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Portfolio Selection
Markowitz Mean Variance Approach
DSA 5303

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APPENDICES

1.0 Introduction

This study focuses on selection of preferred stock portfolios using the mean variance model developed by Markowitz in 1952[1]. The stock mix utilized in this study was from publicly held companies trading on the New York Stock Exchange with market capitalizations ranging from small (less than 2 billion) to large size (over trillion dollars)[2].

1.1 Purpose

The purpose of this study is to:

1. identify the appetite of an individual investor for assuming risk in order to obtain a desired return on investment;
2. evaluate a mix of stocks in various categories that could be considered by an individual investor based on their risk-reward tradeoffs; and
3. identify the optimum portfolio that could be considered by the investor that minimizes risk ("variance") for a desired return ("mean return") using Markowitz's Mean Variance Model.

1.2 Scope

This study consisted of the following tasks:

1. identification and grouping of publicly held companies into three categories, small cap, mid cap, and large cap based on their individual market capitalizations;
2. estimation of annual returns of these stocks over a period of 14 years, from 2007 to 2021;
3. development of the efficient frontier of the asset mix in each stock category that leads to selection of a stock mix along the minimum variance curve above the minimum mean variance point;
4. development of a dashboard that can be used to collect preference of individual investors; and
5. recommendation of the optimum portfolio based on the preference of an individual investor.

2.0 Study Methodology

Several RStudio packages were used to perform the necessary analysis. quantMod[3] was used to download stock data and to perform preliminary analysis. The stock data was transformed into timeSeries objects to facilitate the processing of the data using the R time series package[4]. Portfolio optimization was performed using R's fportfolio package[5].

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[1] Markowitz, H.M. (1952), "Portfolio Selection" Journal of Finance, 7, no. 1, 77-91

[2] https://www.morningstar.com. Grouping based on Morningstar.com. Stock data obtained from New York Stock Exchange.

[3] https://www.quantmod.com

[4] https://cran.r-project.org/web/packages/timeSeries/timeSeries.pdf

[5] www2.uaem.mx/r-mirror/web/packages/fPortfolio/fPortfolio.pdf

fPortolio is an open source R package that permits development of the efficient frontier from a mix of assets based on one of several models, including the mean variance model. Other models such as lower partial moment portfolio and conditional value at risk portfolio can also be selected to perform the analysis. For this study, however, Markowitz's mean variance model for optimum portfolio selection was utilized during this study. Theoretical framework of Markowitz's mean variance model is presented in Section 3.0.

The analysis was conducted on three categories of stocks to identify the optimal portfolios for small cap, mid cap, and large cap stocks. Once the optimal portfolio was identified for each of these categories, a final analysis was conducted on a mix of assets that included stocks from all 3 categories to identify an optimum portfolio that can be utilized by an individual investor based on his or her appetite for risk while obtaining the desired portfolio return.

Finally, a web interface was created using RStudio package, Shiny[6] that allows users to develop their individual optimum portfolio based on the category of stocks they select and the constraints they identify for a given objective function that allows investors to pick a portfolio based on their target maximum returns and minimum risk.

3.0 Theoretical Framework

Based on Markowitz (1952), the problem of portfolio selection as modeled by fPortfolio is as follows:

$$\begin{aligned} &\min_{w} \; w^T \hat{\Sigma} \, w \\ &s.t. \\ &\qquad w^T \hat{\mu} = \overline{r} \\ &\qquad w^T 1 = 1 \end{aligned}$$

The formula expresses that we minimize the variance covariance risk σbar^2 = w^T ∑w where the matrix ∑ is an estimate of the covariance of the assets. The vector w denotes the individual investments subject to the condition W^{T}1 = 1 that the available capital is fully invested. The expected target return $\overline{r}$ is expressed by the condition $w^T \hat{\mu} = \overline{r}$, where the p-dimensional vector $\hat{\mu}$ estimates the expected mean of the assets.

Markowitz's portfolio model has a unique solution:

$$w^* = \hat{\mu} w_0^* + w_1^*$$

where

$$\begin{aligned} w_0^* &= \frac{1}{\Delta}(B\hat{\Sigma}^{-1}\hat{\mu} - C\hat{\Sigma}^{-1}1) \\ w_1^* &= \frac{1}{\Delta}(C\hat{\Sigma}^{-1}\hat{\mu} - A\hat{\Sigma}^{-1}1) \\ \Delta &= AB - C^2 \end{aligned}$$

with

$$\begin{aligned} A &= \hat{\mu}^T \hat{\Sigma}^{-1} \hat{\mu} \\ B &= 1^T \hat{\Sigma}^{-1} 1 \\ C &= 1^T \hat{\Sigma}^{-1} \hat{\mu}\,. \end{aligned}$$

[6] https://shiny.rstudio.com

The corresponding standard deviation, σbar, is given by:

$$\overline{\sigma} = \sqrt{\frac{1}{\Delta}(\hat{\mu}B - 2\hat{\mu}C + A)}$$
$$\overline{r} = w^T \hat{\mu}\,.$$

The locus of the minimum variance set are hyperbolas. The set inside the hyperbola is the feasible set of mean/standard deviation portfolios, and the border above the minimum variance point is the efficient frontier (upper border). If the investor picks a portfolio on the efficient frontier, he/she obtains the desired return while minimizing the portfolio risk. The portfolios inside the hyperbolas are feasible, but will require the investor to increase the portfolio risk above the values represented by the efficient frontier locus, and will not be chosen by the risk averse investor. This study identifies optimum portfolios that lie on the efficient frontier based on the portfolio risk/reward profile desired by an individual investor.

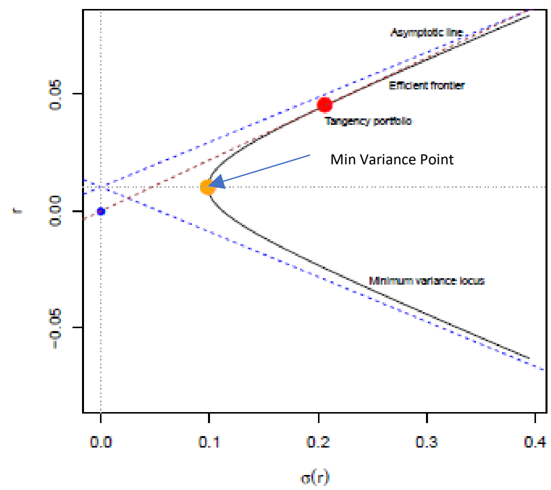


Figure 1: Risk Versus Return View of the Mean Variance Portfolio

4.0 Model Input

4.1 Large Cap Stock Mix

Ten large cap stocks were included in this category (see Table 1). fPortfolio was utilized to estimate the weights of these stocks based on desired return of investor for long-only positions and for positions that allowed for shorting of stocks. Risk free rate of 5% was utilized in the evaluation. A discussion of the analysis and results is presented in Section 5.0. Stock data and annual rate of returns are presented in Appendices A and B, respectively.

Table 1: Large Cap Stock Mix with Market Cap

Stock Symbol	Market Cap ($billion)
AAPL	2,410
MSFT	2,150
GOOG	1,800
IBM	126.35
BP	81.58
XOM	243.72
CSCO	233.34
DUK	80.85
JNJ	453.31
INTLC	217.94

4.2 Mid Cap Stock Mix

Ten mid cap stocks were included in this category (see Table 2). fPortfolio was utilized to estimate the weights of these stocks based on desired return of investor for long-only positions and for positions that allowed for shorting of stocks. Risk free rate of 5% was utilized in the evaluation. A discussion of the analysis and results is presented in Section 5.0. Stock data and annual rate of returns are presented in Appendices A and B, respectively.

Table 2: Mid Cap Stock Mix with Market Cap

Stock Symbol	Market Cap ($billion)
GATX	3.27
LEN	32.84
JBLU	4.68
MLM	22.66
NFLX	229.07
RS	9.98
RJF	17.79
SLAB	6.67
ROST	43.82
WRB	12.98

4.3 Small Cap Stock Mix

Ten small cap stocks were included in this category (see Table 3). fPortfolio was utilized to estimate the weights of these stocks based on desired return of investor for long-only positions and for positions that allowed for shorting of stocks. Risk free rate of 5% was utilized in the evaluation. A discussion of the analysis and results is presented in Section 5.0. Stock data and annual rate of returns are presented in Appendices A and B, respectively.

Table 3: Small Cap Stock Mix with Market Cap

Stock Symbol	Market Cap ($billion)
AOS	11.28
DX	0.599
NNBR	0.295
BLDR	9.22
GME	11.57
SAVA	2.78
AZPN	9.95
FDS	13.50
PVH	7.47
VMI	5.03

Stock data were downloaded for a 14-year time span between 2007 and 2021.

4.4 Mean Variance Portfolio Settings

Time series objects that contain annual return rates for each of the stocks in the 3 stock categories was utilized as input (see Appendix B). Various portfolio specifications were evaluated. Constraints that consisted of long only positions and portfolios that allowed short positions were evaluated. The objective function was set to minimize risk (covariance) for a desired return or to maximize return for a target risk. The solver for the long only constraint was solveRquadProg and that or the short position was solveRshortExact. Covariance was used for target risk and not VaR or CVaR.

A pdf copy of the R code is provided in Appendix C.

5.0 Analysis and Results

5.1 Large Cap Stock Mix

Results of the fPortpolio analysis for large cap stocks are presented on Figures 2 through 5. For the long only strategy, for a target mean return of 15 pct, JNJ (a low risk stock, with return closer to desired mean) has the highest portfolio weight; AAPL and MSFT are also minimally included. For the strategy that includes short sales, BP(an underperforming stock) is heavily short sold, with returns invested in JNJ, CSCO, XOM, and AAPL. Diversification of the portfolio with low risk stocks (XOM and JNJ) allows for investments in more volatile technology stocks.

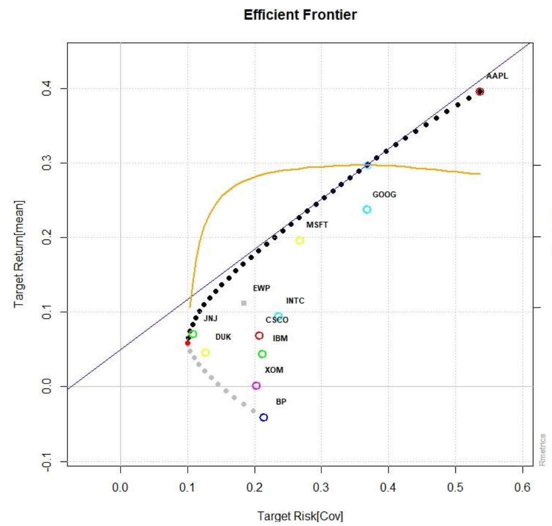


Figure 2: Efficient Frontier, Large Cap, Long Only[6]

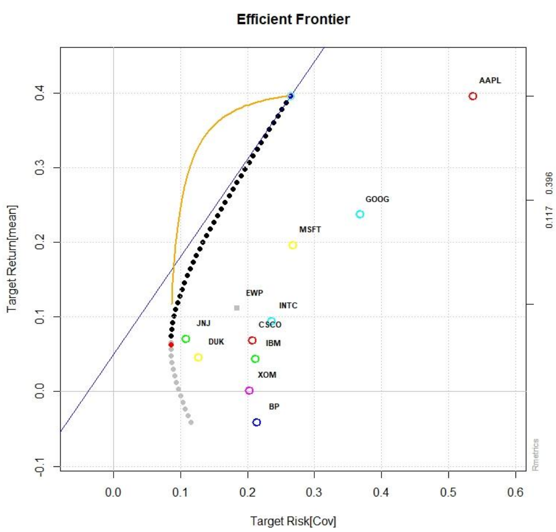


Figure 3: Efficient Frontier, Large Cap, Short Sell[6]

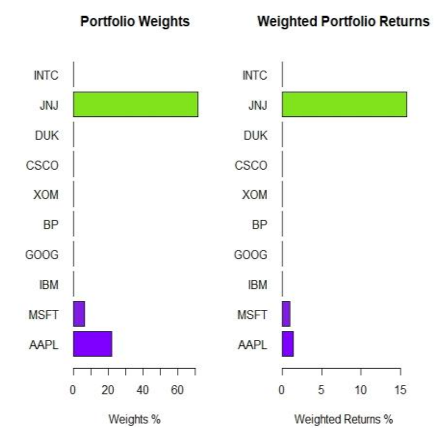


Figure 4: Portfolio Weights, Long Only

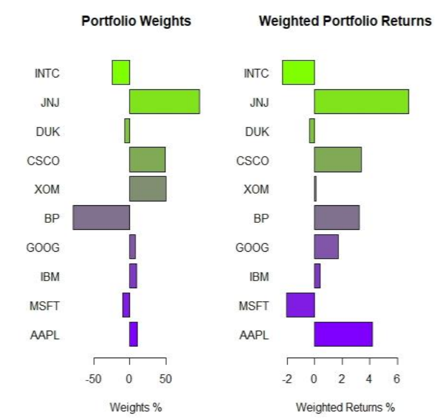


Figure 5: Portfolio Weights, Short Sell

TITLE: LARGE CAP, LONG ONLY

MV Efficient Portfolio
Estimator: covEstimator
Solver: solveRquadprog
Optimize: minRisk
Constraints: LongOnly

Portfolio Weights:

AAPL	MSFT	IBM	GOOG	BP	XOM	CSCO	DUK	JNJ	INTC
0.2180	0.0654	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.7166	0.0000

Covariance Risk Budgets:

AAPL	MSFT	IBM	GOOG	BP	XOM	CSCO	DUK	JNJ	INTC
0.6039	0.0872	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.3090	0.0000

Target Returns and Risks:

mean	Cov
0.1500	0.1657

TITLE: LARGE CAP, SHORT SELL INCLUDED

MV Efficient Portfolio
Estimator: covEstimator
Solver: solveRshortExact
Optimize: minRisk
Constraints: Short

Portfolio Weights:

AAPL	MSFT	IBM	GOOG	BP	XOM	CSCO	DUK	JNJ	INTC
0.1053	-0.1042	0.0894	0.0708	-0.7834	0.4955	0.4891	-0.0765	0.9621	-0.2481

Covariance Risk Budgets:

AAPL	MSFT	IBM	GOOG	BP	XOM	CSCO	DUK	JNJ	INTC
0.2150	-0.1246	0.0494	0.0970	-0.1497	0.1844	0.3207	-0.0428	0.6402	-0.1896

Target Returns and Risks:

mean	Cov
0.1500	0.1076

6) Square root of covariance of risky assets

5.2 Mid Cap Stock Mix

Results of the fPortpolio analysis for mid cap stocks are presented on Figures 6 through 9. For the long only strategy, for a target mean return of 15 pct, WRB, SLAB and ROST (low risk stocks, with return closer to desired mean) have the higher portfolio weights. For the strategy that includes short sales, GATX and LEN (underperforming stocks) are more heavily short sold, with returns invested in WRB, ROST, SLAB, and RJF. Diversification of the portfolio with low risk stocks allows for investments in a more volatile stock such as NFLX.

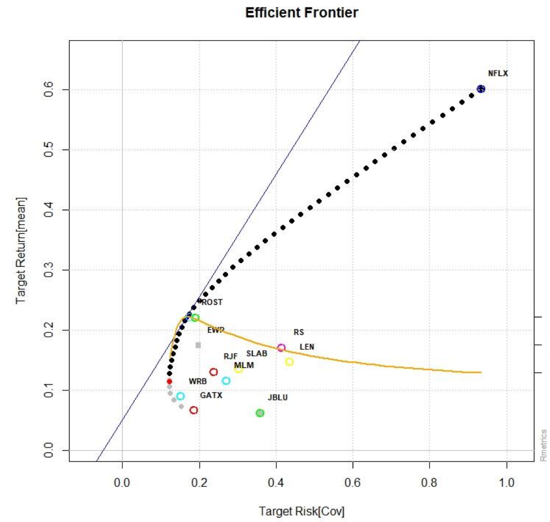


Figure 6: Efficient Frontier, Mid Cap, Long Only

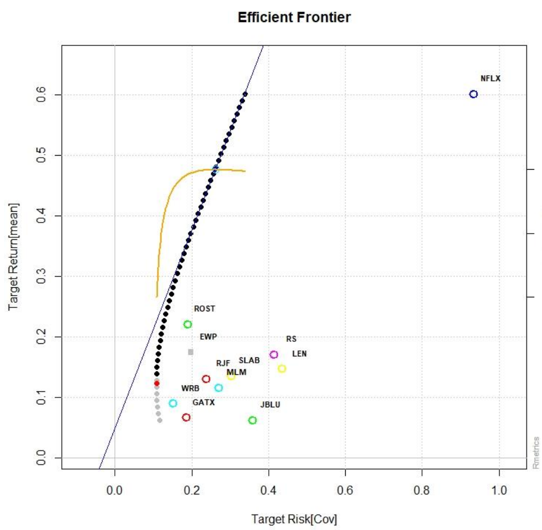


Figure 7: Efficient Frontier, Mid Cap, Short Included

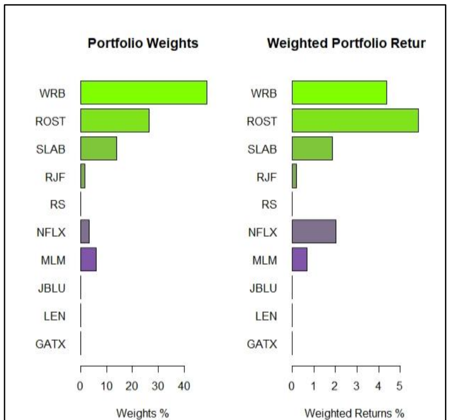


Figure 8: Portfolio Weights, Long Only

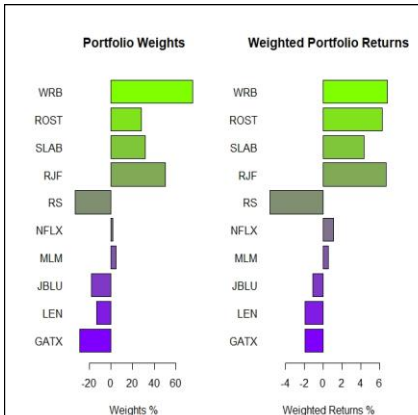


Figure 9 Portfolio Weights, Short Sell

TITLE: MID CAP, LONG ONLY

MV Efficient Portfolio
Estimator: covEstimator
Solver: solveRquadprog
Optimize: minRisk
Constraints: LongOnly

Portfolio Weights:

GATX	LEN	JBLU	MLM	NFLX	RS	RJF	SLAB	ROST	WRB
0.0000	0.0000	0.0000	0.0588	0.0334	0.0000	0.0159	0.1386	0.2647	0.4885

Covariance Risk Budgets:

GATX	LEN	JBLU	MLM	NFLX	RS	RJF	SLAB	ROST	WRB
0.0000	0.0000	0.0000	0.0535	0.0731	0.0000	0.0151	0.1332	0.3140	0.4110

Target Returns and Risks:

mean	Cov
0.1500	0.1284

TITLE: MID CAP, SHORT SELL INCLUDED

MV Efficient Portfolio
Estimator: covEstimator
Solver: solveRshortExact
Optimize: minRisk
Constraints: Short

Portfolio Weights:

GATX	LEN	JBLU	MLM	NFLX	RS	RJF	SLAB	ROST	WRB
-0.2912	-0.1323	-0.1812	0.0477	0.0177	-0.3305	0.5075	0.3211	0.2824	0.7589

Covariance Risk Budgets:

GATX	LEN	JBLU	MLM	NFLX	RS	RJF	SLAB	ROST	WRB
-0.2668	-0.1319	-0.1652	0.0461	0.0257	-0.3373	0.4977	0.3163	0.3024	0.7130

Target Returns and Risks:

mean	Cov
0.1500	0.1094

5.3 Small Cap Stock Mix

Results of the fPortpolio analysis for small cap stocks are presented on Figures 10 through 13. For the long only strategy, for a target mean return of 15 pct, FDS, AZPN and AOS (low risk stocks, with return closer to desired mean) have the higher portfolio weights. For the strategy that includes short sales, BLDR and NNBR (underperforming stocks) are short sold, with returns invested in VMI, FDS, and AOS. Diversification of the portfolio with low risk stocks allows for limited investments in a more volatile stock such as GME and SAVA.

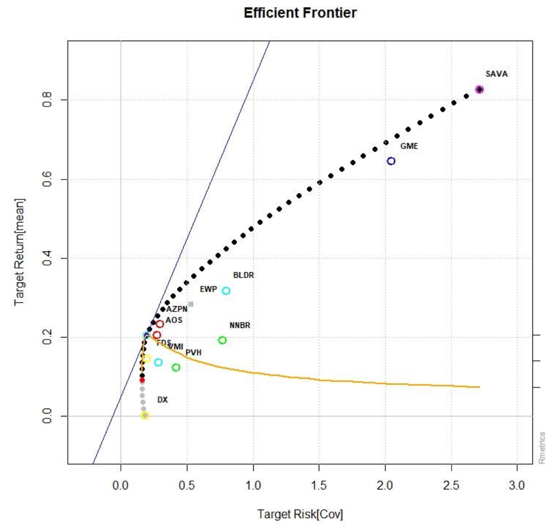


Figure 10: Efficient Frontier, Small Cap, Long Only

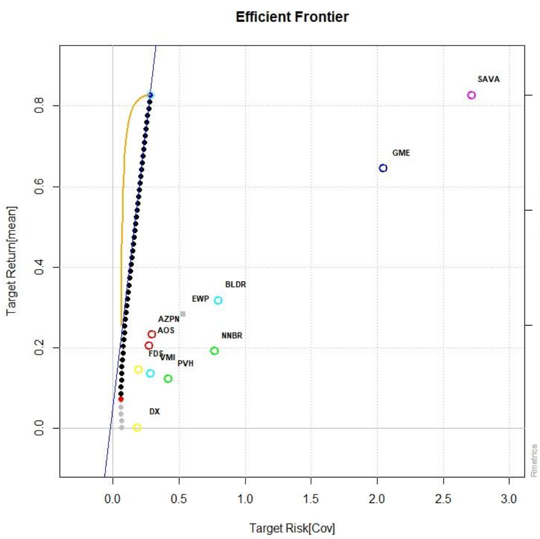


Figure 11: Efficient Frontier, Small Cap, Short Included

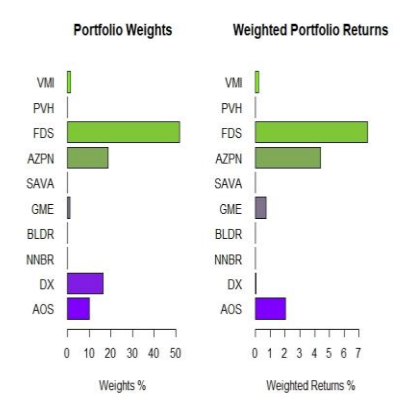


Figure 12: Portfolio Weights, Long Only

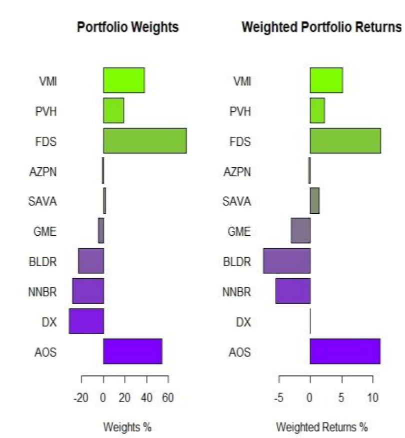


Figure 13: Portfolio Weights, Short Sell

TITLE: SMALL CAP, LONG ONLY

MV Efficient Portfolio
Estimator: covEstimator
Solver: solveRquadprog
Optimize: minRisk
Constraints: LongOnly

Portfolio Weights:

AOS	DX	NNBR	BLDR	GME	SAVA	AZPN	FDS	PVH	VMI
0.1001	0.1661	0.0000	0.0000	0.0112	0.0000	0.1895	0.5188	0.0000	0.0144

Covariance Risk Budgets:

AOS	DX	NNBR	BLDR	GME	SAVA	AZPN	FDS	PVH	VMI
0.1085	0.1285	0.0000	0.0000	0.0197	0.0000	0.2134	0.5158	0.0000	0.0141

Target Returns and Risks:

mean	Cov
0.1500	0.1653

TITLE: SMALL CAP, SHORT SELL INCLUDED

MV Efficient Portfolio
Estimator: covEstimator
Solver: solveRshortExact
Optimize: minRisk
Constraints: Short

Portfolio Weights:

AOS	DX	NNBR	BLDR	GME	SAVA	AZPN	FDS	PVH	VMI
0.5401	-0.3132	-0.2847	-0.2332	-0.0464	0.0170	-0.0094	0.7670	0.1852	0.3777

Covariance Risk Budgets:

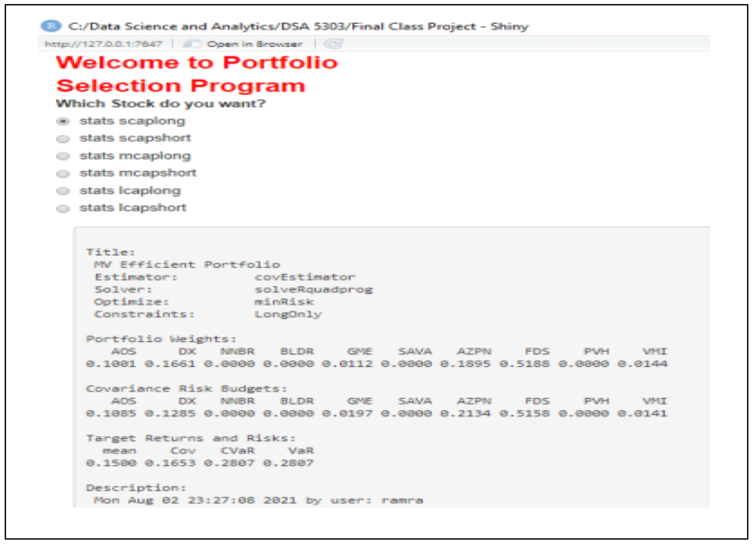
AOS	DX	NNBR	BLDR	GME	SAVA	AZPN	FDS	PVH	VMI
0.6073	-0.2081	-0.3115	-0.3218	-0.0986	0.0431	-0.0112	0.7604	0.1739	0.3664

Target Returns and Risks:

mean	Cov
0.1500	0.0671

5.4 Dashboard Development for User Interface

Using R Shiny package, a dashboard interface was developed, which allows the user to select a portfolio based on their risk reward profile. Once the user selects the type of profile they want to use for investment, the program provides allocation of portfolio weights for the various stocks within each type of portfolio along with risk budgets by stock and mean return and risk of the overall portfolio.



5.5 Mixed Cap Portfolio

A mixed portfolio was constructed using the best performing stocks from small, mixed, and large cap stocks. Underperforming stocks such as BP were also included to allow for potential short sale positions. A total of 14 stocks were included in the analysis. Three strategies were evaluated:

1. Long only positions, desired return 15 pct.
2. Short sale included, desired return 15 pct.
3. Short sale included, maximize return for target risk of 20 pct.

Figures 14 through 18 provided the results of the analysis.

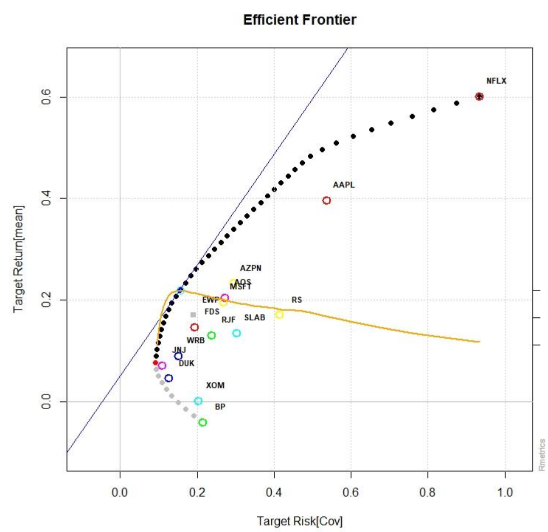


Figure 14: Efficient Frontier, Mixed Cap, Long Only

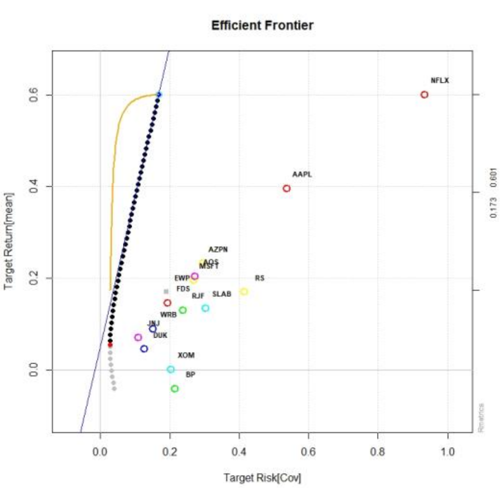


Figure 15: Efficient Frontier, Mixed Cap, Short Included

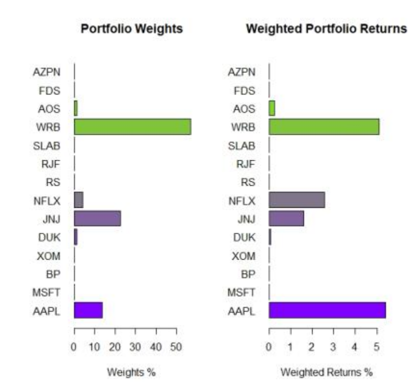


Figure 16: Portfolio Weights, Long Only

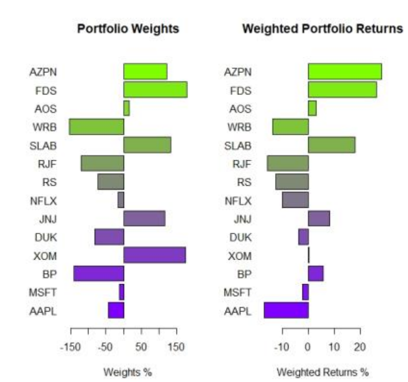


Figure 17: Portfolio Weights, Short Sell

TITLE: MIXED CAP, LONG ONLY

MV Efficient Portfolio
Estimator: covEstimator
Solver: solveRquadprog
Optimize: minRisk
Constraints: LongOnly

Portfolio Weights:
AAPL MSFT BP XOM DUK JNJ NFLX RS RJF SLAB
WRB AOS FDS AZPN
0.1366 0.0000 0.0000 0.0000 0.0119 0.2263 0.0427 0.0000 0.0000 0.0000
0.5707 0.0118 0.0000 0.0000

Covariance Risk Budgets:
AAPL MSFT BP XOM DUK JNJ NFLX RS RJF SLAB
WRB AOS FDS AZPN
0.2689 0.0000 0.0000 0.0000 0.0070 0.1559 0.1185 0.0000 0.0000 0.0000
0.4353 0.0144 0.0000 0.0000

Target Returns and Risks:
mean Cov
0.1500 0.1103

TITLE:MIXED CAP, SHORT SELL INCLUDED

MV Efficient Portfolio
Estimator: covEstimator
Solver: solveRshortExact
Optimize: minRisk
Constraints: Short

Portfolio Weights:
AAPL MSFT BP XOM DUK JNJ NFLX RS RJF SLAB
WRB AOS FDS AZPN
-0.4278 -0.1195 -1.4145 1.7567 -0.8183 1.1691 -0.1663 -0.7378 -1.2105 1.3377
-1.5334 0.1534 1.7928 1.2185

Covariance Risk Budgets:
AAPL MSFT BP XOM DUK JNJ NFLX RS RJF SLAB
WRB AOS FDS AZPN
-1.0067 -0.1498 0.0720 0.3238 -0.3501 0.6609 -0.5790 -0.8214 -1.0819 1.2294 -
1.0252 0.1997 1.7555 1.7730

Target Returns and Risks:
mean Cov
0.1500 0.0399

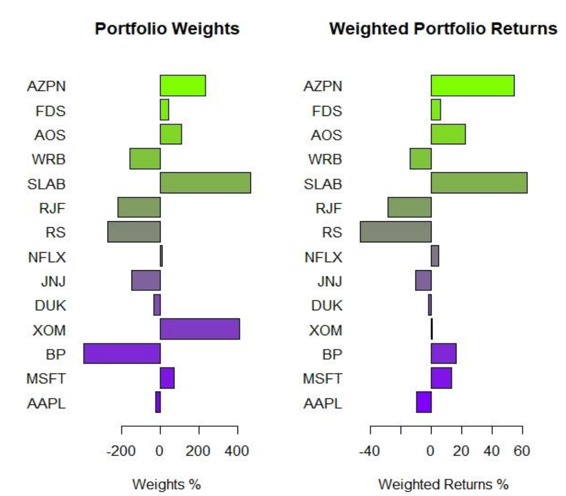


Figure 18: Portfolio Weights, Short Sell, Max Return

TITLE: MIXED CAP, SHORT SELL INCLUDED, MAX RETURN

MV Return Maximized Efficient Portfolio
Estimator: covEstimator
Solver: solveRshortExact
Optimize: maxReturn
Constraints: Short

Portfolio Weights:
AAPL MSFT BP XOM DUK JNJ NFLX RS RJF SLAB
WRB AOS FDS AZPN
-0.0092 0.5834 -3.3170 3.6336 -0.2747 -1.9441 0.1326 -2.9739 -2.1086 4.6483
-1.0619 1.1748 0.2537 2.2630

Covariance Risk Budgets:
AAPL MSFT BP XOM DUK JNJ NFLX RS RJF SLAB
WRB AOS FDS AZPN
-0.0046 0.1277 0.3729 -0.2093 -0.0017 -0.0783 0.1048 -0.5270 -0.2710 0.6375 -
0.0708 0.2719 0.0374 0.6106

Target Returns and Risks:
mean Cov
0.7502 0.2000

Summary of Results: Similar to the individual portfolio results, the long only strategy for mixed cap portfolio also results in higher weights being assigned to stocks (WRB and JNJ) that have less volatility and provide returns within the ball-park of the desired result.

The strategy that includes short selling allows for short sale of underperforming stocks with an eye toward investing in stocks such as WRB, JNJ, AZPN, FDS, and SLAB that have lower risk relative to other stocks when the objective function is set to provide a desired mean portfolio return of 15 pct.

It is worth noting that for the maximum return objective function where the target risk is set at 20 pct, BP is heavily short sold, but other stocks that have a lower risk (much lower than 20 pct risk) are being short sold to provide for investment in riskier stocks (whose risk is closer to the target level set at 20 pct) to allow for maximization of mean portfolio return. This strategy is inherently riskier than long only positions or even the strategy that allows for short sale when the objective function was set to provide a desired return of 15 pct.

6.0 Conclusions

Application of R Studio packages for financial engineering and specifically for portfolio optimization provides a platform for performing expedited yet robust data analysis of the stock market, returns of individual stocks, and risk and reward of stock portfolios, which can lead to optimum portfolio selection based on the risk appetite of investors.

This study used several R Studio packages to upload individual stock data trading at the NYSE, to perform exploratory data analysis, to synthesize the data into time series objects for the performance of portfolio analysis, and to select optimum stock portfolios. Small, mid cap, and large stocks were analyzed in this study. Markowitz's mean variance model was used to evaluate the efficient frontier for various mixes of risky assets using RStudio's fPortfolio package.

Based on the stocks selected in the study, for the long only position, the portfolio consisting of mid cap stocks had the lowest risk (0.1103) for the desired mean return of 0.15. This result could be attributed primarily to the samples of the stocks that were selected and not necessarily to the performance of the overall population of stocks within these categories. Systemic underperformance of the market during the recession of 2008-2009 may have had an effect on performance of the large cap stocks which typically are traded in higher volumes relative to small and mid cap stocks.

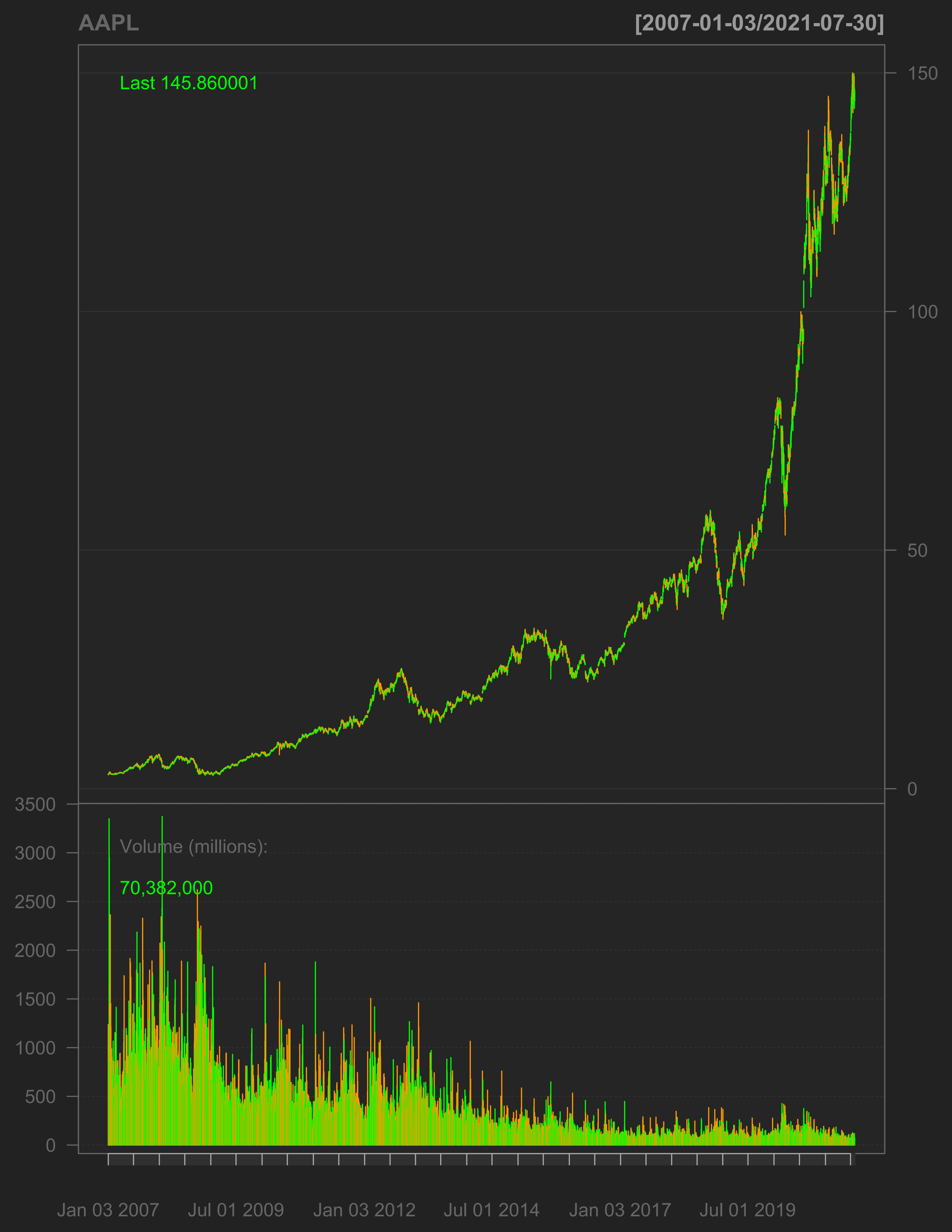
For the strategy that allowed short-selling, all three portfolios had a lower risk estimate relative to their corresponding long only positions. However, this result should be viewed with abundant caution as a "naked" short position taken in the market based on historical data trends over a 14-year time span and annual return rates calculated based on closing prices at the start and the end of the year may not be fully reflective of true variance in the stock prices. When an investor takes a short sale position, he/she can maximize returns should price of the asset fall in the future, but it can also result in significant loss should prices rise above their current price.

The mixed cap portfolio that consisted of a combination of 14 stocks from small, mid, and large caps did perform better than the individual small, mid, and large cap portfolios in that the risk of the portfolio was lower than those for the individual portfolios for both the long only investment strategy and for the strategy that allowed for short sale of risky assets.

APPENDIX A

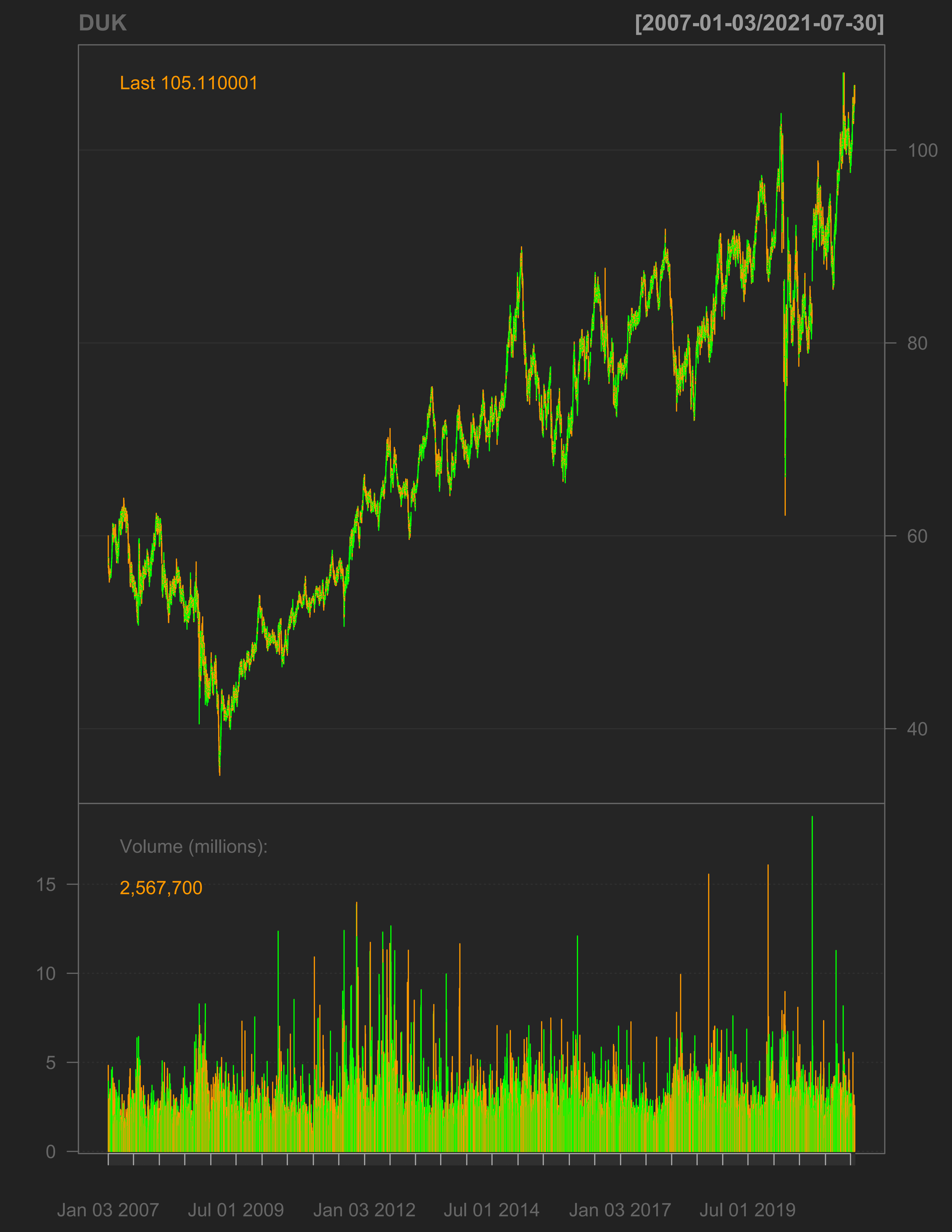
STOCK DATA

LARGE CAP STOCK DATA

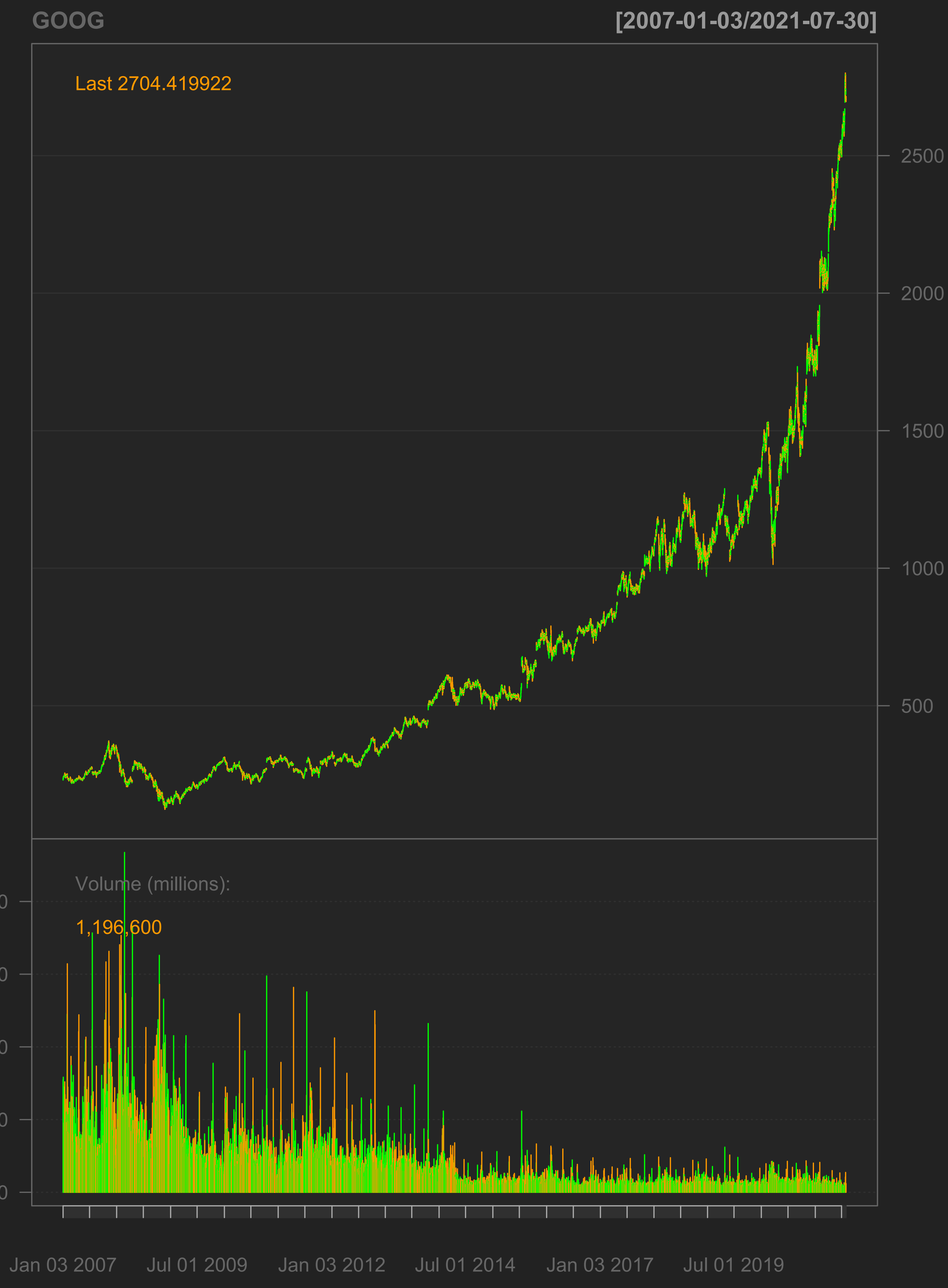

AAPL
[2007-01-03/2021-07-30]
Last 145.860001
150
100
50
0
Volume (millions):
70,382,000
3500
3000
2500
2000
1500
1000
500
0
Jan 03 2007
Jul 01 2009
Jan 03 2012
Jul 01 2014
Jan 03 2017
Jul 01 2019

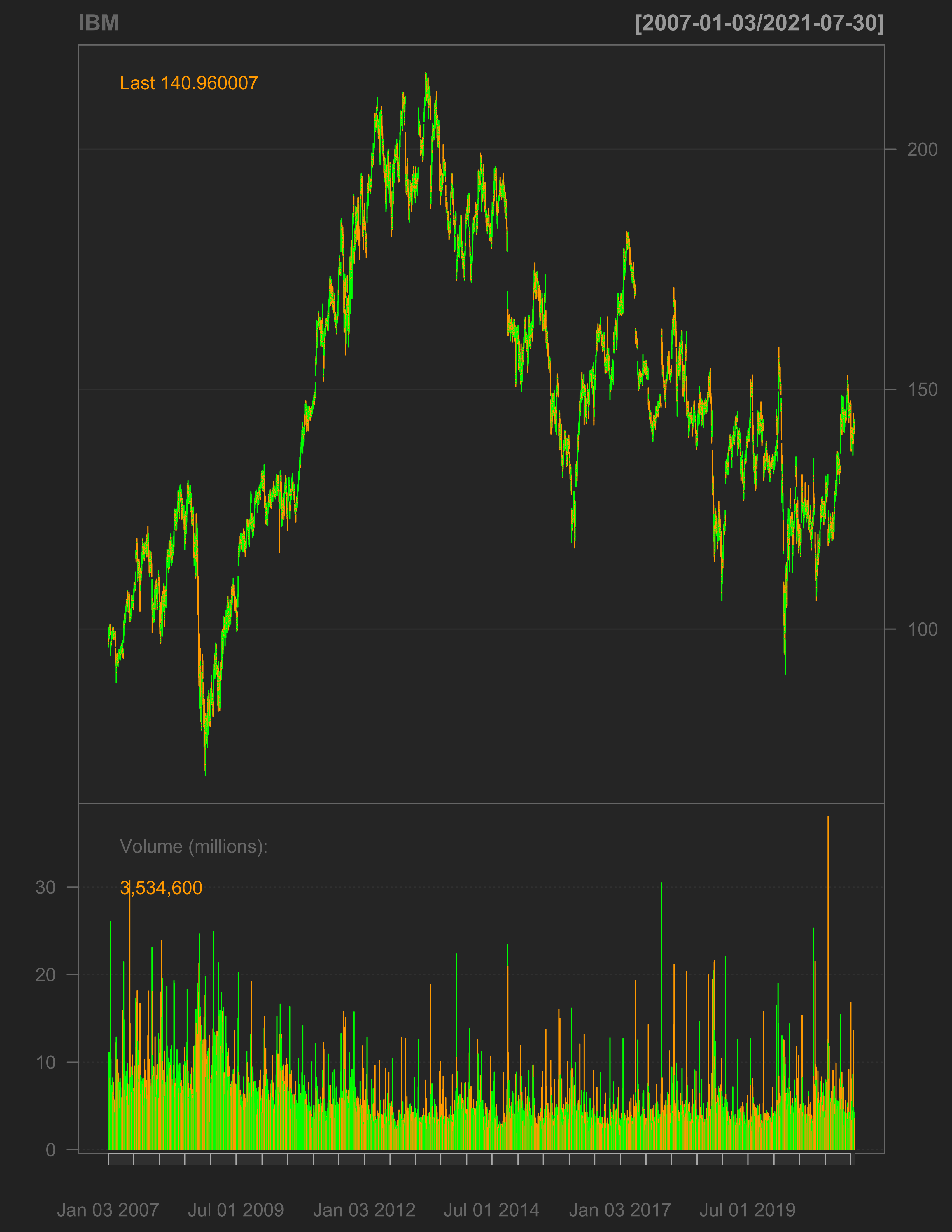

BP
[2007-01-03/2021-07-30]
Last 24.18
80
70
60
50
40
30
20
250
200
150
100
50
0
Volume (millions):
11,419,700
Jan 03 2007
Jul 01 2009
Jan 03 2012
Jul 01 2014
Jan 03 2017
Jul 01 2019

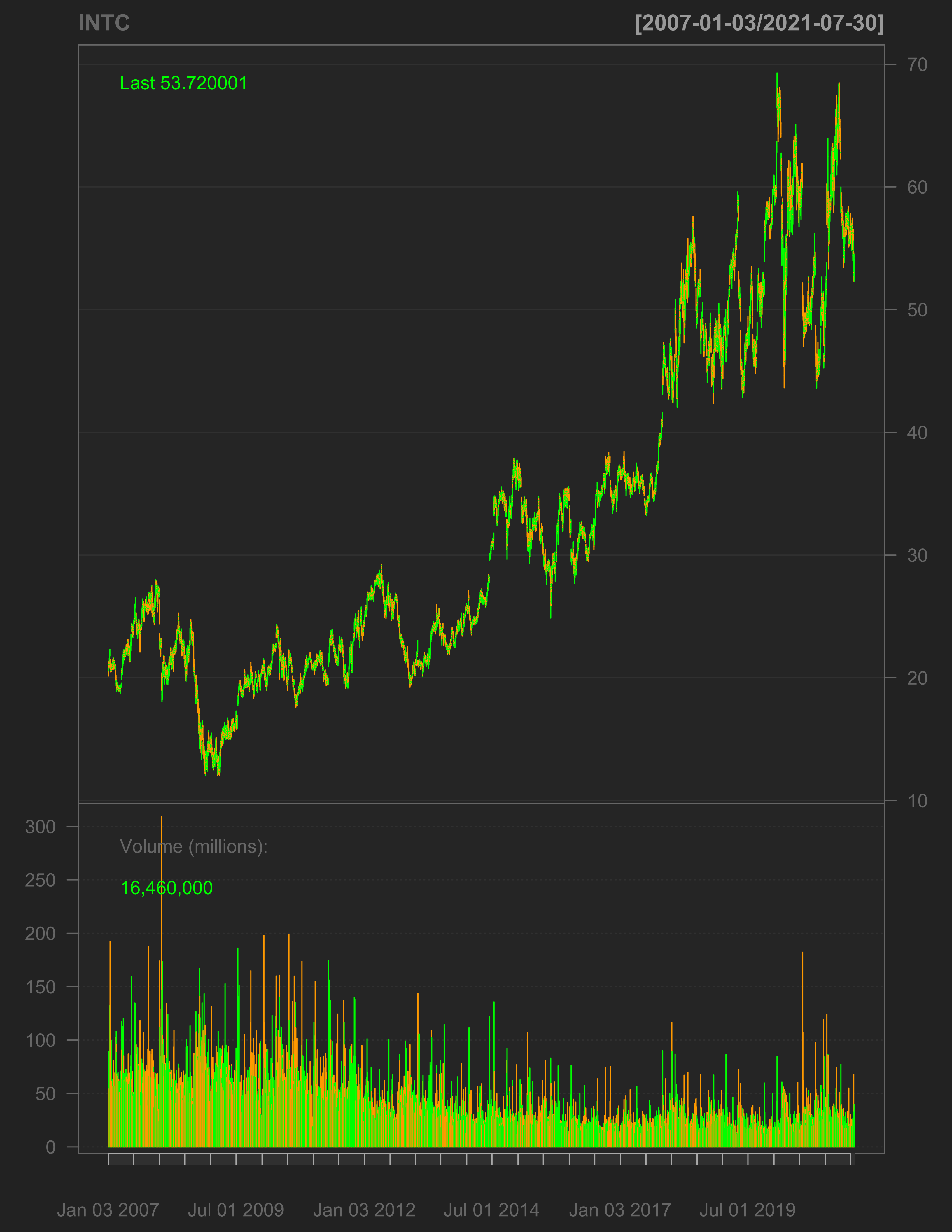

CSCO
[2007-01-03/2021-07-30]
Last 55.369999
60
50
40
30
20
Volume (millions):
13,437,200
500
400
300
200
100
0
Jan 03 2007
Jul 01 2009
Jan 03 2012
Jul 01 2014
Jan 03 2017
Jul 01 2019



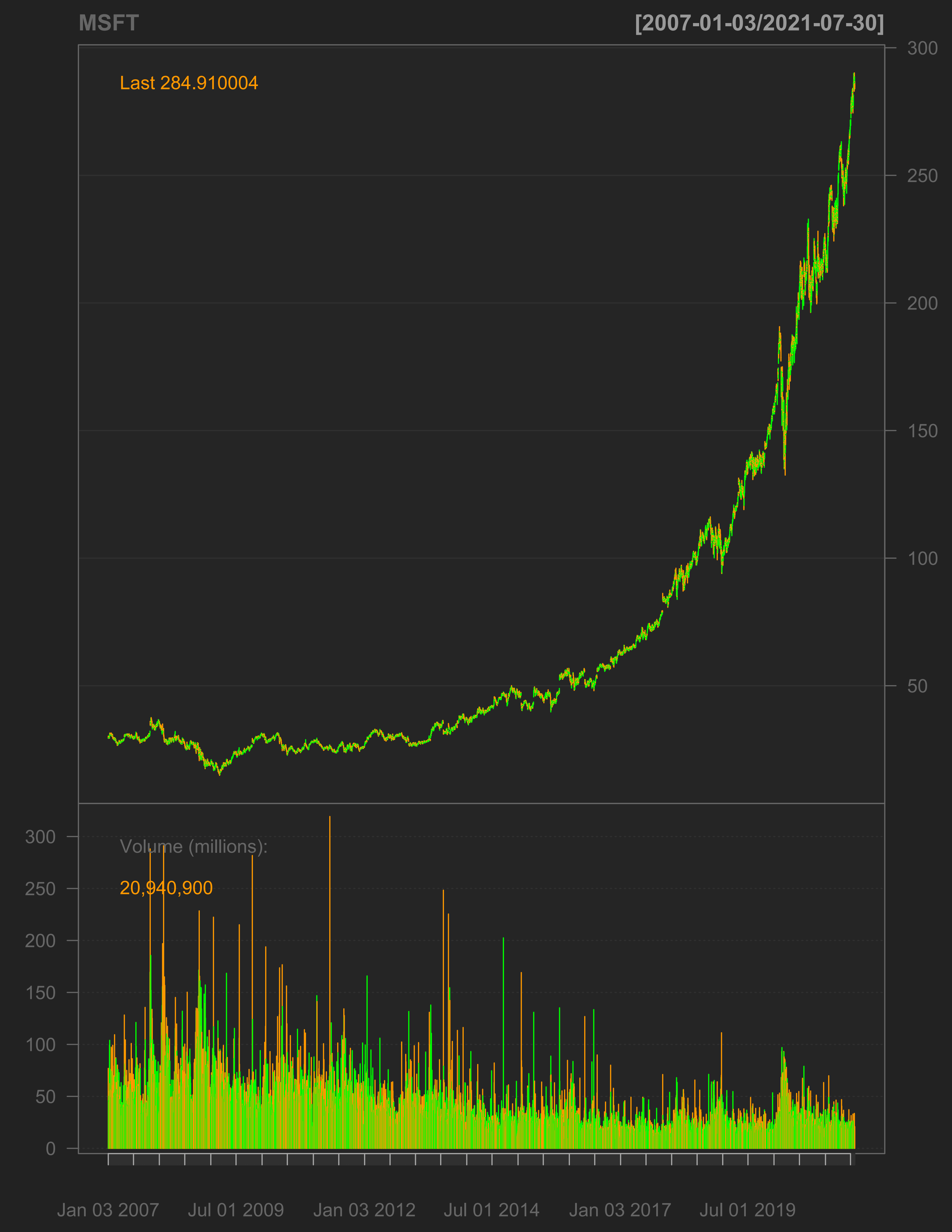
DUK
[2007-01-03/2021-07-30]
Last 105.110001
100
80
60
40
Volume (millions):
2,567,700
15
10
5
0
Jan 03 2007
Jul 01 2009
Jan 03 2012
Jul 01 2014
Jan 03 2017
Jul 01 2019


GOOG
[2007-01-03/2021-07-30]
Last 2704.419922
2500
2000
1500
1000
500
Volume (millions):
1,196,600
40
30
20
10
0
Jan 03 2007
Jul 01 2009
Jan 03 2012
Jul 01 2014
Jan 03 2017
Jul 01 2019


IBM
[2007-01-03/2021-07-30]
Last 140.960007
200
150
100
Volume (millions):
3,534,600
30
20
10
0
Jan 03 2007
Jul 01 2009
Jan 03 2012
Jul 01 2014
Jan 03 2017
Jul 01 2019


INTC
[2007-01-03/2021-07-30]
Last 53.720001
70
60
50
40
30
20
10
Volume (millions):
16,460,000
300
250
200
150
100
50
0
Jan 03 2007
Jul 01 2009
Jan 03 2012
Jul 01 2014
Jan 03 2017
Jul 01 2019

JNJ
[2007-01-03/2021-07-30]
Last 172.199997
160
140
120
100
80
60
100
Volume (millions):
5,346,400
80
60
40
20
0
Jan 03 2007
Jul 01 2009
Jan 03 2012
Jul 01 2014
Jan 03 2017
Jul 01 2019


MSFT
[2007-01-03/2021-07-30]
Last 284.910004
300
250
200
150
100
50
Volume (millions):
20,940,900
300
250
200
150
100
50
0
Jan 03 2007
Jul 01 2009
Jan 03 2012
Jul 01 2014
Jan 03 2017
Jul 01 2019


XOM
[2007-01-03/2021-07-30]
Last 57.57
100
80
60
40
Volume (millions):
28,641,900
120
100
80
60
40
20
0
Jan 03 2007
Jul 01 2009
Jan 03 2012
Jul 01 2014
Jan 03 2017
Jul 01 2019

MID CAP STOCK DATA

GATX
[2007-01-03/2021-07-30]
Last 92.25
100
80
60
40
20
Volume (100,000s):
164,800
40
30
20
10
0
Jan 03 2007
Jul 01 2009
Jan 03 2012
Jul 01 2014
Jan 03 2017
Jul 01 2019

JBLU
[2007-01-03/2021-07-30]
Last 14.79
25
20
15
10
5
Volume (millions):
8,492,800
60
50
40
30
20
10
0
Jan 03 2007
Jul 01 2009
Jan 03 2012
Jul 01 2014
Jan 03 2017
Jul 01 2019

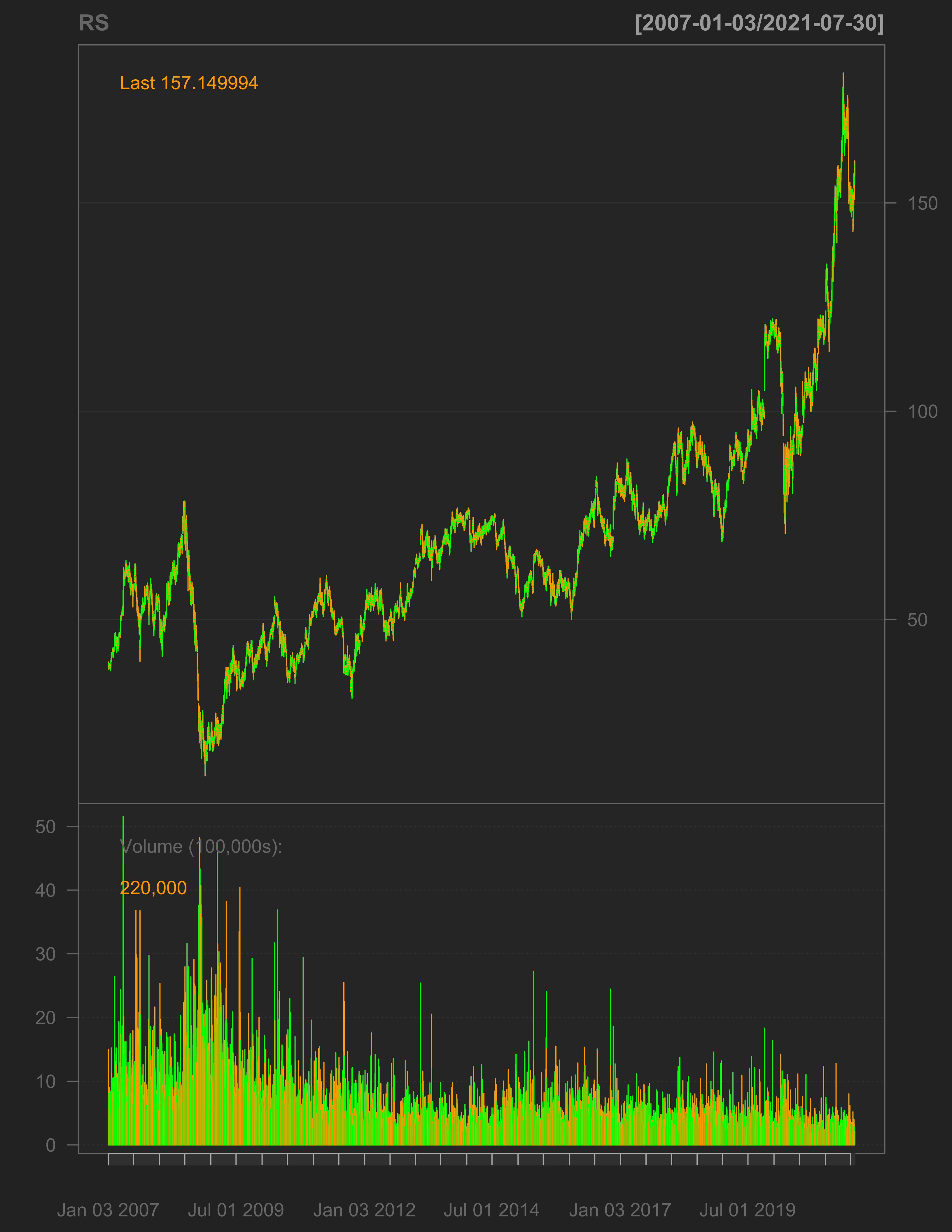

LEN
[2007-01-03/2021-07-30]
Last 105.150002
100
80
60
40
20
0
Volume (millions):
2,035,600
60
50
40
30
20
10
0
Jan 03 2007
Jul 01 2009
Jan 03 2012
Jul 01 2014
Jan 03 2017
Jul 01 2019

MLM
[2007-01-03/2021-07-30]
Last 363.299988
350
300
250
200
150
100
50
Volume (millions):
405,300
15
10
5
0
Jan 03 2007
Jul 01 2009
Jan 03 2012
Jul 01 2014
Jan 03 2017
Jul 01 2019

NFLX
[2007-01-03/2021-07-30]
Last 517.570007
600
500
400
300
200
100
0
Volume (millions):
2,534,900
300
250
200
150
100
50
0
Jan 03 2007
Jul 01 2009
Jan 03 2012
Jul 01 2014
Jan 03 2017
Jul 01 2019

RJF
[2007-01-03/2021-07-30]
Last 129.479996
140
120
100
80
60
40
20
Volume (millions):
663,200
20
15
10
5
0
Jan 03 2007
Jul 01 2009
Jan 03 2012
Jul 01 2014
Jan 03 2017
Jul 01 2019

ROST
[2007-01-03/2021-07-30]
Last 122.690002
120
100
80
60
40
20
Volume (millions):
1,197,800
100
80
60
40
20
0
Jan 03 2007
Jul 01 2009
Jan 03 2012
Jul 01 2014
Jan 03 2017
Jul 01 2019



RS
[2007-01-03/2021-07-30]
Last 157.149994
150
100
50
Volume (100,000s):
220,000
50
40
30
20
10
0
Jan 03 2007
Jul 01 2009
Jan 03 2012
Jul 01 2014
Jan 03 2017
Jul 01 2019

SLAB
[2007-01-03/2021-07-30]
Last 148.990005
150
100
50
Volume (100,000s):
316,000
80
60
40
20
0
Jan 03 2007
Jul 01 2009
Jan 03 2012
Jul 01 2014
Jan 03 2017
Jul 01 2019

WRB
[2007-01-03/2021-07-30]
Last 73.169998
80
70
60
50
40
30
20
10
Volume (millions):
784,300
35
30
25
20
15
10
5
0
Jan 03 2007
Jul 01 2009
Jan 03 2012
Jul 01 2014
Jan 03 2017
Jul 01 2019

SMALL CAP STOCK DATA


AOS
[2007−01−03/2021−07−30]
Last 70.330002
70
60
50
40
30
20
10
Volume (millions):
1,110,900
30
25
20
15
10
5
0
Jan 03 2007
Jul 01 2009
Jan 03 2012
Jul 01 2014
Jan 03 2017
Jul 01 2019


AZPN
[2007−01−03/2021−07−30]
Last 146.259995
150
100
50
0
Volume (millions):
237,900
15
10
5
0
Jan 03 2007
Jul 01 2009
Jan 03 2012
Jul 01 2014
Jan 03 2017
Jul 01 2019


BLDR
[2007−01−03/2021−07−30]
Last 44.5
50
40
30
20
10
0
Volume (millions):
1,445,100
30
25
20
15
10
5
0
Jan 03 2007
Jul 01 2009
Jan 03 2012
Jul 01 2014
Jan 03 2017
Jul 01 2019


DX
[2007−01−03/2021−07−30]
Last 17.450001
30
25
20
15
10
Volume (100,000s):
787,600
25
20
15
10
5
0
Jan 03 2007
Jul 01 2009
Jan 03 2012
Jul 01 2014
Jan 03 2017
Jul 01 2019

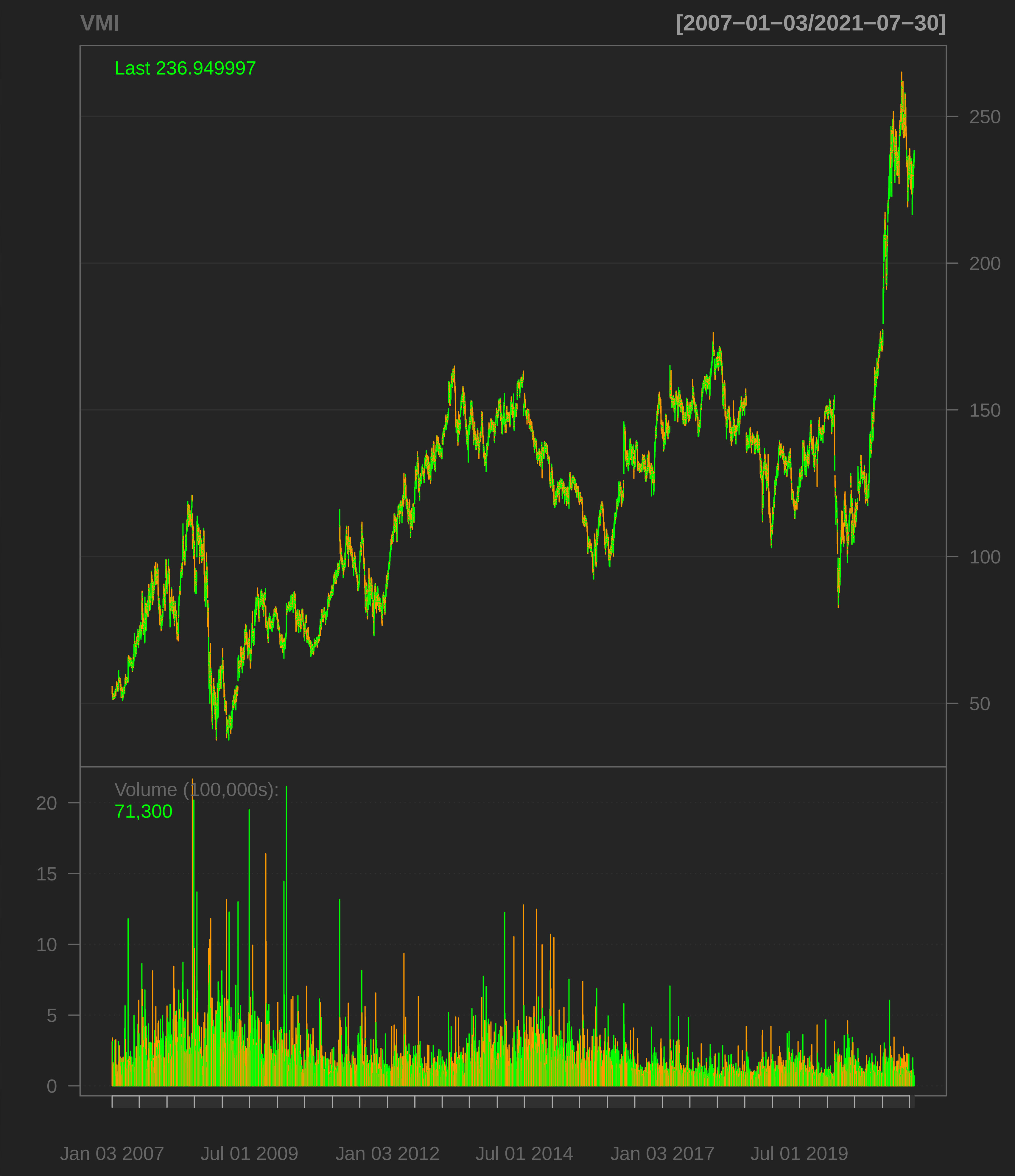

FDS
[2007−01−03/2021−07−30]
Last 357.279999
350
300
250
200
150
100
50
Volume (100,000s):
280,400
50
40
30
20
10
0
Jan 03 2007
Jul 01 2009
Jan 03 2012
Jul 01 2014
Jan 03 2017
Jul 01 2019


GME
[2007−01−03/2021−07−30]
Last 161.119995
500
400
300
200
100
0
Volume (millions):
2,373,500
200
150
100
50
0
Jan 03 2007
Jul 01 2009
Jan 03 2012
Jul 01 2014
Jan 03 2017
Jul 01 2019


NNBR
[2007−01−03/2021−07−30]
Last 6.84
30
25
20
15
10
5
0
Volume (100,000s):
180,100
80
60
40
20
0
Jan 03 2007
Jul 01 2009
Jan 03 2012
Jul 01 2014
Jan 03 2017
Jul 01 2019


PVH
[2007−01−03/2021−07−30]
Last 104.620003
150
100
50
Volume (millions):
1,037,900
15
10
5
0
Jan 03 2007
Jul 01 2009
Jan 03 2012
Jul 01 2014
Jan 03 2017
Jul 01 2019


SAVA
[2007−01−03/2021−07−30]
Last 69.529999
150
100
50
0
Volume (millions):
25,135,300
150
100
50
0
Jan 03 2007
Jul 01 2009
Jan 03 2012
Jul 01 2014
Jan 03 2017
Jul 01 2019


VMI
[2007−01−03/2021−07−30]
Last 236.949997
250
200
150
100
50
Volume (100,000s):
71,300
20
15
10
5
0
Jan 03 2007
Jul 01 2009
Jan 03 2012
Jul 01 2014
Jan 03 2017
Jul 01 2019

APPENDIX B

STOCK ANNUAL RETURN RATE

ANNUAL RETURN RATES

LARGE CAP STOCKS

Date	AAPL	MSFT	IBM	GOOG	BP	XOM	CSCO	DUK	JNJ	INTC
12/31/2007	129.55%	19.02%	11.24%	48.39%	8.77%	22.86%	-1.42%	0.85%	0.86%	30.37%
12/31/2008	-56.91%	-45.39%	-22.15%	-55.51%	-36.12%	-14.79%	-39.79%	-25.58%	-10.30%	-45.01%
12/31/2009	146.90%	56.79%	55.54%	101.52%	24.03%	-14.58%	46.87%	14.66%	7.66%	39.15%
12/31/2010	53.07%	-8.43%	12.12%	-4.20%	-23.81%	7.23%	-15.50%	3.49%	-3.97%	3.09%
12/30/2011	25.56%	-6.99%	25.29%	8.74%	-3.24%	15.92%	-10.63%	23.53%	6.03%	15.31%
12/31/2012	31.40%	2.89%	4.17%	9.52%	-2.57%	2.11%	8.68%	-3.33%	6.89%	-14.97%
12/31/2013	5.42%	40.06%	-2.08%	58.43%	16.74%	16.93%	14.15%	8.17%	30.66%	25.90%
12/31/2014	37.72%	24.16%	-14.46%	-5.97%	-21.58%	-8.65%	24.03%	21.05%	14.17%	39.79%
12/31/2015	-4.64%	19.44%	-14.22%	44.56%	-18.00%	-15.68%	-2.37%	-14.54%	-1.77%	-5.07%
12/30/2016	10.03%	12.00%	20.61%	1.71%	19.58%	15.79%	11.27%	8.73%	12.16%	5.28%
12/29/2017	46.11%	37.66%	-7.57%	35.58%	12.44%	-7.33%	26.74%	8.36%	21.27%	27.27%
12/31/2018	-6.79%	18.74%	-25.91%	-1.03%	-9.78%	-18.47%	13.13%	2.60%	-7.64%	1.67%
12/31/2019	86.16%	55.26%	17.92%	29.10%	-0.47%	2.33%	10.69%	5.69%	13.03%	27.53%
12/31/2020	80.75%	41.04%	-6.09%	31.03%	-45.63%	-40.93%	-6.69%	0.38%	7.89%	-16.76%
8/6/2021	10.14%	30.14%	14.47%	56.44%	24.56%	40.37%	24.22%	16.82%	9.99%	8.23%

ANNUAL RETURN RATES
MID CAP STOCKS

Date	GATX	LEN	JBLU	MLM	NFLX	RS	RJF	SLAB	ROST	WRB
12/31/2007	-15.93%	-65.30%	-58.86%	26.59%	2.38%	36.25%	7.43%	7.25%	-12.73%	-14.19%
12/31/2008	-15.57%	-51.54%	20.34%	-26.79%	12.28%	-63.21%	-47.55%	-33.80%	16.27%	3.99%
12/31/2009	-7.17%	47.29%	-23.24%	-7.90%	84.31%	116.75%	38.76%	95.24%	43.66%	-20.52%
12/31/2010	22.71%	46.83%	21.28%	3.17%	218.93%	18.23%	37.57%	-4.88%	48.09%	11.12%
12/30/2011	23.75%	4.80%	-21.33%	-18.25%	-60.56%	-4.72%	-5.32%	-5.65%	50.29%	25.60%
12/31/2012	-0.82%	96.79%	10.00%	25.02%	33.63%	27.54%	24.45%	-3.73%	13.80%	9.74%
12/31/2013	20.48%	2.30%	49.30%	6.00%	297.63%	22.13%	35.45%	3.61%	38.53%	14.97%
12/31/2014	10.29%	13.27%	85.71%	10.39%	-7.21%	-19.21%	9.77%	9.95%	25.80%	18.14%
12/31/2015	-26.05%	9.15%	42.81%	23.80%	134.38%	-5.48%	1.19%	1.93%	14.17%	6.81%
12/30/2016	44.72%	-12.23%	-1.02%	62.20%	8.24%	37.35%	19.49%	33.91%	21.91%	21.48%
12/29/2017	0.94%	49.81%	-0.36%	-0.22%	55.06%	7.86%	28.92%	35.85%	22.33%	7.73%
12/31/2018	13.92%	-38.09%	-28.11%	-22.24%	39.44%	-17.04%	-16.67%	-10.75%	3.68%	3.15%
12/31/2019	17.00%	42.50%	16.56%	62.70%	20.89%	68.27%	20.23%	47.16%	39.93%	40.24%
12/31/2020	0.40%	36.64%	-22.33%	1.55%	67.11%	-0.01%	6.94%	9.79%	5.49%	-3.88%
8/6/2021	11.55%	36.49%	4.88%	29.11%	-3.73%	27.54%	39.94%	23.84%	0.23%	10.61%

ANNUAL RETURN RATES
SMALL CAP STOCKS

Date	AOS	DX	NNBR	BLDR	GME	SAVA	AZPN	FDS	PVH	VMI
12/31/2007	-7.15%	25.11%	-24.82%	-59.87%	125.40%	17.26%	45.86%	-1.50%	-26.75%	60.09%
12/31/2008	-15.78%	-26.27%	-75.69%	-78.81%	-65.13%	-44.15%	-54.25%	-20.57%	-45.39%	-31.15%
12/31/2009	46.99%	33.49%	72.93%	150.98%	1.29%	-9.46%	32.08%	48.89%	102.09%	27.85%
12/31/2010	31.64%	25.09%	212.12%	-48.70%	4.28%	25.93%	29.59%	42.34%	54.89%	13.10%
12/30/2011	5.36%	-16.39%	-51.46%	3.55%	5.46%	-43.70%	36.61%	-6.91%	11.87%	2.32%
12/31/2012	57.20%	3.40%	52.67%	173.53%	3.98%	-28.68%	59.31%	0.89%	57.48%	50.40%
12/31/2013	71.05%	-15.25%	120.41%	27.78%	96.33%	79.34%	51.23%	23.30%	22.53%	9.21%
12/31/2014	4.58%	3.13%	1.83%	-3.65%	-31.38%	-58.23%	-16.22%	29.63%	-5.77%	-14.83%
12/31/2015	35.81%	-23.03%	-22.47%	61.28%	-17.04%	-13.79%	7.82%	15.50%	-42.54%	-16.52%
12/30/2016	23.61%	7.40%	19.51%	-0.99%	-9.91%	-67.43%	44.81%	0.53%	22.53%	32.90%
12/29/2017	29.42%	2.79%	44.88%	98.63%	-28.94%	0.25%	21.07%	17.95%	52.05%	17.71%
12/31/2018	-30.32%	-18.40%	-75.69%	-49.93%	-29.69%	-78.75%	24.14%	3.82%	-32.26%	-33.10%
12/31/2019	11.57%	-1.28%	37.85%	132.91%	-51.82%	511.76%	47.15%	34.06%	13.13%	35.00%
12/31/2020	15.07%	5.08%	-28.97%	60.61%	209.87%	31.15%	7.71%	23.93%	-10.71%	16.79%
8/6/2021	30.74%	-2.13%	0.61%	15.88%	705.57%	1313.64%	13.60%	8.93%	17.41%	36.85%

ANNUAL RETURN RATES
MIXED CAP STOCKS

Date	AAPL	MSFT	BP	XOM	DUK	JNJ	NFLX	RS	RJF	SLAB	WRB	AOS	FDS	AZPN
12/31/2007	129.55%	19.02%	8.77%	22.86%	0.85%	0.86%	2.38%	36.25%	7.43%	7.25%	-14.19%	-7.15%	-1.50%	45.86%
12/31/2008	-56.91%	-45.39%	-36.12%	-14.79%	-25.58%	-10.30%	12.28%	-63.21%	-47.55%	-33.80%	3.99%	-15.78%	-20.57%	-54.25%
12/31/2009	146.90%	56.79%	24.03%	-14.58%	14.66%	7.66%	84.31%	116.75%	38.76%	95.24%	-20.52%	46.99%	48.89%	32.08%
12/31/2010	53.07%	-8.43%	-23.81%	7.23%	3.49%	-3.97%	218.93%	18.23%	37.57%	-4.88%	11.12%	31.64%	42.34%	29.59%
12/30/2011	25.56%	-6.99%	-3.24%	15.92%	23.53%	6.03%	-60.56%	-4.72%	-5.32%	-5.65%	25.60%	5.36%	-6.91%	36.61%
12/31/2012	31.40%	2.89%	-2.57%	2.11%	-3.33%	6.89%	33.63%	27.54%	24.45%	-3.73%	9.74%	57.20%	0.89%	59.31%
12/31/2013	5.42%	40.06%	16.74%	16.93%	8.17%	30.66%	297.63%	22.13%	35.45%	3.61%	14.97%	71.05%	23.30%	51.23%
12/31/2014	37.72%	24.16%	-21.58%	-8.65%	21.05%	14.17%	-7.21%	-19.21%	9.77%	9.95%	18.14%	4.58%	29.63%	-16.22%
12/31/2015	-4.64%	19.44%	-18.00%	-15.68%	-14.54%	-1.77%	134.38%	-5.48%	1.19%	1.93%	6.81%	35.81%	15.50%	7.82%
12/30/2016	10.03%	12.00%	19.58%	15.79%	8.73%	12.16%	8.24%	37.35%	19.49%	33.91%	21.48%	23.61%	0.53%	44.81%
12/29/2017	46.11%	37.66%	12.44%	-7.33%	8.36%	21.27%	55.06%	7.86%	28.92%	35.85%	7.73%	29.42%	17.95%	21.07%
12/31/2018	-6.79%	18.74%	-9.78%	-18.47%	2.60%	-7.64%	39.44%	-17.04%	-16.67%	-10.75%	3.15%	-30.32%	3.82%	24.14%
12/31/2019	86.16%	55.26%	-0.47%	2.33%	5.69%	13.03%	20.89%	68.27%	20.23%	47.16%	40.24%	11.57%	34.06%	47.15%
12/31/2020	80.75%	41.04%	-45.63%	-40.93%	0.38%	7.89%	67.11%	-0.01%	6.94%	9.79%	-3.88%	15.07%	23.93%	7.71%
8/6/2021	10.14%	30.14%	24.56%	40.37%	16.82%	9.99%	-3.73%	27.54%	39.94%	23.84%	10.61%	30.74%	8.93%	13.60%

APPENDIX C

PDF OF R CODE

```
#Install Relevant Packages

library(tidyverse)
library(dplyr)
library(timeSeries)
library("data.table")
if(require("quantmod",quietly=TRUE))
  install.packages("quantmod",dependencies=TRUE,repos=c(CRAN="http://
cran.rstudio.com"))
library("quantmod")
library("xts")
install.packages("fPortfolio")
library(fPortfolio)

library(ggplot2)
library(ggplotify)

# Small Cap

getSymbols("AOS")
barChart(AOS)

getSymbols("DX")
barChart(DX)

getSymbols("NNBR")
barChart(NNBR)

getSymbols("BLDR")
barChart(BLDR)

getSymbols("GME")
barChart(GME)

getSymbols("SAVA")
barChart(SAVA)

getSymbols("PACB")
barChart(PACB)

getSymbols("AZPN")
barChart(AZPN)

getSymbols("FDS")
barChart(FDS)

getSymbols("PVH")
barChart(PVH)

getSymbols("VMI")
barChart(VMI)

# Small Cap Returns
```

```
# AOS
areturnsAOS<-annualReturn(AOS)
areturnsAOS <-as.data.frame(areturnsAOS)
areturnsAOS <- setDT(areturnsAOS, keep.rownames = TRUE)[]
areturnsAOS$rn = as.Date(areturnsAOS$rn)
class(areturnsAOS$rn)

# DX
areturnsDX<-annualReturn(DX)
areturnsDX <-as.data.frame(areturnsDX)
areturnsDX <- setDT(areturnsDX, keep.rownames = TRUE)[]
areturnsDX$rn = as.Date(areturnsDX$rn)
class(areturnsDX$rn)

# NNBR
areturnsNNBR<-annualReturn(NNBR)
areturnsNNBR <-as.data.frame(areturnsNNBR)
areturnsNNBR <- setDT(areturnsNNBR, keep.rownames = TRUE)[]
areturnsNNBR$rn = as.Date(areturnsNNBR$rn)
class(areturnsNNBR$rn)

# BLDR
areturnsBLDR<-annualReturn(BLDR)
areturnsBLDR <-as.data.frame(areturnsBLDR)
areturnsBLDR <- setDT(areturnsBLDR, keep.rownames = TRUE)[]
areturnsBLDR$rn = as.Date(areturnsBLDR$rn)
class(areturnsBLDR$rn)

#GME
areturnsGME<-annualReturn(GME)
areturnsGME <-as.data.frame(areturnsGME)
areturnsGME <- setDT(areturnsGME, keep.rownames = TRUE)[]
areturnsGME$rn = as.Date(areturnsGME$rn)
class(areturnsGME$rn)

#SAVA
areturnsSAVA<-annualReturn(SAVA)
areturnsSAVA <-as.data.frame(areturnsSAVA)
areturnsSAVA <- setDT(areturnsSAVA, keep.rownames = TRUE)[]
areturnsSAVA$rn = as.Date(areturnsSAVA$rn)
class(areturnsSAVA$rn)

#PACB
areturnsPACB<-annualReturn(PACB)
areturnsPACB <-as.data.frame(areturnsPACB)
areturnsPACB <- setDT(areturnsPACB, keep.rownames = TRUE)[]
areturnsPACB$rn = as.Date(areturnsPACB$rn)
class(areturnsPACB$rn)

##AZPN
areturnsAZPN<-annualReturn(AZPN)
areturnsAZPN <-as.data.frame(areturnsAZPN)
areturnsAZPN <- setDT(areturnsAZPN, keep.rownames = TRUE)[]
areturnsAZPN$rn = as.Date(areturnsAZPN$rn)
```

```
class(areturnsAZPN$rn)

##FDS
areturnsFDS<-annualReturn(FDS)
areturnsFDS <-as.data.frame(areturnsFDS)
areturnsFDS <- setDT(areturnsFDS, keep.rownames = TRUE)[]
areturnsFDS$rn = as.Date(areturnsFDS$rn)
class(areturnsFDS$rn)

#PVH
areturnsPVH<-annualReturn(PVH)
areturnsPVH <-as.data.frame(areturnsPVH)
areturnsPVH <- setDT(areturnsPVH, keep.rownames = TRUE)[]
areturnsPVH$rn = as.Date(areturnsPVH$rn)
class(areturnsPVH$rn)

#VMI
areturnsVMI<-annualReturn(VMI)
areturnsVMI <-as.data.frame(areturnsVMI)
areturnsVMI <- setDT(areturnsVMI, keep.rownames = TRUE)[]
areturnsVMI$rn = as.Date(areturnsVMI$rn)
class(areturnsVMI$rn)

scap<-cbind(areturnsVMI$rn, areturnsAOS$yearly.returns, areturnsDX$yearly.returns,
areturnsNNBR$yearly.returns, areturnsBLDR$yearly.returns,
areturnsGME$yearly.returns, areturnsSAVA$yearly.returns,
areturnsAZPN$yearly.returns,areturnsFDS$yearly.returns,areturnsPVH$yearly.returns,
areturnsVMI$yearly.returns)

scap<-as.data.frame(scap)
scap$V1 <- as.Date(scap$V1)
scap$V1 <- as.Date(scap$V1, format = "%Y-%m-%d")
class(scap$V2)

scap$V2 <- as.numeric(scap$V2)
scap$V3 <- as.numeric(scap$V3)
scap$V4 <- as.numeric(scap$V4)
scap$V5 <- as.numeric(scap$V5)
scap$V6 <- as.numeric(scap$V6)
scap$V7 <- as.numeric(scap$V7)
scap$V8 <- as.numeric(scap$V8)
scap$V9 <- as.numeric(scap$V9)
scap$V10 <- as.numeric(scap$V10)
scap$V11 <- as.numeric(scap$V11)
scap$V11 <- as.numeric(scap$V11)

colnames(scap) <- c("Date", "AOS", "DX", "NNBR", "BLDR", "GME", "SAVA",
"AZPN", "FDS", "PVH", "VMI")


rownames(scap) <- c()

scap<-timeSeries(scap[,-1], charvec = scap$Date)
class(scap)
```

```
write.csv(scap, "C:/Data Science and Analytics/DSA 5303/Final Class Project/
Small Cap/scap.csv")

# long portfolio with target return at 0.15

spec1<-portfolioSpec()
setRiskFreeRate(spec1)<-.05
setTargetReturn(spec1) <- 0.15

scaplong<-efficientPortfolio(scap, spec = spec1, constraints = "LongOnly")

scaplongfrontier<-portfolioFrontier(scap, spec1)

tailoredFrontierPlot(object = scaplongfrontier, mText = "MV Portfolio -
LongOnly Constraints",
                     risk = "Cov")

par(mfrow = c(1, 2))
col <- rampPalette(ncol(scap), "purple2green")
names <- colnames(scap)
weights <- 100 * as.vector(getWeights(scaplong))
weightedReturns <- weights * getMean(scaplong)
barplot(height = weights, names.arg = names, horiz = TRUE, las = 1, col = col)
title(main = "Portfolio Weights", xlab = "Weights %")
barplot(height = weightedReturns, names.arg = names, horiz = TRUE, las = 1,
col = col)
title(main = "Weighted Portfolio Returns", xlab = "Weighted Returns %")

# short portfolio with target return at 0.15

spec2<-portfolioSpec()
setRiskFreeRate(spec2)<-.05
setTargetReturn(spec2) <- 0.15

setSolver(spec2)<-"solveRshortExact"

scapshort<-efficientPortfolio(scap, spec = spec2, constraints = "Short")

scapshortfrontier<-portfolioFrontier(scap, spec2)

tailoredFrontierPlot(object = scapshortfrontier, mText = "MV Portfolio - Short
Constraints",
                     risk = "Cov")

par(mfrow = c(1, 2))
col <- rampPalette(ncol(scap), "purple2green")
names <- colnames(scap)
weights <- 100 * as.vector(getWeights(scapshort))
weightedReturns <- weights * getMean(scapshort)
barplot(height = weights, names.arg = names, horiz = TRUE, las = 1, col = col)
title(main = "Portfolio Weights", xlab = "Weights %")
barplot(height = weightedReturns, names.arg = names, horiz = TRUE, las = 1,
col = col)
title(main = "Weighted Portfolio Returns", xlab = "Weighted Returns %")
```

```
# short portfolio with target risk at 0.20

spec3<-portfolioSpec()
setRiskFreeRate(spec3)<-.05
setTargetRisk(spec3) <- 0.20

setOptimize(spec3) <- 'maxReturn'
setSolver(spec3)<-"solveRshortExact"

scapshortmaxReturn<-maxreturnPortfolio(scap, spec = spec3, constraints =
"Short")
scapshortfrontiermax<-portfolioFrontier(scap, spec3)

tailoredFrontierPlot(object = scapshortfrontiermax, mText = "MV Portfolio -
LongOnly Constraints",
                     risk = "Cov")

par(mfrow = c(1, 2))
col <- rampPalette(ncol(scap), "purple2green")
names <- colnames(scap)
weights <- 100 * as.vector(getWeights(scapshortmaxReturn))
weightedReturns <- weights * getMean(scapshortmaxReturn)
barplot(height = weights, names.arg = names, horiz = TRUE, las = 1, col = col)
title(main = "Portfolio Weights", xlab = "Weights %")
barplot(height = weightedReturns, names.arg = names, horiz = TRUE, las = 1,
col = col)
title(main = "Weighted Portfolio Returns", xlab = "Weighted Returns %")

#Mid Cap Stocks

getSymbols("GATX")
barChart(GATX)

getSymbols("LEN")
barChart(LEN)

getSymbols("JBLU")
barChart(JBLU)

getSymbols("MLM")
barChart(MLM)

getSymbols("NFLX")
barChart(NFLX)

getSymbols("RS")
barChart(RS)

getSymbols("RJF")
barChart(RJF)

getSymbols("SLAB")
```

```
barChart(SLAB)

getSymbols("ROST")
barChart(ROST)

getSymbols("WRB")
barChart(WRB)

# Mid Cap Returns
# GATX
areturnsGATX<-annualReturn(GATX)
areturnsGATX <-as.data.frame(areturnsGATX)
areturnsGATX <- setDT(areturnsGATX, keep.rownames = TRUE)[]
areturnsGATX$rn = as.Date(areturnsGATX$rn)
class(areturnsGATX$rn)

# LEN
areturnsLEN<-annualReturn(LEN)
areturnsLEN <-as.data.frame(areturnsLEN)
areturnsLEN <- setDT(areturnsLEN, keep.rownames = TRUE)[]
areturnsLEN$rn = as.Date(areturnsLEN$rn)
class(areturnsLEN$rn)

# JBLU
areturnsJBLU<-annualReturn(JBLU)
areturnsJBLU <-as.data.frame(areturnsJBLU)
areturnsJBLU <- setDT(areturnsJBLU, keep.rownames = TRUE)[]
areturnsJBLU$rn = as.Date(areturnsJBLU$rn)
class(areturnsJBLU$rn)

# MLM
areturnsMLM<-annualReturn(MLM)
areturnsMLM <-as.data.frame(areturnsMLM)
areturnsMLM <- setDT(areturnsMLM, keep.rownames = TRUE)[]
areturnsMLM$rn = as.Date(areturnsMLM$rn)
class(areturnsMLM$rn)

# NFLX
areturnsNFLX<-annualReturn(NFLX)
areturnsNFLX <-as.data.frame(areturnsNFLX)
areturnsNFLX <- setDT(areturnsNFLX, keep.rownames = TRUE)[]
areturnsNFLX$rn = as.Date(areturnsNFLX$rn)
class(areturnsNFLX$rn)


# RS
areturnsRS<-annualReturn(RS)
areturnsRS <-as.data.frame(areturnsRS)
areturnsRS <- setDT(areturnsRS, keep.rownames = TRUE)[]
areturnsRS$rn = as.Date(areturnsRS$rn)
class(areturnsRS$rn)

# RJF
areturnsRJF<-annualReturn(RJF)
```

```
areturnsRJF <-as.data.frame(areturnsRJF)
areturnsRJF <- setDT(areturnsRJF, keep.rownames = TRUE)[]
areturnsRJF$rn = as.Date(areturnsRJF$rn)
class(areturnsRJF$rn)


# SLAB
areturnsSLAB<-annualReturn(SLAB)
areturnsSLAB <-as.data.frame(areturnsSLAB)
areturnsSLAB <- setDT(areturnsSLAB, keep.rownames = TRUE)[]
areturnsSLAB$rn = as.Date(areturnsSLAB$rn)
class(areturnsSLAB$rn)

# ROST
areturnsROST<-annualReturn(ROST)
areturnsROST <-as.data.frame(areturnsROST)
areturnsROST <- setDT(areturnsROST, keep.rownames = TRUE)[]
areturnsROST$rn = as.Date(areturnsROST$rn)
class(areturnsROST$rn)


# WRB
areturnsWRB<-annualReturn(WRB)
areturnsWRB <-as.data.frame(areturnsWRB)
areturnsWRB <- setDT(areturnsWRB, keep.rownames = TRUE)[]
areturnsWRB$rn = as.Date(areturnsWRB$rn)
class(areturnsWRB$rn)

mcap<-cbind(areturnsWRB$rn, areturnsGATX$yearly.returns,
areturnsLEN$yearly.returns, areturnsJBLU$yearly.returns,
areturnsMLM$yearly.returns, areturnsNFLX$yearly.returns, areturnsRS$yearly.returns,
areturnsRJF$yearly.returns,areturnsSLAB$yearly.returns,areturnsROST$yearly.returns,
areturnsWRB$yearly.returns)

mcap<-as.data.frame(mcap)
mcap$V1 <- as.Date(mcap$V1)
mcap$V1 <- as.Date(mcap$V1, format = "%Y-%m-%d")

mcap$V2 <- as.numeric(mcap$V2)
mcap$V3 <- as.numeric(mcap$V3)
mcap$V4 <- as.numeric(mcap$V4)
mcap$V5 <- as.numeric(mcap$V5)
mcap$V6 <- as.numeric(mcap$V6)
mcap$V7 <- as.numeric(mcap$V7)
mcap$V8 <- as.numeric(mcap$V8)
mcap$V9 <- as.numeric(mcap$V9)
mcap$V10 <- as.numeric(mcap$V10)
mcap$V11 <- as.numeric(mcap$V11)

colnames(mcap) <- c("Date", "GATX", "LEN", "JBLU", "MLM", "NFLX", "RS", "RJF",
"SLAB", "ROST", "WRB")

rownames(mcap) <- c()
```

```
mcap<-timeSeries(mcap[,-1], charvec = mcap$Date)
class(mcap)

write.csv(mcap, "C:/Data Science and Analytics/DSA 5303/Final Class Project/
Mid Cap/mcap.csv")


# long portfolio with target return at 0.15

spec4<-portfolioSpec()
setRiskFreeRate(spec4)<-0.05
setTargetReturn(spec4)<- 0.15

mcaplong<-efficientPortfolio(mcap, spec = spec4, constraints = "LongOnly")

mcaplongfrontier<-portfolioFrontier(mcap, spec4)

tailoredFrontierPlot(object = mcaplongfrontier, mText = "MV Portfolio -
LongOnly Constraints",
                     risk = "Cov")


par(mfrow = c(1, 2))
col <- rampPalette(ncol(mcap), "purple2green")
names <- colnames(mcap)
weights <- 100 * as.vector(getWeights(mcaplong))
weightedReturns <- weights * getMean(mcaplong)
barplot(height = weights, names.arg = names, horiz = TRUE, las = 1, col = col)
title(main = "Portfolio Weights", xlab = "Weights %")
barplot(height = weightedReturns, names.arg = names, horiz = TRUE, las = 1,
col = col)
title(main = "Weighted Portfolio Returns", xlab = "Weighted Returns %")

# short portfolio with target return at 0.15

spec5<-portfolioSpec()
setRiskFreeRate(spec5)<-0.05
setTargetReturn(spec5)<- 0.15
setSolver(spec5)<-"solveRshortExact"

mcapshort<-efficientPortfolio(mcap, spec = spec5, constraints = "Short")

mcapshortfrontier<-portfolioFrontier(mcap, spec5)

tailoredFrontierPlot(object = mcapshortfrontier, mText = "MV Portfolio - Short
Constraints",
                     risk = "Cov")


par(mfrow = c(1, 2))
col <- rampPalette(ncol(mcap), "purple2green")
names <- colnames(mcap)
weights <- 100 * as.vector(getWeights(mcapshort))
weightedReturns <- weights * getMean(mcapshort)
```

```
barplot(height = weights, names.arg = names, horiz = TRUE, las = 1, col = col)
title(main = "Portfolio Weights", xlab = "Weights %")
barplot(height = weightedReturns, names.arg = names, horiz = TRUE, las = 1,
col = col)
title(main = "Weighted Portfolio Returns", xlab = "Weighted Returns %")

# short portfolio with target risk at 0.20

spec6<-portfolioSpec()
setRiskFreeRate(spec6)<-0.05
setTargetRisk(spec6)<- 0.20
setSolver(spec6)<-"solveRshortExact"

setOptimize(spec6) <- 'maxReturn'

mcapshortmaxReturn<-maxreturnPortfolio(scap, spec = spec6, constraints =
"Short")

mcapshortfrontiermax<-portfolioFrontier(mcap, spec6)

tailoredFrontierPlot(object = mcapshortfrontiermax, mText = "MV Portfolio -
Short Constraints",
                     risk = "Cov")


par(mfrow = c(1, 2))
col <- rampPalette(ncol(mcap), "purple2green")
names <- colnames(mcap)
weights <- 100 * as.vector(getWeights(mcapshortmaxReturn))
weightedReturns <- weights * getMean(mcapshortmaxReturn)
barplot(height = weights, names.arg = names, horiz = TRUE, las = 1, col = col)
title(main = "Portfolio Weights", xlab = "Weights %")
barplot(height = weightedReturns, names.arg = names, horiz = TRUE, las = 1,
col = col)
title(main = "Weighted Portfolio Returns", xlab = "Weighted Returns %")

#### large cap

getSymbols("AAPL")
barChart(AAPL)

getSymbols("MSFT")
barChart(MSFT)

getSymbols("GOOG")
barChart(GOOG)

getSymbols("IBM")
barChart(IBM)

getSymbols("BP")
barChart(BP)

getSymbols("XOM")
```

```
barChart(XOM)

getSymbols("CSCO")
barChart(CSCO)

getSymbols("DUK")
barChart(DUK)

getSymbols("JNJ")
barChart(JNJ)

getSymbols("INTC")
barChart(INTC)


## large cap returns

# AAPL
areturnsAAPL<-annualReturn(AAPL)
areturnsAAPL <-as.data.frame(areturnsAAPL)
areturnsAAPL <- setDT(areturnsAAPL, keep.rownames = TRUE)[]
areturnsAAPL$rn = as.Date(areturnsAAPL$rn)
class(areturnsAAPL$rn)

# MSFT
areturnsMSFT<-annualReturn(MSFT)
areturnsMSFT <-as.data.frame(areturnsMSFT)
areturnsMSFT <- setDT(areturnsMSFT, keep.rownames = TRUE)[]
areturnsMSFT$rn = as.Date(areturnsMSFT$rn)
class(areturnsMSFT$rn)

# IBM
areturnsIBM<-annualReturn(IBM)
areturnsIBM <-as.data.frame(areturnsIBM)
areturnsIBM <- setDT(areturnsIBM, keep.rownames = TRUE)[]
areturnsIBM$rn = as.Date(areturnsIBM$rn)
class(areturnsIBM$rn)

# GOOG
areturnsGOOG<-annualReturn(GOOG)
areturnsGOOG <-as.data.frame(areturnsGOOG)
areturnsGOOG <- setDT(areturnsGOOG, keep.rownames = TRUE)[]
areturnsGOOG$rn = as.Date(areturnsGOOG$rn)
class(areturnsGOOG$rn)

# BP
areturnsBP<-annualReturn(BP)
areturnsBP <-as.data.frame(areturnsBP)
areturnsBP <- setDT(areturnsBP, keep.rownames = TRUE)[]
areturnsBP$rn = as.Date(areturnsBP$rn)
class(areturnsBP$rn)

# XOM
areturnsXOM<-annualReturn(XOM)
```

```
areturnsXOM <-as.data.frame(areturnsXOM)
areturnsXOM <- setDT(areturnsXOM, keep.rownames = TRUE)[]
areturnsXOM$rn = as.Date(areturnsXOM$rn)
class(areturnsXOM$rn)

# CSCO
areturnsCSCO<-annualReturn(CSCO)
areturnsCSCO <-as.data.frame(areturnsCSCO)
areturnsCSCO <- setDT(areturnsCSCO, keep.rownames = TRUE)[]
areturnsCSCO$rn = as.Date(areturnsCSCO$rn)
class(areturnsCSCO$rn)

# DUK
areturnsDUK<-annualReturn(DUK)
areturnsDUK <-as.data.frame(areturnsDUK)
areturnsDUK <- setDT(areturnsDUK, keep.rownames = TRUE)[]
areturnsDUK$rn = as.Date(areturnsDUK$rn)
class(areturnsDUK$rn)

# JNJ
areturnsJNJ<-annualReturn(JNJ)
areturnsJNJ <-as.data.frame(areturnsJNJ)
areturnsJNJ <- setDT(areturnsJNJ, keep.rownames = TRUE)[]
areturnsJNJ$rn = as.Date(areturnsJNJ$rn)
class(areturnsJNJ$rn)

# INTC
areturnsINTC<-annualReturn(INTC)
areturnsINTC <-as.data.frame(areturnsINTC)
areturnsINTC <- setDT(areturnsINTC, keep.rownames = TRUE)[]
areturnsINTC$rn = as.Date(areturnsINTC$rn)
class(areturnsINTC$rn)


lcap<-cbind(areturnsINTC$rn, areturnsAAPL$yearly.returns,
areturnsMSFT$yearly.returns, areturnsIBM$yearly.returns,
areturnsGOOG$yearly.returns, areturnsBP$yearly.returns,
areturnsXOM$yearly.returns,
areturnsCSCO$yearly.returns,areturnsDUK$yearly.returns,areturnsJNJ$yearly.returns,
areturnsINTC$yearly.returns)
lcap<-as.data.frame(lcap)
lcap$V1 <- as.Date(lcap$V1)
lcap$V1 <- as.Date(lcap$V1, format = "%Y-%m-%d")
class(lcap$V2)

lcap$V2 <- as.numeric(lcap$V2)
lcap$V3 <- as.numeric(lcap$V3)
lcap$V4 <- as.numeric(lcap$V4)
lcap$V5 <- as.numeric(lcap$V5)
lcap$V6 <- as.numeric(lcap$V6)
lcap$V7 <- as.numeric(lcap$V7)
lcap$V8 <- as.numeric(lcap$V8)
lcap$V9 <- as.numeric(lcap$V9)
lcap$V10 <- as.numeric(lcap$V10)
```

```
lcap$V11 <- as.numeric(lcap$V11)

colnames(lcap) <- c("Date", "AAPL", "MSFT", "IBM", "GOOG", "BP", "XOM",
"CSCO", "DUK", "JNJ", "INTC")


rownames(lcap) <- c()

lcap<-timeSeries(lcap[,-1], charvec = lcap$Date)
class(lcap)

write.csv(lcap, "C:/Data Science and Analytics/DSA 5303/Final Class Project/
Large Cap/lcap.csv")



# long position with target return of 0.15

spec7<-portfolioSpec()
setRiskFreeRate(spec7)<-0.05
setTargetReturn(spec7)<- 0.15

lcaplong<-efficientPortfolio(lcap, spec = spec7, constraints = "LongOnly")

lcaplongfrontier<-portfolioFrontier(lcap, spec7)

tailoredFrontierPlot(object = lcaplongfrontier, mText = "MV Portfolio -
LongOnly Constraints",
                     risk = "Cov")


par(mfrow = c(1, 2))
col <- rampPalette(ncol(lcap), "purple2green")
names <- colnames(lcap)
weights <- 100 * as.vector(getWeights(lcaplong))
weightedReturns <- weights * getMean(mcaplong)
barplot(height = weights, names.arg = names, horiz = TRUE, las = 1, col = col)
title(main = "Portfolio Weights", xlab = "Weights %")
barplot(height = weightedReturns, names.arg = names, horiz = TRUE, las = 1,
col = col)
title(main = "Weighted Portfolio Returns", xlab = "Weighted Returns %")

# short position with target return of 0.15

spec8<-portfolioSpec()
setRiskFreeRate(spec8)<-0.05
setTargetReturn(spec8)<- 0.15
setSolver(spec8)<-"solveRshortExact"

lcapshort<-efficientPortfolio(lcap, spec = spec8, constraints = "Short")

lcapshortfrontier<-portfolioFrontier(lcap, spec8)
```

```
tailoredFrontierPlot(object = lcapshortfrontier, mText = "MV Portfolio -
ShortOnly Constraints",
                     risk = "Cov")


par(mfrow = c(1, 2))
col <- rampPalette(ncol(lcap), "purple2green")
names <- colnames(lcap)
weights <- 100 * as.vector(getWeights(lcapshort))
weightedReturns <- weights * getMean(lcapshort)
barplot(height = weights, names.arg = names, horiz = TRUE, las = 1, col = col)
title(main = "Portfolio Weights", xlab = "Weights %")
barplot(height = weightedReturns, names.arg = names, horiz = TRUE, las = 1,
col = col)
title(main = "Weighted Portfolio Returns", xlab = "Weighted Returns %")


# short portfolio with target risk at 0.20

spec9<-portfolioSpec()
setRiskFreeRate(spec9)<-0.05
setTargetRisk(spec9)<- 0.20
setSolver(spec9)<-"solveRshortExact"

setOptimize(spec9) <- 'maxReturn'

lcapshortmaxReturn<-maxreturnPortfolio(lcap, spec = spec9, constraints =
"Short")

lcapshortfrontiermax<-portfolioFrontier(lcap, spec9)

tailoredFrontierPlot(object = lcapshortfrontiermax, mText = "MV Portfolio -
Short Constraints",
                     risk = "Cov")


par(mfrow = c(2, 2))
col <- rampPalette(ncol(lcap), "purple2green")
names <- colnames(lcap)
weights <- 100 * as.vector(getWeights(lcapshortmaxReturn))
weightedReturns <- weights * getMean(lcapshortmaxReturn)
barplot(height = weights, names.arg = names, horiz = TRUE, las = 1, col = col)
title(main = "Portfolio Weights", xlab = "Weights %")
barplot(height = weightedReturns, names.arg = names, horiz = TRUE, las = 1,
col = col)
title(main = "Weighted Portfolio Returns", xlab = "Weighted Returns %")

# combination of small, mid cap, and large cap stocks

mixedcap<-cbind(areturnsAAPL$rn, areturnsAAPL$yearly.returns,
areturnsMSFT$yearly.returns, areturnsBP$yearly.returns,
areturnsXOM$yearly.returns,  areturnsDUK$yearly.returns,
```

```
                areturnsJNJ$yearly.returns, areturnsNFLX$yearly.returns,
areturnsRS$yearly.returns,
areturnsRJF$yearly.returns,areturnsSLAB$yearly.returns,
                areturnsWRB$yearly.returns, areturnsAOS$yearly.returns,
areturnsFDS$yearly.returns, areturnsAZPN$yearly.returns)

mixedcap<-as.data.frame(mixedcap)
mixedcap$V1 <- as.Date(mixedcap$V1)
mixedcap$V1 <- as.Date(mixedcap$V1, format = "%Y-%m-%d")
class(mixedcap$VMI)

mixedcap$V2 <- as.numeric(mixedcap$V2)
mixedcap$V3 <- as.numeric(mixedcap$V3)
mixedcap$V4 <- as.numeric(mixedcap$V4)
mixedcap$V5 <- as.numeric(mixedcap$V5)
mixedcap$V6 <- as.numeric(mixedcap$V6)
mixedcap$V7 <- as.numeric(mixedcap$V7)
mixedcap$V8 <- as.numeric(mixedcap$V8)
mixedcap$V9 <- as.numeric(mixedcap$V9)
mixedcap$V10 <- as.numeric(mixedcap$V10)
mixedcap$V11 <- as.numeric(mixedcap$V11)
mixedcap$V12 <- as.numeric(mixedcap$V12)
mixedcap$V13 <- as.numeric(mixedcap$V13)
mixedcap$V14 <- as.numeric(mixedcap$V14)
mixedcap$V15 <- as.numeric(mixedcap$V15)


colnames(mixedcap) <- c("Date", "AAPL", "MSFT", "BP", "XOM", "DUK", "JNJ",
"NFLX", "RS", "RJF", "SLAB", "WRB", "AOS", "FDS", "AZPN")


rownames(mixedcap) <- c()

mixedcap<-timeSeries(mixedcap[,-1], charvec = mixedcap$Date)
class(mixedcap)

write.csv(mixedcap, "C:/Data Science and Analytics/DSA 5303/Final Class
Project/Mixed Cap/mixedcap.csv")

# long position with target return of 0.15

spec10<-portfolioSpec()
setRiskFreeRate(spec10)<-0.05
setTargetReturn(spec10)<- 0.15

mixedcaplong<-efficientPortfolio(mixedcap, spec = spec10, constraints =
"LongOnly")

mixedcaplongfrontier<-portfolioFrontier(mixedcap, spec10)

tailoredFrontierPlot(object = mixedcaplongfrontier, mText = "MV Portfolio -
LongOnly Constraints",
                     risk = "Cov")
```

```
par(mfrow = c(1, 1))

par(mfrow = c(1, 2))
col <- rampPalette(ncol(mixedcap), "purple2green")
names <- colnames(mixedcap)
weights <- 100 * as.vector(getWeights(mixedcaplong))
weightedReturns <- weights * getMean(mixedcaplong)
barplot(height = weights, names.arg = names, horiz = TRUE, las = 1, col = col)
title(main = "Portfolio Weights", xlab = "Weights %")
barplot(height = weightedReturns, names.arg = names, horiz = TRUE, las = 1,
col = col)
title(main = "Weighted Portfolio Returns", xlab = "Weighted Returns %")

# short position with target return of 0.15

spec11<-portfolioSpec()
setRiskFreeRate(spec11)<-0.05
setTargetReturn(spec11)<- 0.15
setSolver(spec11)<-"solveRshortExact"

mixedcapshort<-efficientPortfolio(mixedcap, spec = spec11, constraints =
"Short")

mixedcapshortfrontier<-portfolioFrontier(mixedcap, spec11)

tailoredFrontierPlot(object = mixedcapshortfrontier, mText = "MV Portfolio -
ShortOnly Constraints",
                     risk = "Cov")


par(mfrow = c(1, 2))
col <- rampPalette(ncol(mixedcap), "purple2green")
names <- colnames(mixedcap)
weights <- 100 * as.vector(getWeights(mixedcapshort))
weightedReturns <- weights * getMean(mixedcapshort)
barplot(height = weights, names.arg = names, horiz = TRUE, las = 1, col = col)
title(main = "Portfolio Weights", xlab = "Weights %")
barplot(height = weightedReturns, names.arg = names, horiz = TRUE, las = 1,
col = col)
title(main = "Weighted Portfolio Returns", xlab = "Weighted Returns %")


# short portfolio with target risk at 0.20

spec12<-portfolioSpec()
setRiskFreeRate(spec12)<-0.05
setTargetRisk(spec12)<- 0.20
setSolver(spec12)<-"solveRshortExact"

setOptimize(spec12) <- 'maxReturn'

mixedcapshortmaxReturn<-maxreturnPortfolio(mixedcap, spec = spec12,
constraints = "Short")
```

```
mixedcapshortfrontiermax<-portfolioFrontier(mixedcap, spec12)

tailoredFrontierPlot(object = mixedcapshortfrontiermax, mText = "MV Portfolio
- Short Constraints",
                     risk = "Cov")


par(mfrow = c(1, 2))
col <- rampPalette(ncol(mixedcap), "purple2green")
names <- colnames(mixedcap)
weights <- 100 * as.vector(getWeights(mixedcapshortmaxReturn))
weightedReturns <- weights * getMean(mixedcapshortmaxReturn)
barplot(height = weights, names.arg = names, horiz = TRUE, las = 1, col = col)
title(main = "Portfolio Weights", xlab = "Weights %")
barplot(height = weightedReturns, names.arg = names, horiz = TRUE, las = 1,
col = col)
title(main = "Weighted Portfolio Returns", xlab = "Weighted Returns %")

# long frontier for all frontier points for mixed cap

weightsPlot(mixedcaplongfrontier)
text <- "Mean-Variance Portfolio - Long Only Constraints"
mtext(text, side = 3, line = 3, font = 2, cex = 0.9)
col <- rampPalette(ncol(mixedcap))
weightedReturnsPlot(mixedcaplongfrontier)



# short frontier for all frontier points for mixed cap

weightsPlot(mixedcapshortfrontier)
text <- "Mean-Variance Portfolio - Short Sell"
mtext(text, side = 3, line = 3, font = 2, cex = 0.9)
weightedReturnsPlot(mixedcapshortfrontier, col=col)
covRiskBudgetsPlot(mixedcapshortfrontier)


# shiny basic plots app

library(shiny)

shinyApp(
ui <- fluidPage(
  radioButtons("radio",
               label = HTML('<FONT color="red"><FONT size="5pt">Welcome to
Portfolio Selection Program</FONT></FONT><br> <b>Which Stock do you want?</
b>'),
               c("scaplong" = 1, "scapshort" = 2, "mcaplong"=3, "mcapshort" =
4, "lcaplong" = 5, "lcapshort" = 6)),

  mainPanel(
    plotOutput("plot")
  )
),
```

```
server = function(input, output) {


  output$plot <- renderPlot({

    # Now let us print some stock data
    if(input$radio == 1){

      plot(scaplongfrontier, c(1,2,3,4,8))
    }
    else if(input$radio == 2){plot(scapshortfrontier, c(1,2,3,4,8))
    }
    else if  (input$radio == 3) {plot(mcaplongfrontier, c(1,2,3,4,8))
    } else if (input$radio ==4) {plot(mcapshortfrontier, c(1,2,3,4,8))}
      else if (input$radio ==5) {plot(lcaplongfrontier, c(1,2,3,4,8))}
      else {plot(lcapshortfrontier, c(1,2,3,4,8))}

    })
  }
)

# shiny basic output app

shinyApp(ui = ui, server = server)

library(shiny)

shinyApp(
  ui <- fluidPage(
    radioButtons("radio",
                 label = HTML('<FONT color="red"><FONT size="5pt">Welcome to
Portfolio Selection Program</FONT></FONT><br> <b>Which Stock do you want?</
b>'),
                 c("stats scaplong" = 1, " stats scapshort" = 2, " stats
mcaplong"=3, "stats mcapshort" = 4, "stats lcaplong" = 5, "stats lcapshort" =
6)),

    mainPanel(
      verbatimTextOutput("stats")
    )
  ),


  server = function(input, output) {


    output$stats <- renderPrint({

      # Now let us print some stock data
      if(input$radio == 1){

        scaplong
```

```
      }
      else if(input$radio == 2){scapshort
      }
      else if  (input$radio == 3) {mcaplong
      } else if (input$radio ==4) {mcapshort}
      else if (input$radio ==5) {lcaplong}
      else {lcapshort}

    })
  }
)


shinyApp(ui = ui, server = server)
```