21 | 963834.9 | -5.002638e-03 | -2.716549e-03 | -0.0022860894 |
| ## 22 | 959910.9 | -4.071175e-03 | -4.552102e-03 | 0.0004809279  |
| ## 23 | 963870.5 | 4.124966e-03  | -3.250629e-03 | 0.0073755950  |
| ## 24 | 966174.1 | 2.389948e-03  | 3.850831e-03  | -0.0014608835 |
| ## 25 | 964378.9 | -1.858092e-03 | 1.248096e-03  | -0.0031061873 |
| ## 26 | 955185.3 | -9.533141e-03 | 1.576506e-03  | -0.0111096474 |
| ## 27 | 947280.4 | -8.275839e-03 | -3.935062e-03 | -0.0043407766 |
| ## 28 | 956301.2 | 9.522883e-03  | 2.057991e-03  | 0.0074648915  |
| ## 29 | 961619.7 | 5.561490e-03  | 6.729747e-03  | -0.0011682562 |
| ## 30 | 961729.6 | 1.143279e-04  | 4.462578e-03  | -0.0043482502 |
| ## 31 | 964412.1 | 2.789225e-03  | 5.766511e-03  | -0.0029772860 |
| ## 32 | 968475.0 | 4.212846e-03  | 1.153902e-03  | 0.0030589447  |
| ## 33 | 974462.9 | 6.182751e-03  | 9.724824e-04  | 0.0052102688  |
| ## 34 | 985041.2 | 1.085552e-02  | 9.895290e-03  | 0.0009602291  |
| ## 35 | 969898.1 | -1.537304e-02 | -8.622533e-03 | -0.0067505103 |
| ## 36 | 971967.5 | 2.133647e-03  | 6.307504e-03  | -0.0041738574 |
| ## 37 | 975808.7 | 3.951984e-03  | 2.750049e-03  | 0.0012019349  |
| ## 38 | 981414.2 | 5.744425e-03  | 5.930226e-03  | -0.0001858012 |
| ## 39 | 958674.6 | -2.317016e-02 | -1.402117e-02 | -0.0091489834 |
| ## 40 | 942527.8 | -1.684284e-02 | -7.684849e-03 | -0.0091579869 |
| ## 41 | 935235.7 | -7.736790e-03 | -6.640611e-03 | -0.0010961792 |
| ## 42 | 951310.5 | 1.718792e-02  | 1.030984e-02  | 0.0068780821  |
| ## 43 | 944935.6 | -6.701114e-03 | -1.568557e-03 | -0.0051325574 |
| ## 44 | 934675.5 | -1.085797e-02 | -2.266243e-02 | 0.0118044619  |
| ## 45 | 929188.0 | -5.871107e-03 | -5.210354e-03 | -0.0006607527 |
| ## 46 | 937509.8 | 8.956057e-03  | 1.119964e-02  | -0.0022435868 |
| ## 47 | 939496.3 | 2.118890e-03  | 5.877599e-04  | 0.0015311299  |
| ## 48 | 902444.2 | -3.943822e-02 | -5.066451e-03 | -0.0343717668 |
| ## 49 | 915291.8 | 1.423645e-02  | 1.625461e-02  | -0.0020181651 |
| ## 50 | 896641.7 | -2.037619e-02 | -1.416096e-02 | -0.0062152266 |
| ## 51 | 873916.6 | -2.534471e-02 | -1.861844e-02 | -0.0067262646 |
| ## 52 | 861781.6 | -1.388574e-02 | -2.912366e-02 | 0.0152379208  |
| ## 53 | 865308.0 | 4.092011e-03  | 9.219529e-03  | -0.0051275178 |



|        |               |               |               |               |
|--------|---------------|---------------|---------------|---------------|
| ## 54  | 866427.4      | 1.293620e-03  | -6.683903e-03 | 0.0079775234  |
| ## 55  | 889219.5      | 2.630584e-02  | 2.311726e-02  | 0.0031885762  |
| ## 56  | 894318.6      | 5.734422e-03  | 4.409686e-03  | 0.0013247360  |
| ## 57  | 885452.7      | -9.913603e-03 | 5.253382e-04  | -0.0104389412 |
| ## 58  | 898375.9      | 1.459495e-02  | 1.644570e-02  | -0.0018507509 |
| ## 59  | 903565.3      | 5.776424e-03  | 3.154749e-03  | 0.0026216754  |
| ## 60  | 913008.8      | 1.045146e-02  | 1.714023e-02  | -0.0066887656 |
| ## 61  | 911597.1      | -1.546250e-03 | 2.242031e-03  | -0.0037882809 |
| ## 62  | 916412.5      | 5.282399e-03  | 9.561437e-03  | -0.0042790373 |
| ## 63  | 912295.3      | -4.492802e-03 | -1.626132e-03 | -0.0028666695 |
| ## 64  | 915691.1      | 3.722304e-03  | 3.436549e-03  | 0.0002857545  |
| ## 65  | 908019.4      | -8.378022e-03 | -7.848453e-03 | -0.0005295683 |
| ## 66  | 915476.0      | 8.211917e-03  | 1.062529e-02  | -0.0024133753 |
| ## 67  | 908758.2      | -7.338084e-03 | -2.383790e-03 | -0.0049542940 |
| ## 68  | 907693.8      | -1.171247e-03 | 1.373063e-03  | -0.0025443097 |
| ## 69  | 903308.4      | -4.831365e-03 | -5.805257e-03 | 0.0009738917  |
| ## 70  | 906280.8      | 3.290571e-03  | 8.955759e-05  | 0.0032010130  |
| ## 71  | 916111.1      | 1.084684e-02  | 9.545984e-03  | 0.0013008534  |
| ## 72  | 891829.4      | -2.650511e-02 | -2.057905e-02 | -0.0059260532 |
| ## 73  | 893646.6      | 2.037564e-03  | -2.046805e-03 | 0.0040843693  |
| ## 74  | 894620.0      | 1.089223e-03  | -2.432163e-03 | 0.0035213851  |
| ## 75  | 883825.0      | -1.206660e-02 | -1.683012e-02 | 0.0047635175  |
| ## 76  | 884708.7      | 9.999039e-04  | 1.119624e-02  | -0.0101963357 |
| ## 77  | 875520.5      | -1.038561e-02 | 4.355704e-03  | -0.0147413141 |
| ## 78  | 879655.3      | 4.722768e-03  | 1.025893e-02  | -0.0055361653 |
| ## 79  | 876766.8      | -3.283695e-03 | 8.423217e-03  | -0.0117069122 |
| ## 80  | 886616.6      | 1.123425e-02  | 5.222773e-03  | 0.0060114800  |
| ## 81  | 895228.0      | 9.712631e-03  | 1.476842e-03  | 0.0082357887  |
| ## 82  | 895887.8      | 7.370413e-04  | 4.086419e-04  | 0.0003283994  |
| ## 83  | 890849.8      | -5.623539e-03 | -2.965883e-03 | -0.0026576553 |
| ## 84  | 902802.6      | 1.341735e-02  | 1.706448e-02  | -0.0036471354 |
| ## 85  | 899844.4      | -3.276730e-03 | -4.781253e-03 | 0.0015045238  |
| ## 86  | 898578.1      | -1.407221e-03 | 2.498900e-03  | -0.0039061212 |
| ## 87  | 898638.6      | 6.732859e-05  | 2.861306e-03  | -0.0027939771 |
| ## 88  | 896493.3      | -2.387233e-03 | -2.205496e-03 | -0.0001817371 |
| ## 89  | 908530.2      | 1.342663e-02  | 3.964634e-03  | 0.0094619911  |
| ## 90  | 905887.1      | -2.909226e-03 | -1.450288e-03 | -0.0014589380 |
| ## 91  | 900728.1      | -5.694992e-03 | 4.007209e-03  | -0.0097022017 |
| ## 92  | 895555.4      | -5.742776e-03 | -8.958450e-03 | 0.0032156731  |
| ## 93  | 894173.6      | -1.542975e-03 | 4.220745e-04  | -0.0019650500 |
| ## 94  | 704903.5      | -2.116704e-01 | -1.828218e-03 | -0.2098421382 |
| ## 95  | 707082.6      | 3.091288e-03  | 9.087387e-03  | -0.0059960986 |
| ## 96  | 701957.2      | -7.248686e-03 | -9.040455e-03 | 0.0017917688  |
| ## 97  | 704377.7      | 3.448188e-03  | 9.457555e-03  | -0.0060093679 |
| ## 98  | 713915.3      | 1.354052e-02  | 6.926392e-03  | 0.0066141285  |
| ## 99  | 710951.5      | -4.151417e-03 | -1.750009e-03 | -0.0024014082 |
| ## 100 | 721112.7      | 1.429237e-02  | 5.988232e-03  | 0.0083041347  |
| ##     | SPY_Valuation |               |               |               |
| ## 1   | 950000.0      |               |               |               |
| ## 2   | 947264.6      |               |               |               |
| ## 3   | 940345.5      |               |               |               |
| ## 4   | 946567.3      |               |               |               |
| ## 5   | 947228.8      |               |               |               |



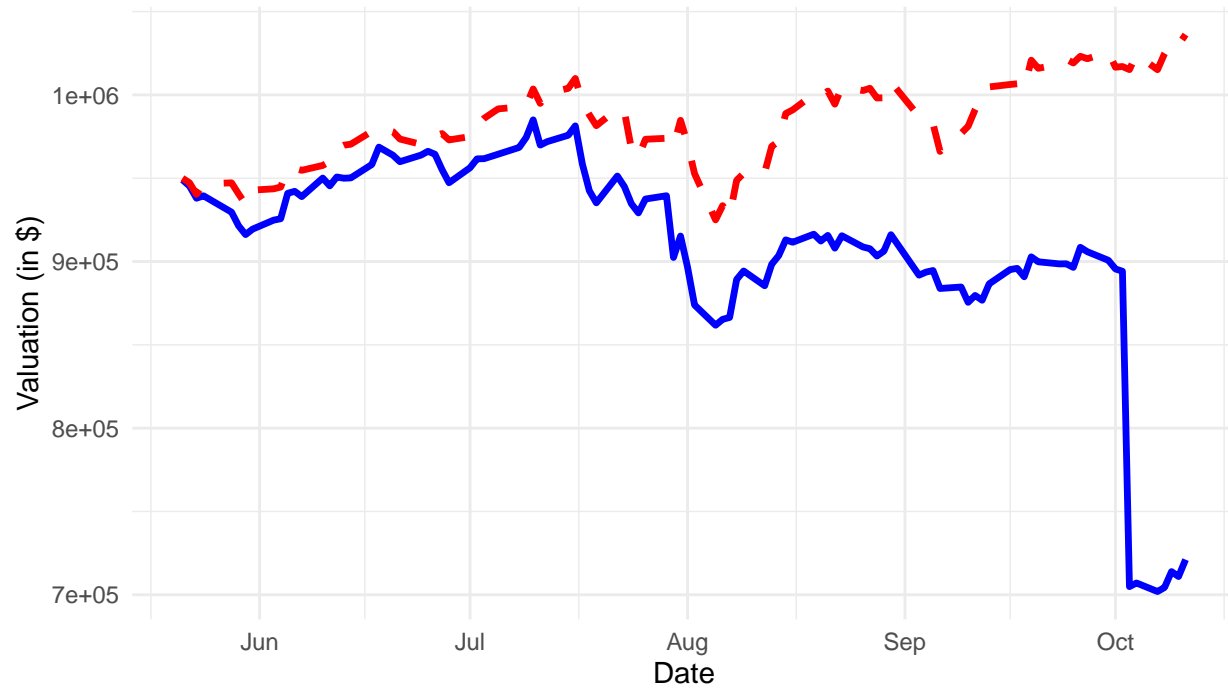
|       |           |
|-------|-----------|
| ## 6  | 940595.8  |
| ## 7  | 934356.2  |
| ## 8  | 942866.4  |
| ## 9  | 943635.2  |
| ## 10 | 944690.0  |
| ## 11 | 955917.8  |
| ## 12 | 955900.0  |
| ## 13 | 954737.8  |
| ## 14 | 957687.8  |
| ## 15 | 959994.2  |
| ## 16 | 967878.7  |
| ## 17 | 969827.4  |
| ## 18 | 970417.4  |
| ## 19 | 978141.0  |
| ## 20 | 980626.1  |
| ## 21 | 977962.2  |
| ## 22 | 973510.4  |
| ## 23 | 970345.9  |
| ## 24 | 974082.5  |
| ## 25 | 975298.3  |
| ## 26 | 976835.9  |
| ## 27 | 972991.9  |
| ## 28 | 974994.4  |
| ## 29 | 981555.8  |
| ## 30 | 985936.1  |
| ## 31 | 991621.5  |
| ## 32 | 992765.7  |
| ## 33 | 993731.2  |
| ## 34 | 1003564.4 |
| ## 35 | 994911.2  |
| ## 36 | 1001186.6 |
| ## 37 | 1003939.9 |
| ## 38 | 1009893.5 |
| ## 39 | 995733.6  |
| ## 40 | 988081.5  |
| ## 41 | 981520.1  |
| ## 42 | 991639.4  |
| ## 43 | 990083.9  |
| ## 44 | 967646.2  |
| ## 45 | 962604.4  |
| ## 46 | 973385.3  |
| ## 47 | 973957.4  |
| ## 48 | 969022.9  |
| ## 49 | 984774.0  |
| ## 50 | 970828.6  |
| ## 51 | 952753.3  |
| ## 52 | 925005.6  |
| ## 53 | 933533.8  |
| ## 54 | 927294.1  |
| ## 55 | 948730.6  |
| ## 56 | 952914.2  |
| ## 57 | 953414.8  |
| ## 58 | 969094.4  |

```
## 59      972151.6
## 60      988814.6
## 61      991031.5
## 62     1000507.2
## 63      998880.2
## 64     1002312.9
## 65      994446.3
## 66     1005012.6
## 67     1002616.9
## 68     1003993.5
## 69      998165.1
## 70      998254.5
## 71     1007783.8
## 72      987044.6
## 73      985024.3
## 74      982628.5
## 75      966090.8
## 76      976907.4
## 77      981162.5
## 78      991228.2
## 79      999577.5
## 80     1004798.1
## 81     1006282.0
## 82     1006693.2
## 83     1003707.5
## 84     1020835.2
## 85     1015954.3
## 86     1018493.1
## 87     1021407.3
## 88     1019154.6
## 89     1023195.2
## 90     1021711.3
## 91     1025805.5
## 92     1016615.9
## 93     1017044.9
## 94     1015185.6
## 95     1024410.9
## 96     1015149.8
## 97     1024750.6
## 98     1031848.5
## 99     1030042.7
## 100     1036210.9
```

```
ggplot(valuation_df, aes(x = timestamp)) +
  geom_line(aes(y = Total_Valuation, color = "Portfolio Valuation"), linewidth = 1.2) +
  geom_line(aes(y = SPY_Valuation, color = "SPY Valuation"), linewidth = 1.2, linetype = "dashed") +
  labs(title = "Portfolio Valuation vs SPY Valuation Over Time",
       x = "Date",
       y = "Valuation (in $)",
       color = "Legend") +
  theme_minimal() +
  scale_color_manual(values = c("Portfolio Valuation" = "blue", "SPY Valuation" = "red")) +
  theme(legend.position = "bottom")
```

### 5.2.2 Valuation vs. Day

Portfolio Valuation vs SPY Valuation Over Time



Legend — Portfolio Valuation — SPY Valuation

```
for (i in seq_along(stocks)) {  
  if (stocks[i] != 'SPY') {  
    stock_valuation_col <- paste(stocks[i], "valuation", sep = "_")  
    valuation_df[paste(stocks[i], "relative_valuation", sep = "_")] <-  
      valuation_df[[stock_valuation_col]] / valuation_df$Total_Valuation  
  }  
}  
  
valuation_df$Cash_relative_valuation <- cash_reserve / valuation_df$Total_Valuation  
  
# Gather the data for the area plot (stocks and cash relative valuations)  
relative_valuation_long <- valuation_df %>%  
  select(timestamp, ends_with("relative_valuation")) %>%  
  pivot_longer(cols = -timestamp, names_to = "Stock", values_to = "Relative_Valuation")  
  
# Replace stock names for readability  
relative_valuation_long$Stock <- gsub("_relative_valuation", "", relative_valuation_long$Stock)  
  
# Create the area plot  
ggplot(relative_valuation_long, aes(x = as.Date(timestamp), y = Relative_Valuation, fill = Stock)) +  
  geom_area(position = "stack") +  
  labs(title = "Relative Valuation of Stocks and Cash Over Time",  
       x = "Date",
```

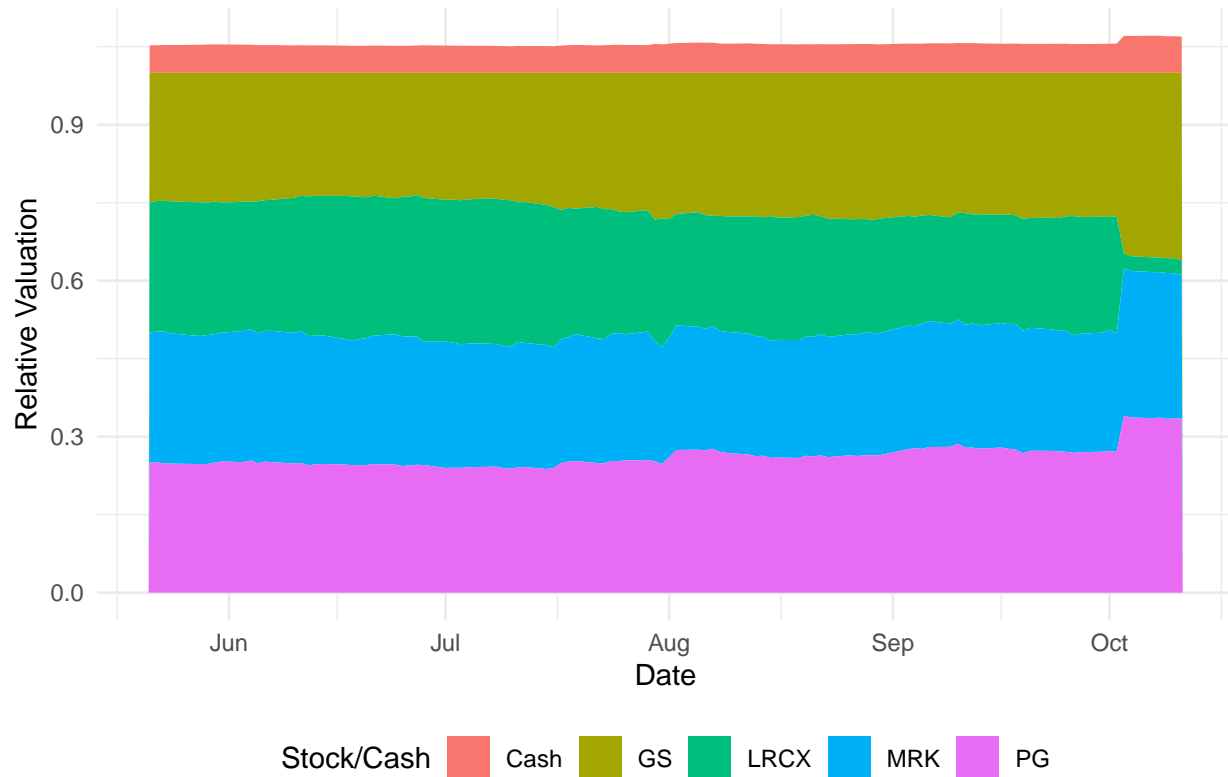
```

y = "Relative Valuation",
fill = "Stock/Cash") +
theme_minimal() +
theme(legend.position = "bottom")

```

### 5.2.3 Relative valuation for the Allocations of the Portfolio

#### Relative Valuation of Stocks and Cash Over Time



#### 1. Overall Stability:

- The allocations appear to be relatively stable throughout the period, indicating that the portfolio is mostly consistent in its composition.

#### 2. Changes in Stocks:

- There is a significant fluctuations in the proportion allocated to individual stocks, especially around the beginning of October. A sharp decrease of the relative valuation of LRCX was witnessed and the underlying reasons have been discussed in 5.2.1.2 Least Return Difference Date

#### 3. Cash Allocation:

- The cash allocation (red) remains fairly low and constant, suggesting that the portfolio stayed heavily invested in stocks with minimal adjustments to the cash reserve over time.