Assignment 2

MIE1622 REPORT
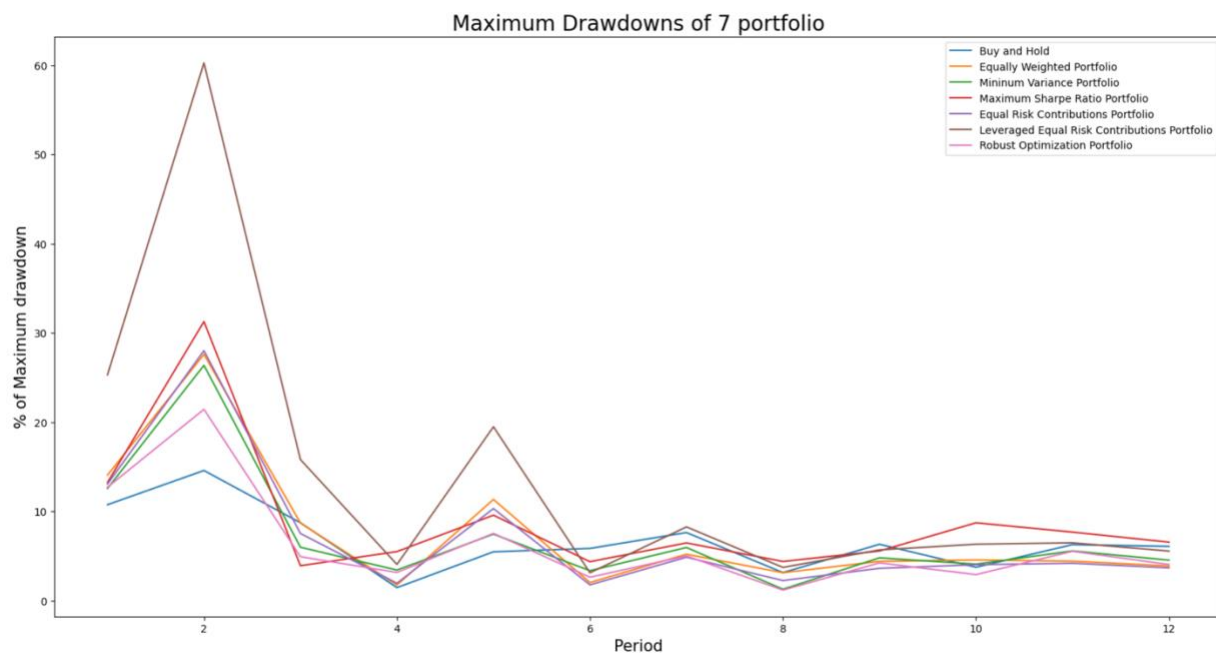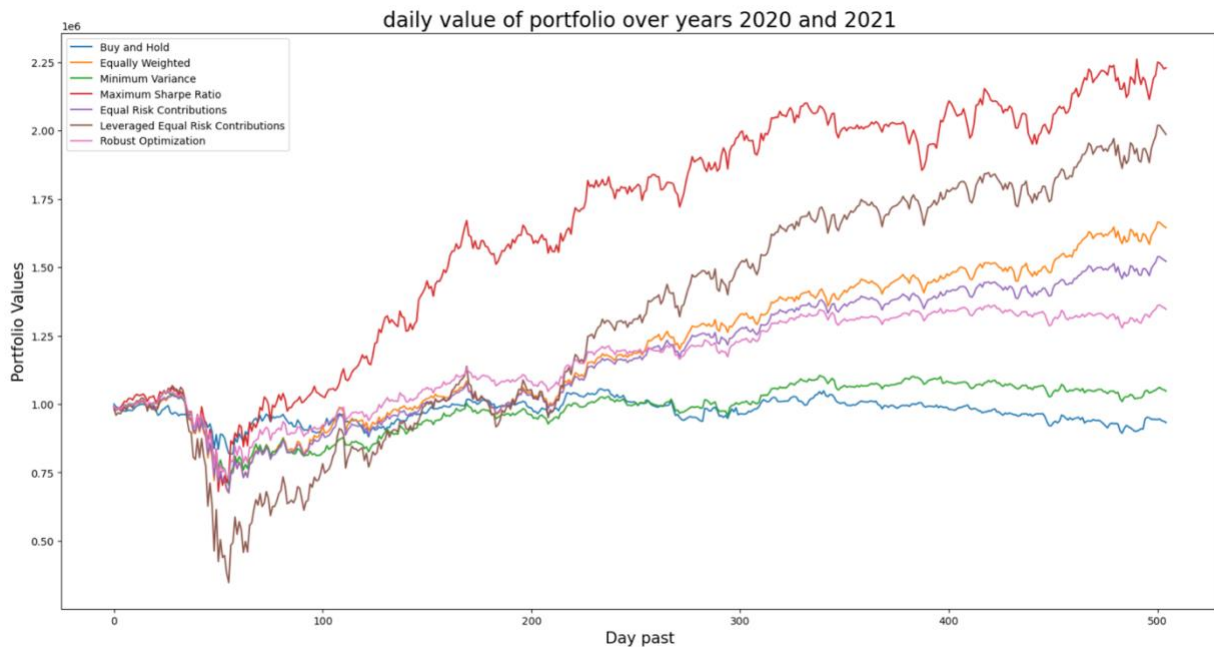
Tongfei Li

1004759460
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Testing strategies for 2020-2021:

daily value of portfolio over years 2020 and 2021

Maximum Drawdowns of 7 portfolio

Looking at the dynamic changes graph of robust, it tends to use 'T' as dominant stock, since its weight is larger than 0.2 all the time, this is similar to minimum variance, it also uses give a high weight to 'T'. Compared to minimum variance, robust does not significantly reduce trading, while compared to sharpe ratio, robust does reduce trading, since sharpe ratio strategy tends

to maximize one or two different stocks at each period, while robust and minimum variance tends to give high weight to specific stock for consecutive periods.

Looking at the maximum drawdown curve, we can see that all 7 portfolio values experience a significant drawdown at period 2, during the time, maximum drawdown of equal risk contributions is the largest, buy and hold is the smallest. It can also be seen in the daily portfolio value graph, that during day of around 40-100, every portfolio value shows a downward trend, but leveraged equal risk portfolio descend the most, buy and hold descend the least. Moreover, there's also a drawdown at period 5, equal risk contribution is also the largest, buy and hold the smallest. We may guess that during stock market recession, buy and hold is the best strategy to maintain the portfolio value and leverage equal risk may experience the most fluctuation.

Comparing our three new strategies, we can see that, during sudden fall of overall stock value (day 30-100), robust behaves the best, followed by equal risk and leveraged equal risk, they all lead to different degrees of fall in portfolio value. In the mid period (around day 140-210), leveraged equal risk quickly retore the value, and behaves very similar to equal risk contribution. While after day 250, leveraged equal risk grow rapidly and surpass the other two strategies, robust and equal risk behaves similar in the last days.

Comparing the daily values of 7 strategies, we can see that during market turbulence, especially for overall recession, leveraged equal risk contributions leads to the most fluctuated portfolio value. During day of around 40-100, every portfolio value shows a downward trend, but leveraged equal risk portfolio descend the most. Moreover, during the recession period, buy and hold strategy leads to the least lost in portfolio value, but buy and hold strategy is the worst one when stock market increases, we can see that for 300-500 days, every portfolio value increases, except minimum variance and buy and hold. At the end, maximum sharp ratio behaves the best, followed by leveraged equal risk, equally weighted, equal risk and robust, they all lead to an increase in overall value, while minimum variance and buy & hold are not good strategies in this trading period since they do not increase overall values. If I am to choose one strategy to manage my own portfolio, I may choose maximum sharpe ratio, since it makes respectable income here, and the strategy is considerably stable during market recession.

Testing strategies for 2008-2009:

daily value of portfolio over years 2008 and 2009

Maximum Drawdowns of 7 portfolio
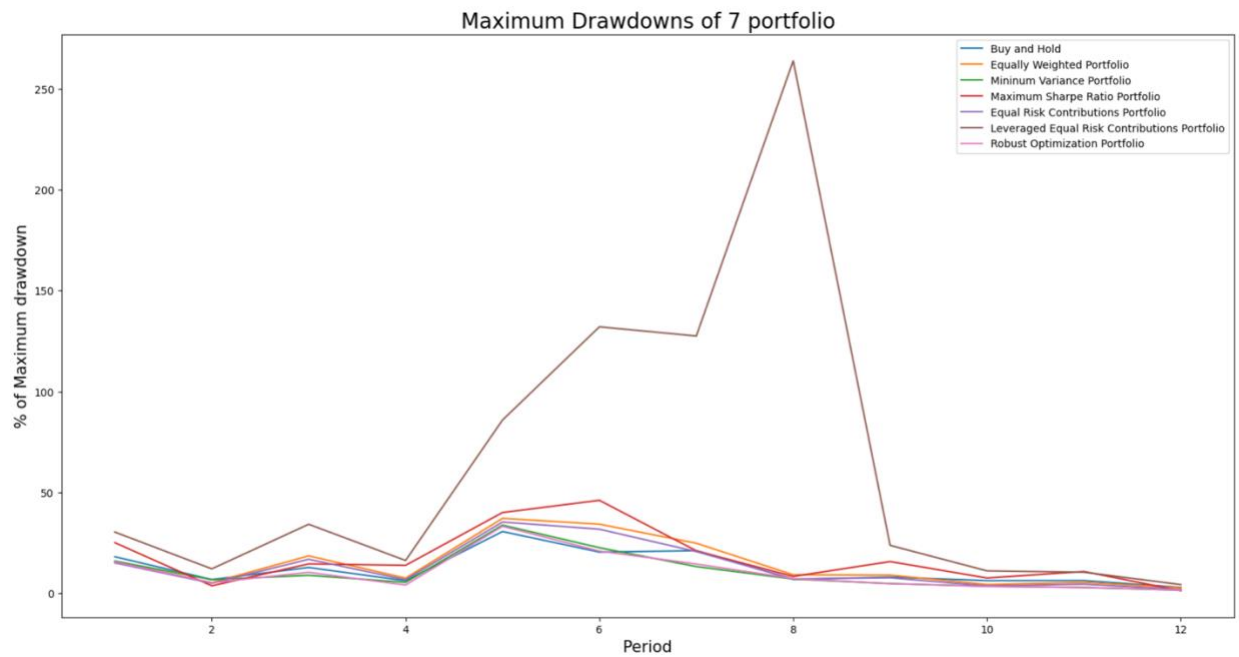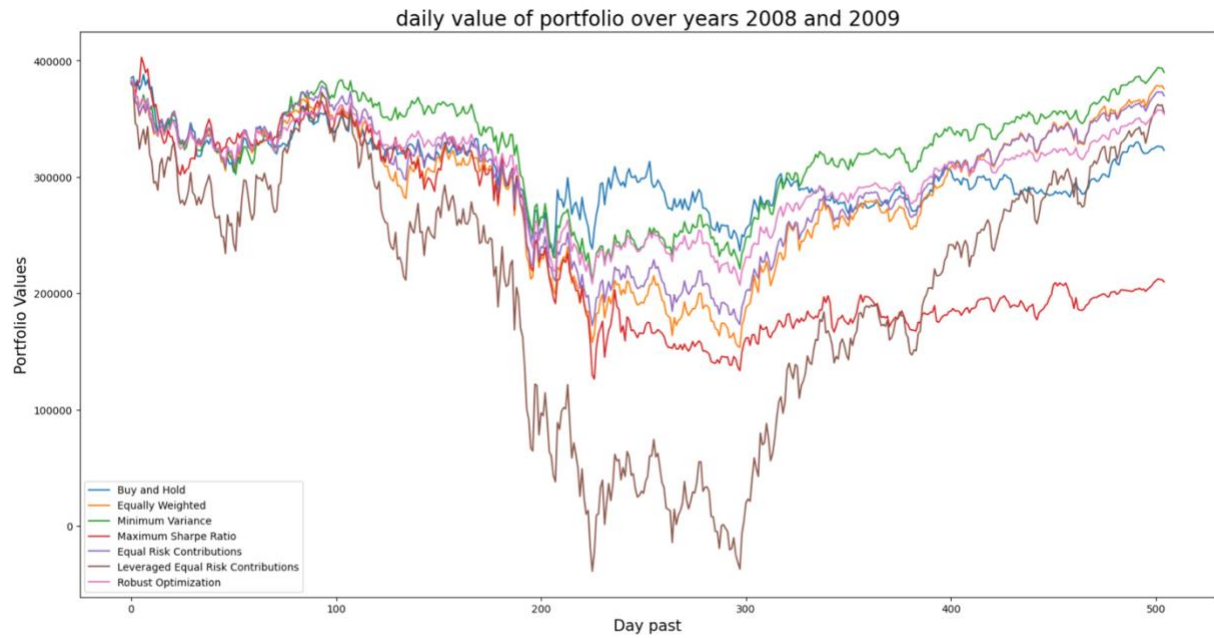
For the dynamic changes in portfolio allocation, we can see that robust does reduce trading compared to strategies 3 and 4. Robust in 2008 and 2009 holds the stocks for consecutive periods, for example, 'T' is greater than 0.1 for any period, it keeps holding 'HOG' from period 1 to 7, 'SONY' from 1 to 4 & 7 to 12, and 'HPG' for any period. While minimum variance has a very messy graph this time, it also chooses 'T' for consecutive times, but the other stocks tend to be chosen for only 1 period and were sold afterward. Maximum sharpe ratio has even larger trading value, since all the curves are like a sharpe corner, it buys and sell almost all its stock in each period.

When we have an overall look at 2008-2009 daily values, we can see that there is a big recession in stock market in these years, almost all portfolio values experience significant falls in these years. Around 150-350 days, there is a very big drop on overall portfolio values. Leverage equal risk drops dramatically, and even lost all its value during the time. On the other hand, buy and hold strategy behaves the best and even experience a little increase.

Comparing 7 strategies during 2008-2009, we can see that buy and hold and minimum variance strategy do best in keeping their values during a sudden market fall, it would be a very good choice to use these two strategies during 2008-2009, but in 2020-2021 that the overall market increases significantly, these wo strategies behave the worst. We can also observe that, equal weight, equal risk and robust behaves very similar during 2008-2009 and 2020-2021. Maximum sharpe ratio, which behaves the best in 2020-2021, ends up being the worst portfolio during 2008-2009.

For the selection of portfolio during 2008-2009, I may classify my answer based on an assumption. If I already know that there's a big drop in stock market in these years, I would choose minimum variance strategy to minimize my loss during the time. If I don't know the market move in the next years, and I am choosing a strategy based on my experience in 2008-2009 and 2020-2021. I would choose equally weighted, which is a middle way between too risky and too conservative. Although leveraged equal risk ends up well in both two investments, I am not a risky investor, and afraid of losing all my money.

Testing strategies for 2022:

daily value of portfolio over years 2022

Maximum Drawdowns of 7 portfolio
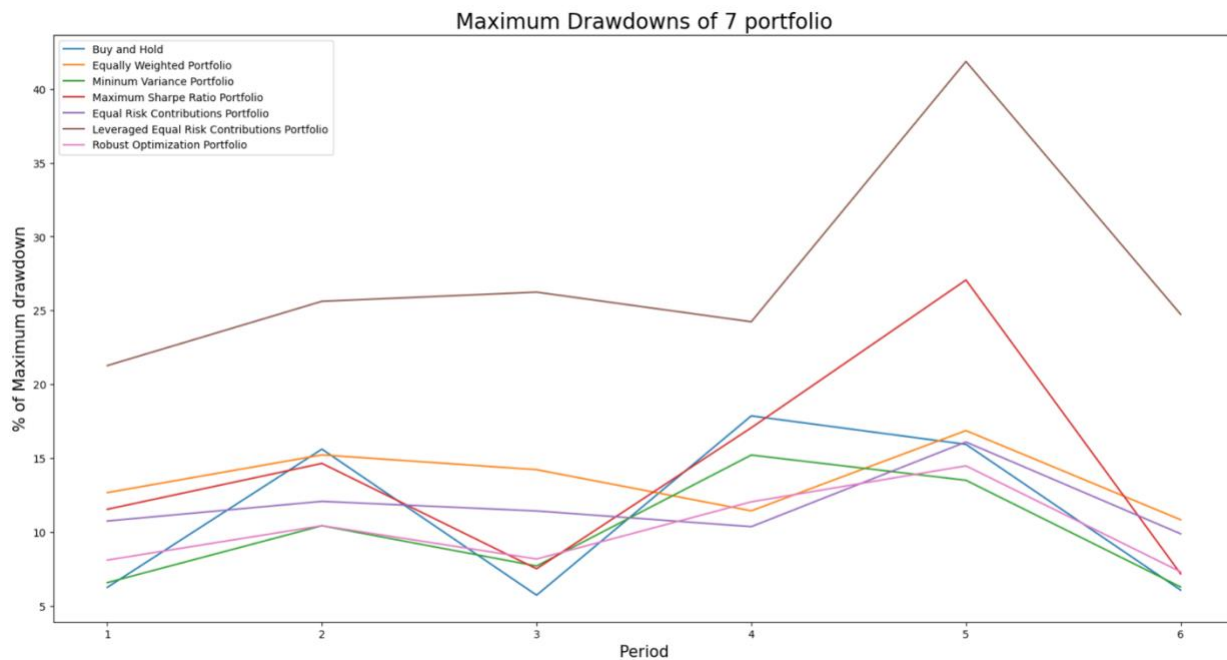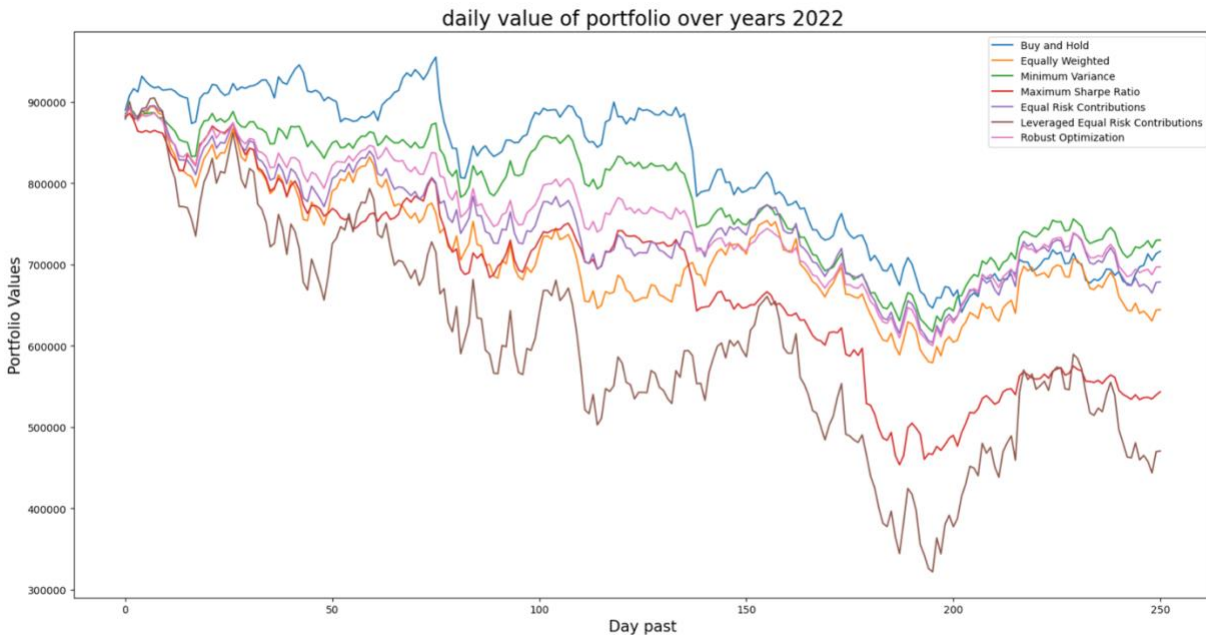
Comparing two maximum drawdown periods, there are some similarities of these two periods, all 7 strategies experience different magnitude of portfolio value fall in these two times, for both periods, leveraged equal weight has the most significant drawdowns. While they are also very different: firstly, the magnitude of drawdown is different, during 2008-2009, all strategies experiences continuous drawdown of more than 20% each period, but for 2022, their lost is less than 15% for most of the time. Leveraged equal risk has its biggest loss of more than 250% in 2008, but in 2022, the largest lost is only 40%, which is comparably very small. Although they

are all called recessions, the level of recession is much smaller in 2022, I would say that the stock market can recover much more easily from the recession of 2022.

Appendix:

Steps to derive gradient for ERC:

$$i=1 \quad j=2 \qquad i=1 \quad j=3 \qquad j=2 \quad j=3 \qquad\qquad W=\begin{bmatrix} W_1 \\ W_2 \\ W_3 \end{bmatrix} \quad Q \begin{bmatrix} Q_{11} & Q_{12} & Q_{13} \\ Q_{21} & Q_{22} & Q_{23} \\ Q_{31} & Q_{32} & Q_{33} \end{bmatrix}$$

$$\sum_{i=1}^{\not{2} \; 3} \sum_{j=i}^{\not{2} \; 3} \left(W_i (QW)_i - W_j (QW)_j \right)^2 = ERC$$

$$2 \times \Big\{$$

$$\left[W_1 (Q_{11} W_1 + Q_{12} W_2 + Q_{13} W_3) - W_2 (Q_{21} W_1 + Q_{22} W_2 + Q_{23} W_3) \right]^2 \qquad i=1 \quad j=2$$

$$+ \left[W_1 (Q_{11} W_1 + Q_{12} W_2 + Q_{13} W_3) - W_3 (Q_{31} W_1 + Q_{32} W_2 + Q_{33} W_3) \right]^2 \qquad i=1 \quad j=3$$

$$+ \left[W_2 (Q_{21} W_1 + Q_{22} W_2 + Q_{23} W_3) - W_3 (Q_{31} W_1 + Q_{32} W_2 + Q_{33} W_3) \right]^2 \Big\} = ERC \qquad i=2 \quad j=3$$

$$\frac{\delta ERC}{\delta W_1} = (W_1(QW)_1 - W_2(QW)_2)(2Q_{11}W_1 + Q_{12}W_2 + Q_{13}W_3 - Q_{21}W_2)$$

$$\boxed{ii=1} \qquad + (W_1(QW)_1 - W_3(QW)_3)(2Q_{11}W_1 + Q_{12}W_2 + Q_{13}W_3 - Q_{31}W_3)$$

$$+ (W_2(QW)_2 - W_3(QW)_3)(W_2 Q_{21} - W_3 Q_{31})$$

$$= (Y[1] - Y[2])(Q[1] \cdot W + Q[1,1]W[1] - Q[2,1]W[2]) \qquad i=1 \quad j=2 \quad ii=i=1$$

$$+ (Y[1] - Y[3])(Q[1] \cdot W + Q[1,1]W[1] - Q[3,1]W[3]) \qquad i=1 \quad j=3 \quad ii=i=1$$

$$+ (Y[2] - Y[3])(Q[2,1]W[2] - Q[3,1]W[3]) \qquad i=2 \quad j=3 \quad ii \neq i$$

2020-2021

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Initial portfolio value = $ 1000012.93


Period 1: start date 01/02/2020, end date 02/28/2020
  Strategy "Buy and Hold", value begin = $ 1000012.93, value end = $ 893956.75
  Strategy "Equally Weighted Portfolio", value begin = $ 990847.26, value end = $ 892113.20
  Strategy "Mininum Variance Portfolio", value begin = $ 992722.33, value end = $ 915686.37
  Strategy "Maximum Sharpe Ratio Portfolio", value begin = $ 990013.60, value end = $ 921430.84
  Strategy "Equal Risk Contributions Portfolio", value begin = $ 991347.66, value end = $ 898553.53
  Strategy "Leveraged Equal Risk Contributions Portfolio", value begin = $ 983188.48, value end = $ 797543.19
  Strategy "Robust Optimization Portfolio", value begin = $ 992182.16, value end = $ 917111.68

Period 2: start date 03/02/2020, end date 04/30/2020
  Strategy "Buy and Hold", value begin = $ 945076.08, value end = $ 949228.39
  Strategy "Equally Weighted Portfolio", value begin = $ 930673.84, value end = $ 861695.04
  Strategy "Mininum Variance Portfolio", value begin = $ 955765.44, value end = $ 849950.92
  Strategy "Maximum Sharpe Ratio Portfolio", value begin = $ 961802.81, value end = $ 1017507.18
  Strategy "Equal Risk Contributions Portfolio", value begin = $ 938343.82, value end = $ 852048.54
  Strategy "Leveraged Equal Risk Contributions Portfolio", value begin = $ 872991.48, value end = $ 700307.46
  Strategy "Robust Optimization Portfolio", value begin = $ 962873.97, value end = $ 947686.89

Period 3: start date 05/01/2020, end date 06/30/2020
  Strategy "Buy and Hold", value begin = $ 937916.81, value end = $ 913415.30
  Strategy "Equally Weighted Portfolio", value begin = $ 830470.53, value end = $ 933423.24
  Strategy "Mininum Variance Portfolio", value begin = $ 825497.84, value end = $ 853044.12
  Strategy "Maximum Sharpe Ratio Portfolio", value begin = $ 974235.67, value end = $ 1177531.09
  Strategy "Equal Risk Contributions Portfolio", value begin = $ 821721.11, value end = $ 916726.09
  Strategy "Leveraged Equal Risk Contributions Portfolio", value begin = $ 635427.98, value end = $ 825565.98
  Strategy "Robust Optimization Portfolio", value begin = $ 919106.94, value end = $ 997986.66

Period 4: start date 07/01/2020, end date 08/31/2020
  Strategy "Buy and Hold", value begin = $ 905419.63, value end = $ 994693.42
  Strategy "Equally Weighted Portfolio", value begin = $ 927026.78, value end = $ 1059914.46
  Strategy "Mininum Variance Portfolio", value begin = $ 855491.85, value end = $ 980609.89
  Strategy "Maximum Sharpe Ratio Portfolio", value begin = $ 1221823.29, value end = $ 1611726.07
  Strategy "Equal Risk Contributions Portfolio", value begin = $ 913043.32, value end = $ 1052312.47
  Strategy "Leveraged Equal Risk Contributions Portfolio", value begin = $ 814167.07, value end = $ 1092430.28
  Strategy "Robust Optimization Portfolio", value begin = $ 1002408.01, value end = $ 1140647.02
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Period 5: start date 09/01/2020, end date 10/30/2020
  Strategy "Buy and Hold", value begin = $ 993194.54, value end = $ 971914.18
  Strategy "Equally Weighted Portfolio", value begin = $ 1067520.37, value end = $ 998430.97
  Strategy "Mininum Variance Portfolio", value begin = $ 982341.42, value end = $ 941610.58
  Strategy "Maximum Sharpe Ratio Portfolio", value begin = $ 1645911.06, value end = $ 1558288.93
  Strategy "Equal Risk Contributions Portfolio", value begin = $ 1060264.75, value end = $ 993650.35
  Strategy "Leveraged Equal Risk Contributions Portfolio", value begin = $ 1104180.42, value end = $ 971135.41
  Strategy "Robust Optimization Portfolio", value begin = $ 1145861.92, value end = $ 1097243.46

Period 6: start date 11/02/2020, end date 12/31/2020
  Strategy "Buy and Hold", value begin = $ 983801.02, value end = $ 1004435.67
  Strategy "Equally Weighted Portfolio", value begin = $ 1007256.21, value end = $ 1193269.10
  Strategy "Mininum Variance Portfolio", value begin = $ 950076.40, value end = $ 1004897.18
  Strategy "Maximum Sharpe Ratio Portfolio", value begin = $ 1556855.51, value end = $ 1797027.91
  Strategy "Equal Risk Contributions Portfolio", value begin = $ 1002031.56, value end = $ 1174990.15
  Strategy "Leveraged Equal Risk Contributions Portfolio", value begin = $ 983572.18, value end = $ 1326560.66
  Strategy "Robust Optimization Portfolio", value begin = $ 1104573.62, value end = $ 1240295.57

Period 7: start date 01/04/2021, end date 02/26/2021
  Strategy "Buy and Hold", value begin = $ 1005601.39, value end = $ 956244.15
  Strategy "Equally Weighted Portfolio", value begin = $ 1179746.74, value end = $ 1266112.17
  Strategy "Mininum Variance Portfolio", value begin = $ 1002899.04, value end = $ 973886.23
  Strategy "Maximum Sharpe Ratio Portfolio", value begin = $ 1744688.95, value end = $ 1860869.91
  Strategy "Equal Risk Contributions Portfolio", value begin = $ 1162370.82, value end = $ 1220568.39
  Strategy "Leveraged Equal Risk Contributions Portfolio", value begin = $ 1297406.15, value end = $ 1412619.24
  Strategy "Robust Optimization Portfolio", value begin = $ 1226826.58, value end = $ 1224412.34

Period 8: start date 03/01/2021, end date 04/30/2021
  Strategy "Buy and Hold", value begin = $ 957791.42, value end = $ 1019731.31
  Strategy "Equally Weighted Portfolio", value begin = $ 1296457.79, value end = $ 1397682.38
  Strategy "Mininum Variance Portfolio", value begin = $ 974255.13, value end = $ 1087543.32
  Strategy "Maximum Sharpe Ratio Portfolio", value begin = $ 1909860.57, value end = $ 2071351.36
  Strategy "Equal Risk Contributions Portfolio", value begin = $ 1244988.35, value end = $ 1357346.43
  Strategy "Leveraged Equal Risk Contributions Portfolio", value begin = $ 1456778.27, value end = $ 1678616.99
  Strategy "Robust Optimization Portfolio", value begin = $ 1234712.84, value end = $ 1367617.85

Period 9: start date 05/03/2021, end date 06/30/2021
  Strategy "Buy and Hold", value begin = $ 1022204.61, value end = $ 987842.85
  Strategy "Equally Weighted Portfolio", value begin = $ 1396558.85, value end = $ 1458103.46
  Strategy "Mininum Variance Portfolio", value begin = $ 1087272.14, value end = $ 1076150.75
  Strategy "Maximum Sharpe Ratio Portfolio", value begin = $ 2062698.91, value end = $ 2025571.75
  Strategy "Equal Risk Contributions Portfolio", value begin = $ 1356210.37, value end = $ 1387544.92
  Strategy "Leveraged Equal Risk Contributions Portfolio", value begin = $ 1672254.29, value end = $ 1734243.53
  Strategy "Robust Optimization Portfolio", value begin = $ 1366451.96, value end = $ 1364339.99

Period 10: start date 07/01/2021, end date 08/31/2021
  Strategy "Buy and Hold", value begin = $ 993283.49, value end = $ 975250.12
  Strategy "Equally Weighted Portfolio", value begin = $ 1465498.66, value end = $ 1516502.72
  Strategy "Mininum Variance Portfolio", value begin = $ 1076184.90, value end = $ 1086092.67
  Strategy "Maximum Sharpe Ratio Portfolio", value begin = $ 2024457.49, value end = $ 2132026.51
  Strategy "Equal Risk Contributions Portfolio", value begin = $ 1393816.56, value end = $ 1446578.89
  Strategy "Leveraged Equal Risk Contributions Portfolio", value begin = $ 1742445.06, value end = $ 1846408.31
  Strategy "Robust Optimization Portfolio", value begin = $ 1367131.45, value end = $ 1406528.04

Period 11: start date 09/01/2021, end date 10/29/2021
  Strategy "Buy and Hold", value begin = $ 974520.08, value end = $ 949068.41
  Strategy "Equally Weighted Portfolio", value begin = $ 1512275.87, value end = $ 1562150.13
  Strategy "Mininum Variance Portfolio", value begin = $ 1080545.49, value end = $ 1056622.72
  Strategy "Maximum Sharpe Ratio Portfolio", value begin = $ 2112491.08, value end = $ 2155041.01
  Strategy "Equal Risk Contributions Portfolio", value begin = $ 1440570.30, value end = $ 1458503.54
  Strategy "Leveraged Equal Risk Contributions Portfolio", value begin = $ 1830369.21, value end = $ 1865775.95
  Strategy "Robust Optimization Portfolio", value begin = $ 1397674.37, value end = $ 1367046.33

Period 12: start date 11/01/2021, end date 12/31/2021
  Strategy "Buy and Hold", value begin = $ 951350.41, value end = $ 932471.35
  Strategy "Equally Weighted Portfolio", value begin = $ 1583499.82, value end = $ 1645256.61

  Strategy "Mininum Variance Portfolio", value begin = $ 1053865.17, value end = $ 1047948.73
  Strategy "Maximum Sharpe Ratio Portfolio", value begin = $ 2123737.56, value end = $ 2229411.63
  Strategy "Equal Risk Contributions Portfolio", value begin = $ 1469097.38, value end = $ 1521981.13
  Strategy "Leveraged Equal Risk Contributions Portfolio", value begin = $ 1882388.82, value end = $ 1986292.51
  Strategy "Robust Optimization Portfolio", value begin = $ 1360433.85, value end = $ 1390792.33
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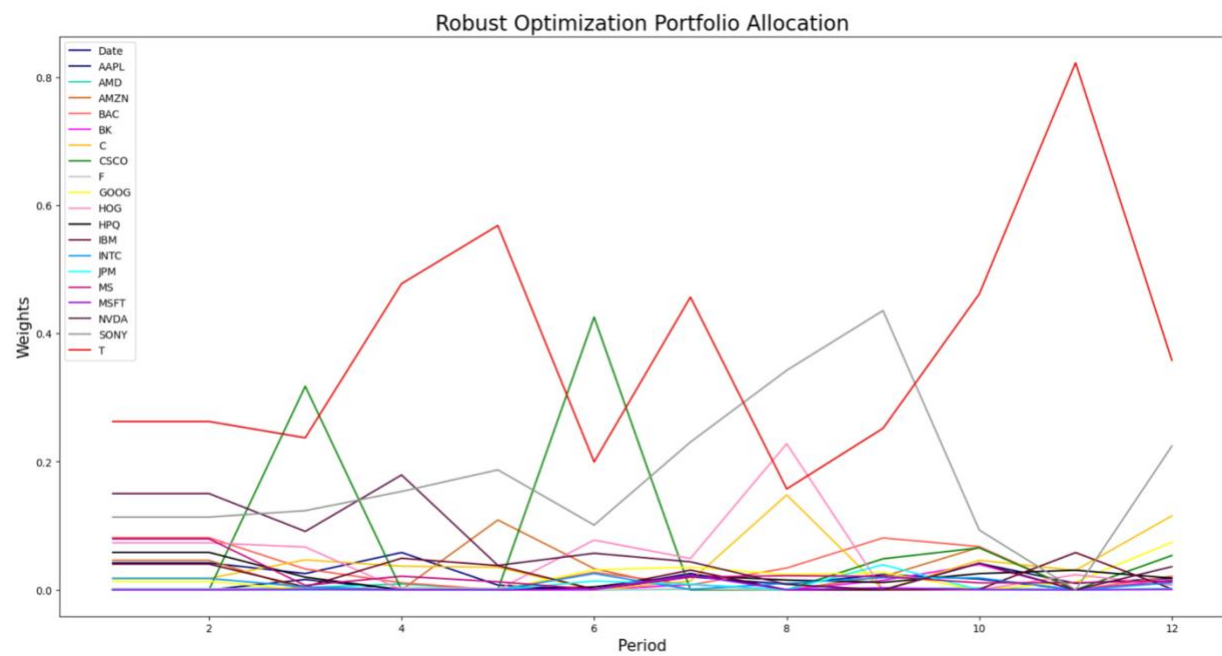
Robust Optimization Portfolio Allocation

2008-2009

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Initial portfolio value = $ 385097.15


Period 1: start date 01/02/2008, end date 02/29/2008
   Strategy "Buy and Hold", value begin = $ 385097.15, value end = $ 325918.34
   Strategy "Equally Weighted Portfolio", value begin = $ 381649.89, value end = $ 326929.57
   Strategy "Mininum Variance Portfolio", value begin = $ 383262.32, value end = $ 327133.76
   Strategy "Maximum Sharpe Ratio Portfolio", value begin = $ 381265.54, value end = $ 332652.59
   Strategy "Equal Risk Contributions Portfolio", value begin = $ 381843.80, value end = $ 329237.58
   Strategy "Leveraged Equal Risk Contributions Portfolio", value begin = $ 380219.95, value end = $ 274975.71
   Strategy "Robust Optimization Portfolio", value begin = $ 382119.84, value end = $ 324780.73

Period 2: start date 03/03/2008, end date 04/30/2008
   Strategy "Buy and Hold", value begin = $ 325807.08, value end = $ 349997.20
   Strategy "Equally Weighted Portfolio", value begin = $ 322097.69, value end = $ 354821.22
   Strategy "Mininum Variance Portfolio", value begin = $ 322708.14, value end = $ 365544.42
   Strategy "Maximum Sharpe Ratio Portfolio", value begin = $ 325785.77, value end = $ 344234.61
   Strategy "Equal Risk Contributions Portfolio", value begin = $ 324437.79, value end = $ 361258.33
   Strategy "Leveraged Equal Risk Contributions Portfolio", value begin = $ 265399.10, value end = $ 338811.66
   Strategy "Robust Optimization Portfolio", value begin = $ 323209.59, value end = $ 347627.06

Period 3: start date 05/01/2008, end date 06/30/2008
   Strategy "Buy and Hold", value begin = $ 357929.49, value end = $ 322881.56
   Strategy "Equally Weighted Portfolio", value begin = $ 366424.15, value end = $ 308970.75
   Strategy "Mininum Variance Portfolio", value begin = $ 372943.92, value end = $ 351396.01
   Strategy "Maximum Sharpe Ratio Portfolio", value begin = $ 349025.01, value end = $ 312518.46
   Strategy "Equal Risk Contributions Portfolio", value begin = $ 372019.91, value end = $ 322338.38
   Strategy "Leveraged Equal Risk Contributions Portfolio", value begin = $ 360320.56, value end = $ 261046.74
   Strategy "Robust Optimization Portfolio", value begin = $ 356160.96, value end = $ 327859.50

Period 4: start date 07/01/2008, end date 08/29/2008
   Strategy "Buy and Hold", value begin = $ 324349.75, value end = $ 326489.53
   Strategy "Equally Weighted Portfolio", value begin = $ 309425.79, value end = $ 315897.27
   Strategy "Mininum Variance Portfolio", value begin = $ 351747.45, value end = $ 356191.71
   Strategy "Maximum Sharpe Ratio Portfolio", value begin = $ 324814.45, value end = $ 314800.05
   Strategy "Equal Risk Contributions Portfolio", value begin = $ 321939.52, value end = $ 326069.31
   Strategy "Leveraged Equal Risk Contributions Portfolio", value begin = $ 260275.90, value end = $ 268655.53
   Strategy "Robust Optimization Portfolio", value begin = $ 327599.29, value end = $ 331499.60
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Period 5: start date 09/02/2008, end date 10/31/2008
  Strategy "Buy and Hold", value begin = $ 333252.73, value end = $ 274022.75
  Strategy "Equally Weighted Portfolio", value begin = $ 316675.00, value end = $ 231420.37
  Strategy "Mininum Variance Portfolio", value begin = $ 348285.30, value end = $ 269008.12
  Strategy "Maximum Sharpe Ratio Portfolio", value begin = $ 306067.46, value end = $ 229119.53
  Strategy "Equal Risk Contributions Portfolio", value begin = $ 325821.99, value end = $ 242519.88
  Strategy "Leveraged Equal Risk Contributions Portfolio", value begin = $ 268174.20, value end = $ 101788.68
  Strategy "Robust Optimization Portfolio", value begin = $ 327455.78, value end = $ 255365.83

Period 6: start date 11/03/2008, end date 12/31/2008
  Strategy "Buy and Hold", value begin = $ 282342.11, value end = $ 305967.56
  Strategy "Equally Weighted Portfolio", value begin = $ 230011.81, value end = $ 198885.85
  Strategy "Mininum Variance Portfolio", value begin = $ 269392.03, value end = $ 248171.86
  Strategy "Maximum Sharpe Ratio Portfolio", value begin = $ 226378.28, value end = $ 175247.44
  Strategy "Equal Risk Contributions Portfolio", value begin = $ 241950.25, value end = $ 212925.39
  Strategy "Leveraged Equal Risk Contributions Portfolio", value begin = $ 100655.03, value end = $ 42523.66
  Strategy "Robust Optimization Portfolio", value begin = $ 257377.27, value end = $ 247818.51

Period 7: start date 01/02/2009, end date 02/27/2009
  Strategy "Buy and Hold", value begin = $ 313366.90, value end = $ 258275.19
  Strategy "Equally Weighted Portfolio", value begin = $ 207366.91, value end = $ 169935.27
  Strategy "Mininum Variance Portfolio", value begin = $ 256220.00, value end = $ 244191.77
  Strategy "Maximum Sharpe Ratio Portfolio", value begin = $ 174617.67, value end = $ 145423.65
  Strategy "Equal Risk Contributions Portfolio", value begin = $ 221818.39, value end = $ 189370.10
  Strategy "Leveraged Equal Risk Contributions Portfolio", value begin = $ 60243.21, value end = $ -4615.46
  Strategy "Robust Optimization Portfolio", value begin = $ 252858.41, value end = $ 226597.29

Period 8: start date 03/02/2009, end date 04/30/2009
  Strategy "Buy and Hold", value begin = $ 248688.22, value end = $ 286368.72
  Strategy "Equally Weighted Portfolio", value begin = $ 161713.12, value end = $ 260066.85
  Strategy "Mininum Variance Portfolio", value begin = $ 234567.38, value end = $ 319272.82
  Strategy "Maximum Sharpe Ratio Portfolio", value begin = $ 138446.34, value end = $ 180431.92
  Strategy "Equal Risk Contributions Portfolio", value begin = $ 181450.05, value end = $ 272163.75
  Strategy "Leveraged Equal Risk Contributions Portfolio", value begin = $ -20425.31, value end = $ 160390.72
  Strategy "Robust Optimization Portfolio", value begin = $ 218761.50, value end = $ 288718.53

Period 9: start date 05/01/2009, end date 06/30/2009
  Strategy "Buy and Hold", value begin = $ 287805.37, value end = $ 285824.08
  Strategy "Equally Weighted Portfolio", value begin = $ 259634.59, value end = $ 273277.43
  Strategy "Mininum Variance Portfolio", value begin = $ 316795.52, value end = $ 320209.62
  Strategy "Maximum Sharpe Ratio Portfolio", value begin = $ 179243.52, value end = $ 184965.16
  Strategy "Equal Risk Contributions Portfolio", value begin = $ 271673.02, value end = $ 282178.13
  Strategy "Leveraged Equal Risk Contributions Portfolio", value begin = $ 159465.69, value end = $ 180485.35
  Strategy "Robust Optimization Portfolio", value begin = $ 287339.22, value end = $ 291357.63

Period 10: start date 07/01/2009, end date 08/31/2009
  Strategy "Buy and Hold", value begin = $ 286766.63, value end = $ 298338.27
  Strategy "Equally Weighted Portfolio", value begin = $ 272967.79, value end = $ 321758.02
  Strategy "Mininum Variance Portfolio", value begin = $ 319905.14, value end = $ 341208.10
  Strategy "Maximum Sharpe Ratio Portfolio", value begin = $ 180487.01, value end = $ 195121.88
  Strategy "Equal Risk Contributions Portfolio", value begin = $ 282189.10, value end = $ 321266.71
  Strategy "Leveraged Equal Risk Contributions Portfolio", value begin = $ 180497.63, value end = $ 258532.04
  Strategy "Robust Optimization Portfolio", value begin = $ 291263.00, value end = $ 311543.34

Period 11: start date 09/01/2009, end date 10/30/2009
  Strategy "Buy and Hold", value begin = $ 291703.36, value end = $ 290193.57
  Strategy "Equally Weighted Portfolio", value begin = $ 310182.86, value end = $ 328338.22
  Strategy "Mininum Variance Portfolio", value begin = $ 333054.13, value end = $ 349860.30
  Strategy "Maximum Sharpe Ratio Portfolio", value begin = $ 186739.28, value end = $ 186512.54
  Strategy "Equal Risk Contributions Portfolio", value begin = $ 311516.78, value end = $ 330336.91
  Strategy "Leveraged Equal Risk Contributions Portfolio", value begin = $ 239055.30, value end = $ 276648.61
  Strategy "Robust Optimization Portfolio", value begin = $ 304326.78, value end = $ 318253.99

Period 12: start date 11/02/2009, end date 12/31/2009
  Strategy "Buy and Hold", value begin = $ 288596.05, value end = $ 323101.02
  Strategy "Equally Weighted Portfolio", value begin = $ 329690.48, value end = $ 375806.51
  Strategy "Mininum Variance Portfolio", value begin = $ 347270.53, value end = $ 389939.36

  Strategy "Maximum Sharpe Ratio Portfolio", value begin = $ 185539.21, value end = $ 209901.43
  Strategy "Equal Risk Contributions Portfolio", value begin = $ 331002.07, value end = $ 369925.36
  Strategy "Leveraged Equal Risk Contributions Portfolio", value begin = $ 277966.26, value end = $ 355640.82
  Strategy "Robust Optimization Portfolio", value begin = $ 316472.33, value end = $ 353821.11
```
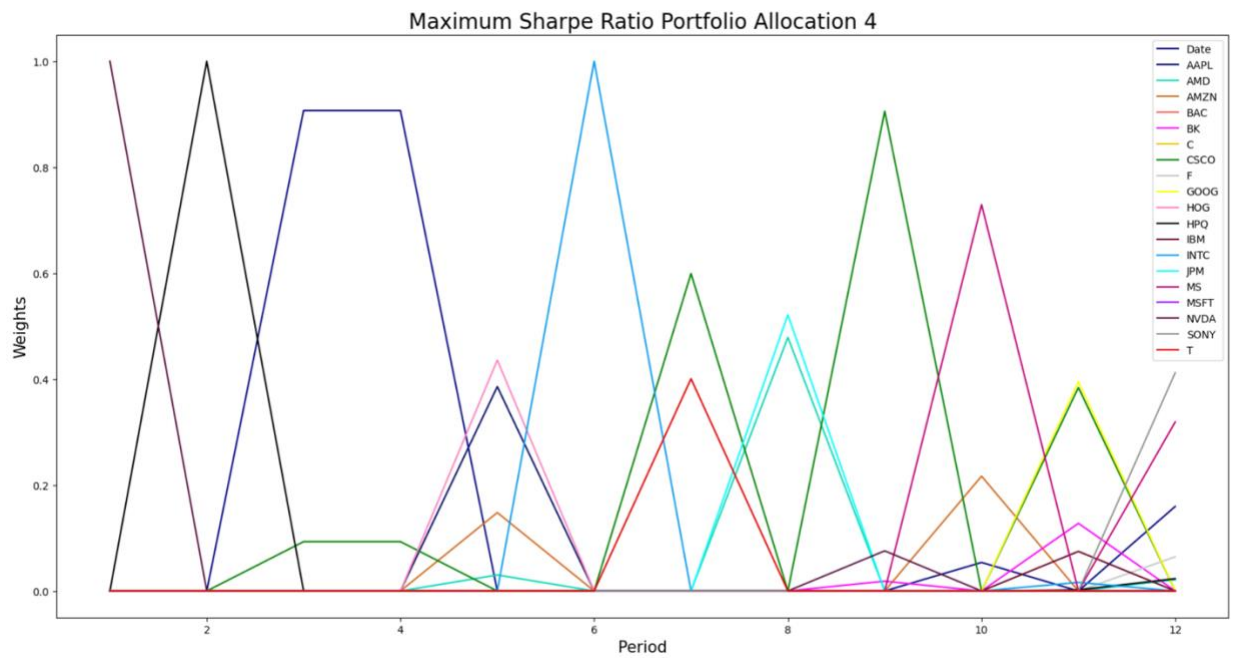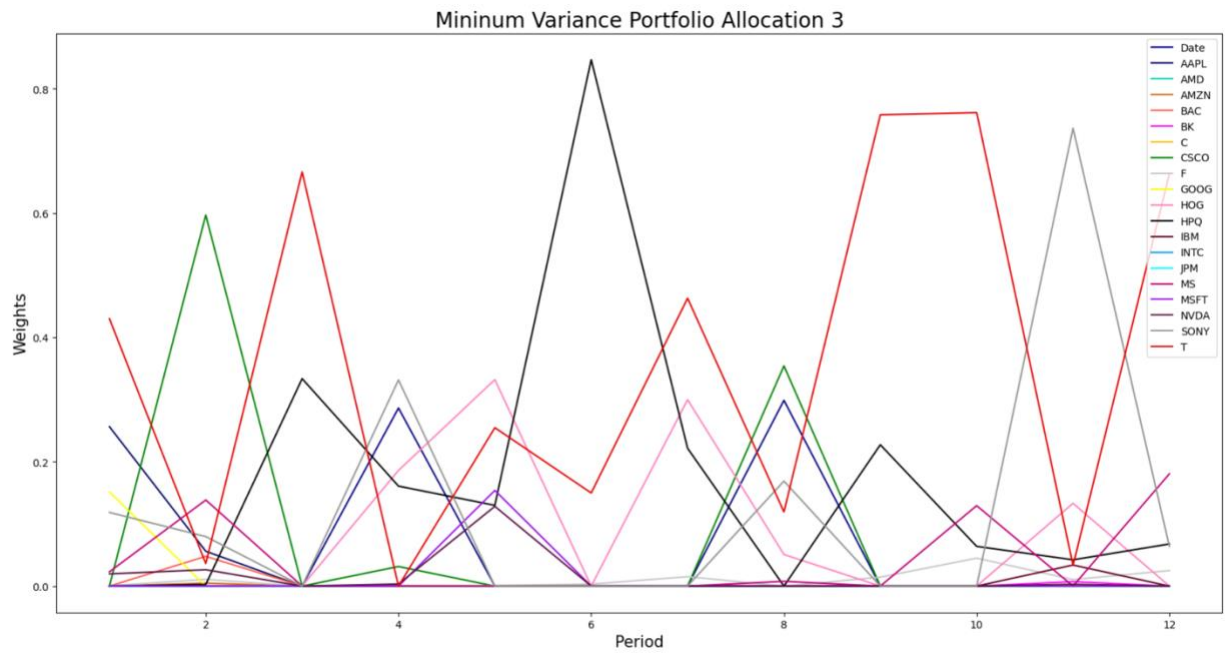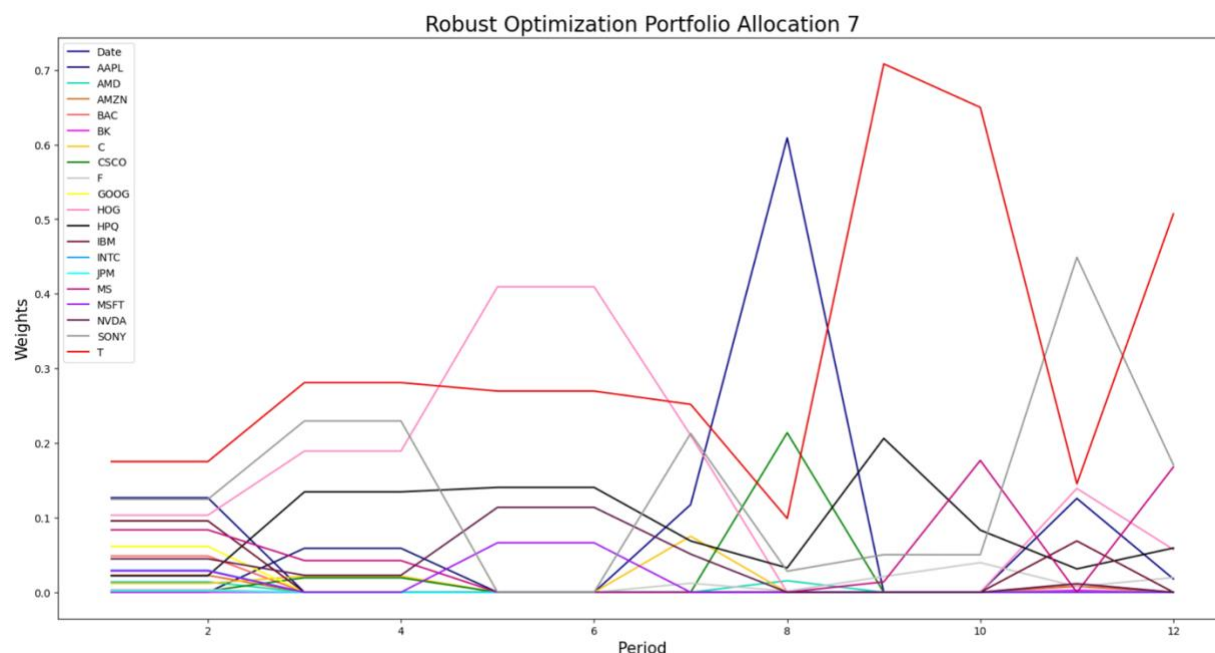
Mininum Variance Portfolio Allocation 3

Maximum Sharpe Ratio Portfolio Allocation 4

Robust Optimization Portfolio Allocation 7

2022

```
Initial portfolio value = $ 890077.15


Period 1: start date 01/03/2022, end date 02/28/2022
  Strategy "Buy and Hold", value begin = $ 890077.15, value end = $ 924072.93
  Strategy "Equally Weighted Portfolio", value begin = $ 881997.57, value end = $ 802549.65
  Strategy "Mininum Variance Portfolio", value begin = $ 885877.61, value end = $ 863404.89
  Strategy "Maximum Sharpe Ratio Portfolio", value begin = $ 881222.74, value end = $ 800309.12
  Strategy "Equal Risk Contributions Portfolio", value begin = $ 882551.39, value end = $ 815422.86
  Strategy "Leveraged Equal Risk Contributions Portfolio", value begin = $ 879137.35, value end = $ 744692.74
  Strategy "Robust Optimization Portfolio", value begin = $ 883675.91, value end = $ 828053.68

Period 2: start date 03/01/2022, end date 04/29/2022
  Strategy "Buy and Hold", value begin = $ 921940.14, value end = $ 807230.89
  Strategy "Equally Weighted Portfolio", value begin = $ 783067.12, value end = $ 705796.90
  Strategy "Mininum Variance Portfolio", value begin = $ 854911.78, value end = $ 782984.66
  Strategy "Maximum Sharpe Ratio Portfolio", value begin = $ 783852.12, value end = $ 694355.70
  Strategy "Equal Risk Contributions Portfolio", value begin = $ 799393.69, value end = $ 738431.74
  Strategy "Leveraged Equal Risk Contributions Portfolio", value begin = $ 712631.90, value end = $ 590374.84
  Strategy "Robust Optimization Portfolio", value begin = $ 819303.00, value end = $ 758423.10

Period 3: start date 05/02/2022, end date 06/30/2022
  Strategy "Buy and Hold", value begin = $ 806237.92, value end = $ 877550.83
  Strategy "Equally Weighted Portfolio", value begin = $ 716066.23, value end = $ 654767.51
  Strategy "Mininum Variance Portfolio", value begin = $ 786319.94, value end = $ 820781.99
  Strategy "Maximum Sharpe Ratio Portfolio", value begin = $ 687982.05, value end = $ 735574.17
  Strategy "Equal Risk Contributions Portfolio", value begin = $ 747227.59, value end = $ 710649.53
  Strategy "Leveraged Equal Risk Contributions Portfolio", value begin = $ 607990.07, value end = $ 534899.50
  Strategy "Robust Optimization Portfolio", value begin = $ 762682.75, value end = $ 763333.31

Period 4: start date 07/01/2022, end date 08/31/2022
  Strategy "Buy and Hold", value begin = $ 892738.72, value end = $ 742946.10
  Strategy "Equally Weighted Portfolio", value begin = $ 656646.38, value end = $ 679030.46
  Strategy "Mininum Variance Portfolio", value begin = $ 826010.57, value end = $ 712583.58
  Strategy "Maximum Sharpe Ratio Portfolio", value begin = $ 732613.48, value end = $ 613024.63
  Strategy "Equal Risk Contributions Portfolio", value begin = $ 714696.66, value end = $ 703553.56
  Strategy "Leveraged Equal Risk Contributions Portfolio", value begin = $ 542961.86, value end = $ 520625.50
  Strategy "Robust Optimization Portfolio", value begin = $ 768423.48, value end = $ 687380.71
```

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Period 5: start date 09/01/2022, end date 10/31/2022
  Strategy "Buy and Hold", value begin = $ 742641.68, value end = $ 682506.51
  Strategy "Equally Weighted Portfolio", value begin = $ 675547.95, value end = $ 646239.65
  Strategy "Mininum Variance Portfolio", value begin = $ 711130.48, value end = $ 700756.52
  Strategy "Maximum Sharpe Ratio Portfolio", value begin = $ 607823.63, value end = $ 538757.80
  Strategy "Equal Risk Contributions Portfolio", value begin = $ 701769.31, value end = $ 677307.66
  Strategy "Leveraged Equal Risk Contributions Portfolio", value begin = $ 517062.95, value end = $ 468005.46
  Strategy "Robust Optimization Portfolio", value begin = $ 685725.94, value end = $ 683426.53

Period 6: start date 11/01/2022, end date 12/30/2022
  Strategy "Buy and Hold", value begin = $ 683477.34, value end = $ 716351.42
  Strategy "Equally Weighted Portfolio", value begin = $ 648031.33, value end = $ 644576.31
  Strategy "Mininum Variance Portfolio", value begin = $ 708743.30, value end = $ 730311.91
  Strategy "Maximum Sharpe Ratio Portfolio", value begin = $ 533809.69, value end = $ 543536.74
  Strategy "Equal Risk Contributions Portfolio", value begin = $ 680930.60, value end = $ 678629.40
  Strategy "Leveraged Equal Risk Contributions Portfolio", value begin = $ 475225.56, value end = $ 470706.38
  Strategy "Robust Optimization Portfolio", value begin = $ 687911.27, value end = $ 697261.11
```