Assignment 2
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Part 1. Implement investment strategies in Matlab

In this report, three different new strategies were investigated: Equal Risk Contributions, Leveraged Equal Risk Contributions, Robust Mean Variance. All seven strategies were tested over the financial crisis period from 2008-2009.

For Robust Min Variance optimization, the target portfolio return was selected as the min variance portfolio return. The reason is that during the financial crisis, the risk is expected to be minimized, so the max return term in the robust optimization constrain is lower bounded by the min variance portfolio return, which is again associated with the minimum risk. In that case, the Robust Min Variance optimization is optimized under the worst-case scenario.

Part 2. Analyze the results

The output from the Matlab were included in Appendix A. The figure 2.1 below shows the portfolio value for seven strategies over 2015-2016.

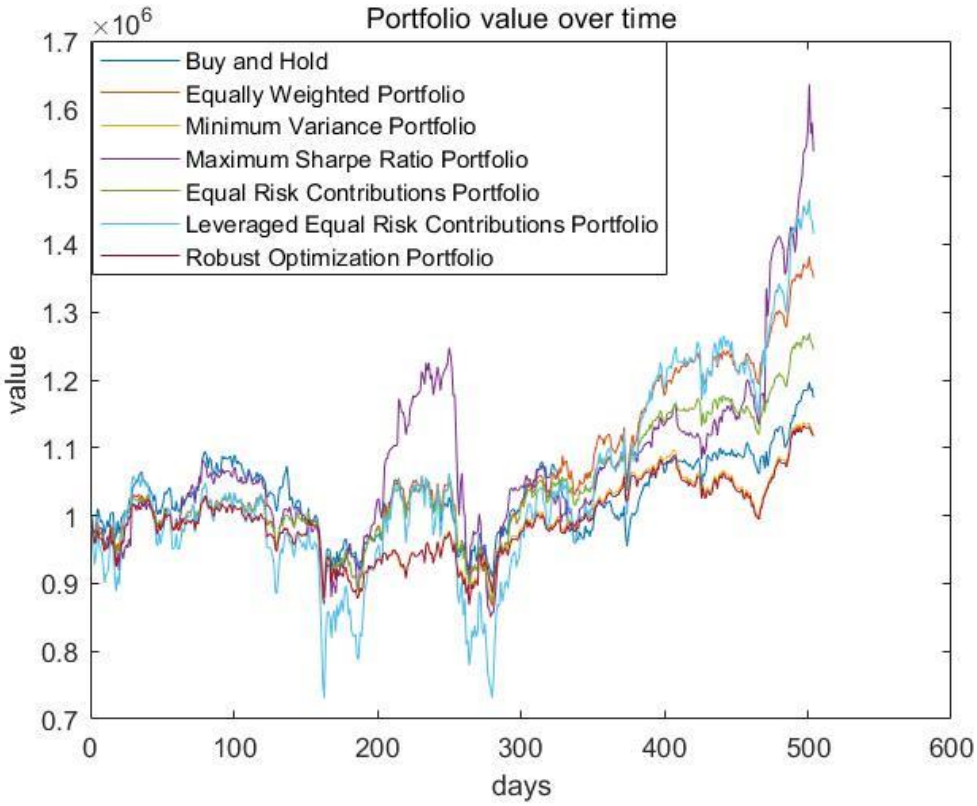

Fig 2.1 Daily portfolio value over 2015-2016

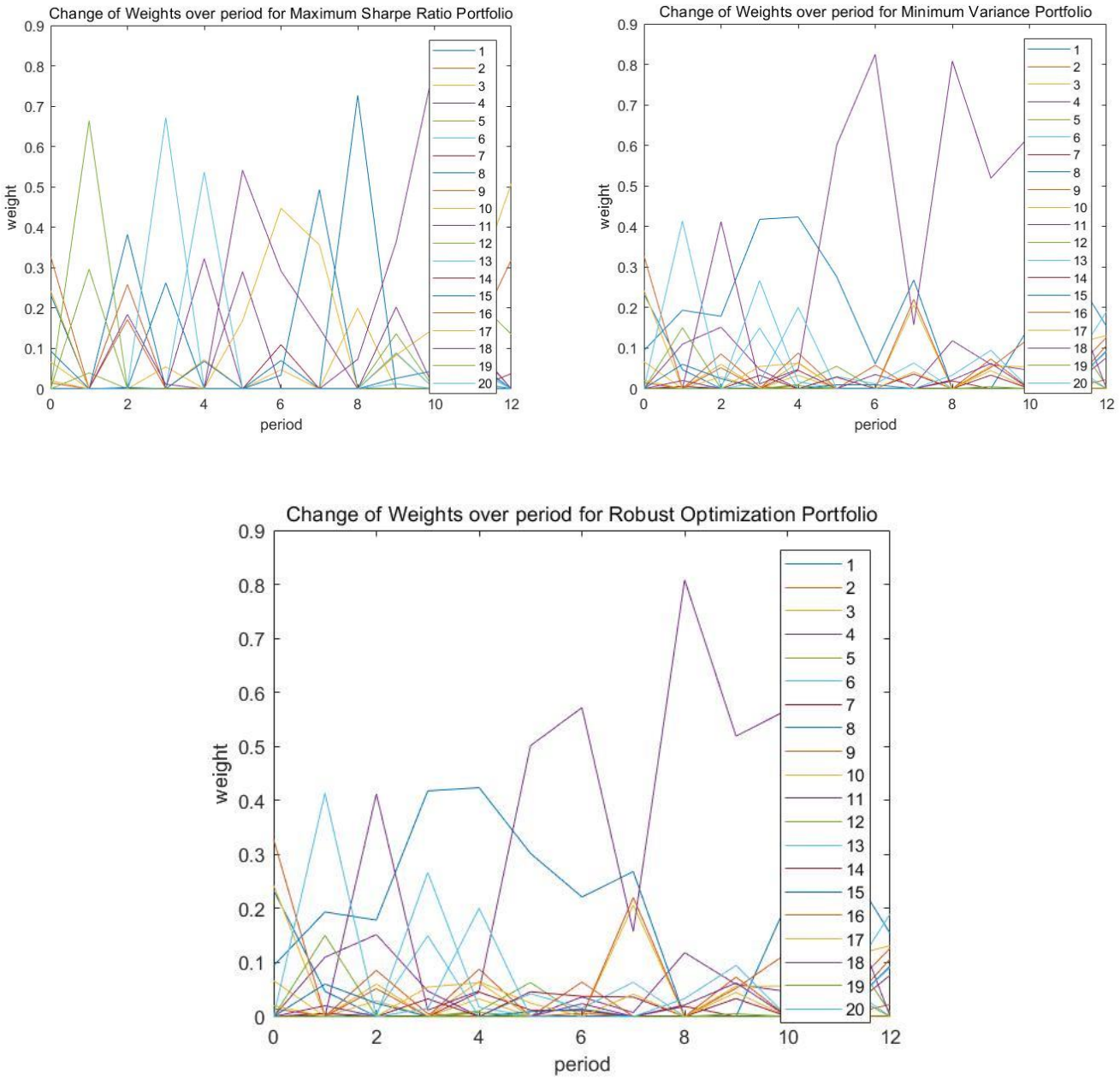

Fig 2.2 Dynamic change of weights for three selected strategies over 2015-2016

Asset Allocation Comparison

The Robust Optimization Portfolio reduces some trading around period 4 and 6 for stock INTC and AMD compared to the Min Variance Portfolio for which the portfolio takes more positions in stock INTC. During period 4 and 6, the market was experiencing downside risks, the portfolio minimizes the uncertainties of the market by reducing trades. Compared to the Max Sharpe Ratio portfolio, portfolio 3 and 7 thus experienced less fluctuations.

Comparison Among Seven Strategies

Referring to fig 2.1, the Equal Risk Contribution portfolio gives the 4th highest return by the end of the 2 years period. During the big drops of the market, the risk was spread over equally to the assets allocated, thus the portfolio was within some of the most steady portfolios, which were the ones that did not drop below the Min Variance portfolio return. The Leveraged portfolio almost doubled the return given by Equal Risk portfolio whereas dropped significantly during the market drops. Additionally, the Leveraged portfolio was highly volatile compared with all the other ones. The Robust portfolio follows mostly with the regular Min Variance portfolio whereas the robust portfolio dropped a little bit less compared with the Min Variance portfolio.

When comparing the Leveraged portfolios with the Max Sharpe Ratio portfolios, there are some similar points. They both capture the greatest return when the market goes well but drops significantly when the market goes down. For me, as an investor, I would choose Leveraged portfolios or Max Sharpe Ratio portfolios when the market is obviously trending up or a bull market, as they will capture the greatest momentum and profits faster. Other than that, I would choose a more steady portfolio such as Robust Min Variance optimization or Min Variance optimization.

Part 3. Test trading strategies for 2008 and 2009

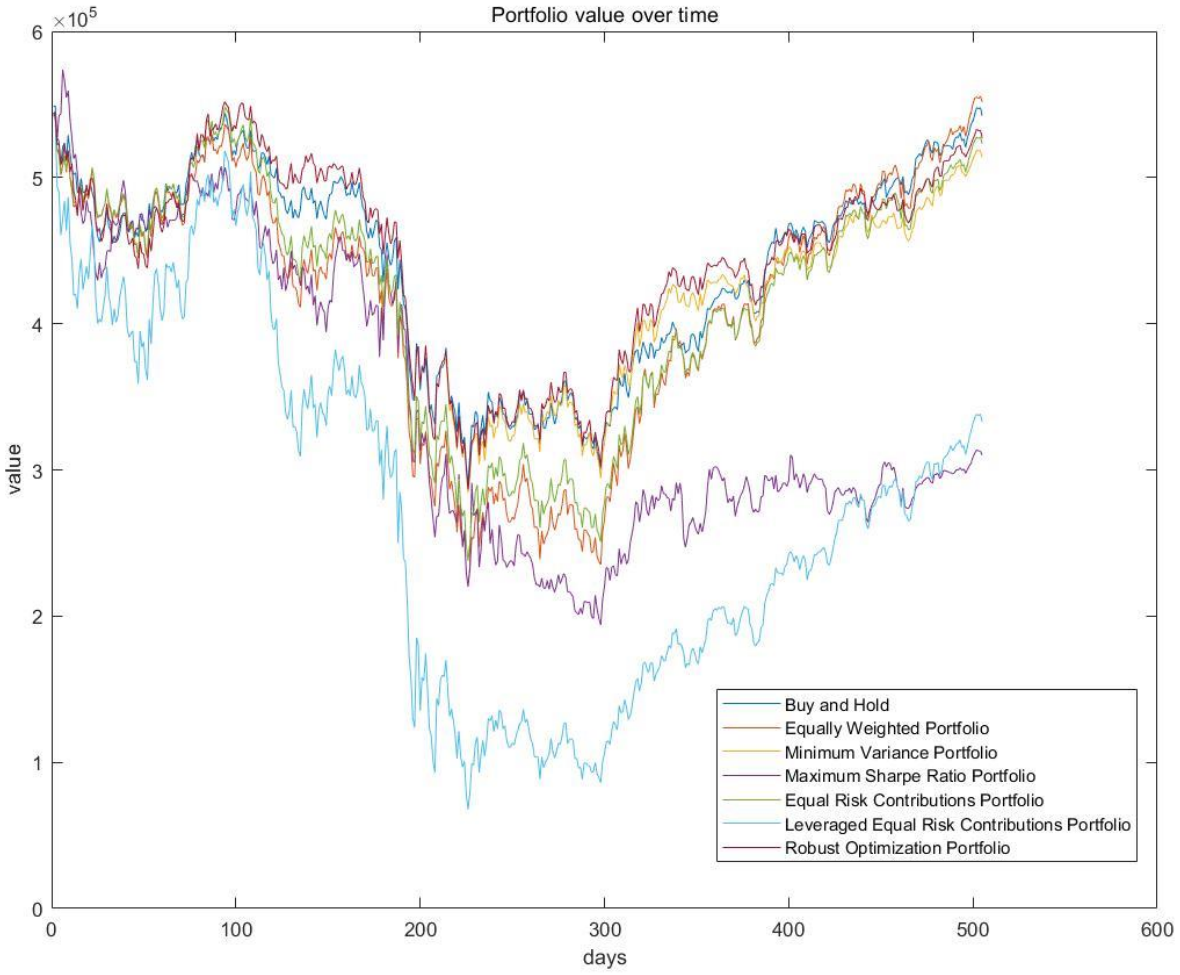

Fig 3.1 Daily Portfolio Value over 2008-2009

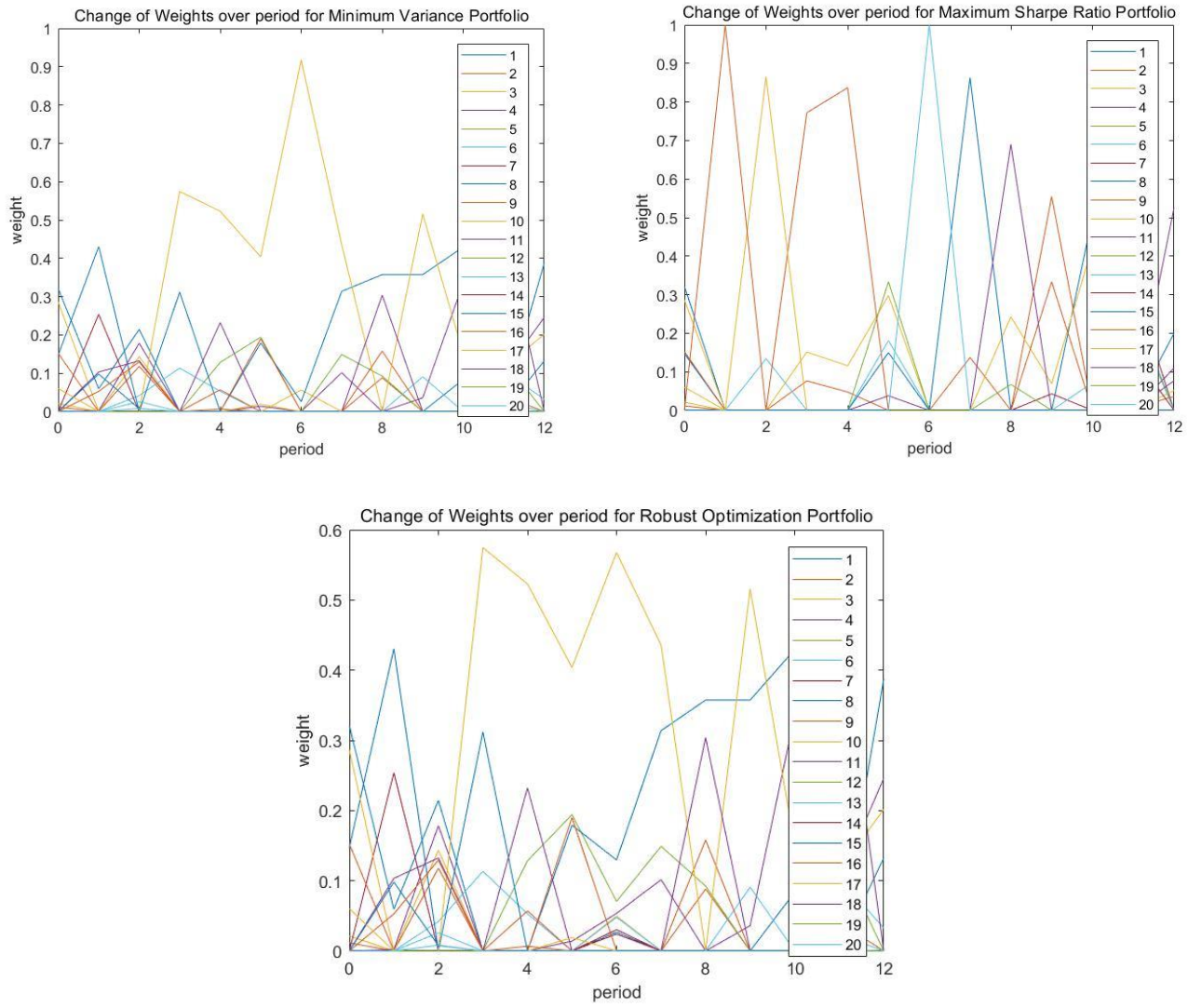

Fig 3.2 Dynamic portfolio allocation for Robust Optimization, Min Variance, Max Sharpe Ratio portfolio.

Asset Allocation Comparison

The Robust Optimization Portfolio reduces some trading around period 2 to period 6 compared to the Min Variance Portfolio for which the portfolio. During period 4, the market starts plummeting, the portfolio minimizes the uncertainties of the market by reducing trades. For Max Sharpe Ratio, the portfolio trades much more frequently than the other two portfolios whereas its portfolio value were significantly lower than the other two portfolios. The Max Sharpe Ratio captures too much downside losses.

Comparison Among Seven Strategies

Referring to fig 3.1, the Equal Risk Contribution and Equally Weighted portfolio have similar trend during the financial crisis with Equal Risk Contribution slightly above the other. Overall, these two portfolios performed moderately, and the money lost was in the medium range among those tested portfolios. However, the Leveraged portfolio performed the worst during the crisis and reason was that the strategy was long biased and when the crisis happened, and the portfolio was still on leverage, then the losses would be doubled so the portfolio value dropped significantly and was hard to recover. Out of the seven tested portfolios, the min variance optimization and the robust portfolio was among the best when dealing with market crisis. The robust portfolio dropped slowest and recovered fasted during the crisis. This will remain a lot of time for the investor to make decisions regarding the risk management. During 2008-2009 period, I would choose robust

optimization portfolio as it takes into consideration regarding the uncertainties such as financial crisis and other uncertain things. When the market recovers, it also recovers the fastest.

Appendix A

Matlab output for 2015-2016

Reading daily prices datafile - Daily_closing_prices.csv

Initial portfolio value = $ 1000002.12

Period 1: start date 1/2/2015, end date 2/27/2015
Strategy "Buy and Hold", value begin = $ 1000002.12, value end = $ 1043785.08
Strategy "Equally Weighted Portfolio", value begin = $ 992867.18, value end = $ 1020457.29
Strategy "Minimum Variance Portfolio", value begin = $ 991448.09, value end = $ 1016801.18
Strategy "Maximum Sharpe Ratio Portfolio", value begin = $ 990051.86, value end = $ 1007912.46
Strategy "Equal Risk Contributions Portfolio", value begin = $ 992744.22, value end = $ 1018983.77
Strategy "Leveraged Equal Risk Contributions Portfolio", value begin = $ 989643.16, value end = $ 1042214.17
Strategy "Robust Optimization Portfolio", value begin = $ 991447.96, value end = $ 1016802.94

Period 2: start date 3/2/2015, end date 4/30/2015
Strategy "Buy and Hold", value begin = $ 1045234.09, value end = $ 1069877.19
Strategy "Equally Weighted Portfolio", value begin = $ 1031209.96, value end = $ 1011693.90
Strategy "Minimum Variance Portfolio", value begin = $ 1024143.17, value end = $ 1014488.48
Strategy "Maximum Sharpe Ratio Portfolio", value begin = $ 1017369.72, value end = $ 1056052.57
Strategy "Equal Risk Contributions Portfolio", value begin = $ 1028916.74, value end = $ 1013157.37
Strategy "Leveraged Equal Risk Contributions Portfolio", value begin = $ 1048743.55, value end = $ 1016471.47
Strategy "Robust Optimization Portfolio", value begin = $ 1024145.71, value end = $ 1014491.99

Period 3: start date 5/1/2015, end date 6/30/2015
Strategy "Buy and Hold", value begin = $ 1085647.24, value end = $ 1027659.63
Strategy "Equally Weighted Portfolio", value begin = $ 1021689.68, value end = $ 987901.30
Strategy "Minimum Variance Portfolio", value begin = $ 1009542.69, value end = $ 970610.59
Strategy "Maximum Sharpe Ratio Portfolio", value begin = $ 1057389.27, value end = $ 1015536.43
Strategy "Equal Risk Contributions Portfolio", value begin = $ 1019648.45, value end = $ 986351.73
Strategy "Leveraged Equal Risk Contributions Portfolio", value begin = $ 1019587.39, value end = $ 952787.49
Strategy "Robust Optimization Portfolio", value begin = $ 1009546.51, value end = $ 970613.49

Period 4: start date 7/1/2015, end date 8/31/2015
Strategy "Buy and Hold", value begin = $ 1035245.91, value end = $ 947793.98
Strategy "Equally Weighted Portfolio", value begin = $ 991783.18, value end = $ 934674.45
Strategy "Minimum Variance Portfolio", value begin = $ 973182.23, value end = $ 933246.83
Strategy "Maximum Sharpe Ratio Portfolio", value begin = $ 1011274.88, value end = $ 924906.85
Strategy "Equal Risk Contributions Portfolio", value begin = $ 989989.73, value end = $ 936741.33
Strategy "Leveraged Equal Risk Contributions Portfolio", value begin = $ 952566.73, value end = $ 849888.33
Strategy "Robust Optimization Portfolio", value begin = $ 973185.10, value end = $ 933248.83

Period 5: start date 9/1/2015, end date 10/30/2015
Strategy "Buy and Hold", value begin = $ 912055.56, value end = $ 1027307.87
Strategy "Equally Weighted Portfolio", value begin = $ 904858.73, value end = $ 1023197.55
Strategy "Minimum Variance Portfolio", value begin = $ 901284.87, value end = $ 941700.88
Strategy "Maximum Sharpe Ratio Portfolio", value begin = $ 879882.42, value end = $ 1099037.41
Strategy "Equal Risk Contributions Portfolio", value begin = $ 906706.74, value end = $ 1015852.95
Strategy "Leveraged Equal Risk Contributions Portfolio", value begin = $ 819452.50, value end = $ 1017195.79
Strategy "Robust Optimization Portfolio", value begin = $ 901849.54, value end = $ 943053.07

Period 6: start date 11/2/2015, end date 12/31/2015
Strategy "Buy and Hold", value begin = $ 1039856.20, value end = $ 1003328.46
Strategy "Equally Weighted Portfolio", value begin = $ 1040169.78, value end = $ 1035658.74
Strategy "Minimum Variance Portfolio", value begin = $ 946279.96, value end = $ 960969.24
Strategy "Maximum Sharpe Ratio Portfolio", value begin = $ 1102195.57, value end = $ 1217116.66
Strategy "Equal Risk Contributions Portfolio", value begin = $ 1032403.67, value end = $ 1026888.13
Strategy "Leveraged Equal Risk Contributions Portfolio", value begin = $ 1029650.34, value end = $ 1018608.62
Strategy "Robust Optimization Portfolio", value begin = $ 949255.82, value end = $ 957700.19

Period 7: start date 1/4/2016, end date 2/29/2016
Strategy "Buy and Hold", value begin = $ 994608.85, value end = $ 970570.87
Strategy "Equally Weighted Portfolio", value begin = $ 1015257.52, value end = $ 954755.12
Strategy "Minimum Variance Portfolio", value begin = $ 950081.42, value end = $ 945452.59
Strategy "Maximum Sharpe Ratio Portfolio", value begin = $ 1176005.33, value end = $ 1007547.18
Strategy "Equal Risk Contributions Portfolio", value begin = $ 1007523.36, value end = $ 955765.42
Strategy "Leveraged Equal Risk Contributions Portfolio", value begin = $ 994719.95, value end = $ 892290.33
Strategy "Robust Optimization Portfolio", value begin = $ 945730.60, value end = $ 941121.88

Period 8: start date 3/1/2016, end date 4/29/2016
Strategy "Buy and Hold", value begin = $ 999683.25, value end = $ 975547.52
Strategy "Equally Weighted Portfolio", value begin = $ 982789.93, value end = $ 1053018.75
Strategy "Minimum Variance Portfolio", value begin = $ 957067.28, value end = $ 989995.94
Strategy "Maximum Sharpe Ratio Portfolio", value begin = $ 1030924.26, value end = $ 1002744.25
Strategy "Equal Risk Contributions Portfolio", value begin = $ 982324.28, value end = $ 1032826.54
Strategy "Leveraged Equal Risk Contributions Portfolio", value begin = $ 912266.72, value end = $ 1006219.74
Strategy "Robust Optimization Portfolio", value begin = $ 952683.42, value end = $ 985380.13

Period 9: start date 5/2/2016, end date 6/30/2016
Strategy "Buy and Hold", value begin = $ 982170.01, value end = $ 1000838.49
Strategy "Equally Weighted Portfolio", value begin = $ 1066375.24, value end = $ 1108174.38
Strategy "Minimum Variance Portfolio", value begin = $ 994524.54, value end = $ 1063881.22
Strategy "Maximum Sharpe Ratio Portfolio", value begin = $ 1006602.86, value end = $ 1094968.17
Strategy "Equal Risk Contributions Portfolio", value begin = $ 1042086.93, value end = $ 1086677.13
Strategy "Leveraged Equal Risk Contributions Portfolio", value begin = $ 1011870.94, value end = $ 1099912.84
Strategy "Robust Optimization Portfolio", value begin = $ 989866.71, value end = $ 1058913.39

Period 10: start date 7/1/2016, end date 8/31/2016
Strategy "Buy and Hold", value begin = $ 1003605.67, value end = $ 1067751.34
Strategy "Equally Weighted Portfolio", value begin = $ 1119287.36, value end = $ 1225385.61
Strategy "Minimum Variance Portfolio", value begin = $ 1064191.29, value end = $ 1050228.72

Strategy "Maximum Sharpe Ratio Portfolio", value begin = $ 1094371.76, value end = $ 1116489.27
Strategy "Equal Risk Contributions Portfolio", value begin = $ 1094388.51, value end = $ 1156386.46
Strategy "Leveraged Equal Risk Contributions Portfolio", value begin = $ 1102878.70, value end = $ 1228380.11
Strategy "Robust Optimization Portfolio", value begin = $ 1059254.03, value end = $ 1044731.44

Period 11: start date 9/1/2016, end date 10/31/2016
Strategy "Buy and Hold", value begin = $ 1073361.15, value end = $ 1090939.15
Strategy "Equally Weighted Portfolio", value begin = $ 1227229.83, value end = $ 1225847.02
Strategy "Minimum Variance Portfolio", value begin = $ 1046641.68, value end = $ 1021182.80
Strategy "Maximum Sharpe Ratio Portfolio", value begin = $ 1115237.32, value end = $ 1178252.49
Strategy "Equal Risk Contributions Portfolio", value begin = $ 1158247.34, value end = $ 1146802.64
Strategy "Leveraged Equal Risk Contributions Portfolio", value begin = $ 1225962.49, value end = $ 1201679.92
Strategy "Robust Optimization Portfolio", value begin = $ 1041945.69, value end = $ 1016580.73

Period 12: start date 11/1/2016, end date 12/30/2016
Strategy "Buy and Hold", value begin = $ 1077523.53, value end = $ 1173675.24
Strategy "Equally Weighted Portfolio", value begin = $ 1212151.94, value end = $ 1350187.55
Strategy "Minimum Variance Portfolio", value begin = $ 1007745.47, value end = $ 1122270.69
Strategy "Maximum Sharpe Ratio Portfolio", value begin = $ 1158161.05, value end = $ 1536967.45
Strategy "Equal Risk Contributions Portfolio", value begin = $ 1134909.78, value end = $ 1244806.67
Strategy "Leveraged Equal Risk Contributions Portfolio", value begin = $ 1184820.94, value end = $ 1414874.10
Strategy "Robust Optimization Portfolio", value begin = $ 1003203.83, value end = $ 1117209.68
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Appendix B

Matlab output for 2008-2009

Reading daily prices datafile - Daily_closing_prices20082009.csv

Initial portfolio value = $ 548247.97

Period 1: start date 1/2/2008, end date 2/29/2008
Strategy "Buy and Hold", value begin = $ 548247.97, value end = $ 465217.72
Strategy "Equally Weighted Portfolio", value begin = $ 544324.36, value end = $ 470049.97
Strategy "Minimum Variance Portfolio", value begin = $ 543917.73, value end = $ 461704.10
Strategy "Maximum Sharpe Ratio Portfolio", value begin = $ 542792.84, value end = $ 473578.92
Strategy "Equal Risk Contributions Portfolio", value begin = $ 544291.88, value end = $ 471753.09
Strategy "Leveraged Equal Risk Contributions Portfolio", value begin = $ 542891.26, value end = $ 397523.63
Strategy "Robust Optimization Portfolio", value begin = $ 543917.73, value end = $ 461704.10

Period 2: start date 3/3/2008, end date 4/30/2008
Strategy "Buy and Hold", value begin = $ 462553.95, value end = $ 511257.48
Strategy "Equally Weighted Portfolio", value begin = $ 463715.11, value end = $ 510244.23
Strategy "Minimum Variance Portfolio", value begin = $ 454200.29, value end = $ 524614.71
Strategy "Maximum Sharpe Ratio Portfolio", value begin = $ 463802.42, value end = $ 485738.40
Strategy "Equal Risk Contributions Portfolio", value begin = $ 465184.34, value end = $ 520200.41

Strategy "Leveraged Equal Risk Contributions Portfolio", value begin = $ 390637.45, value end = $ 483279.32
Strategy "Robust Optimization Portfolio", value begin = $ 454200.29, value end = $ 524614.71

Period 3: start date 5/1/2008, end date 6/30/2008
Strategy "Buy and Hold", value begin = $ 526490.95, value end = $ 486095.76
Strategy "Equally Weighted Portfolio", value begin = $ 527213.37, value end = $ 446545.68
Strategy "Minimum Variance Portfolio", value begin = $ 539326.47, value end = $ 495775.68
Strategy "Maximum Sharpe Ratio Portfolio", value begin = $ 489702.66, value end = $ 423569.79
Strategy "Equal Risk Contributions Portfolio", value begin = $ 537219.35, value end = $ 461392.89
Strategy "Leveraged Equal Risk Contributions Portfolio", value begin = $ 497793.46, value end = $ 356873.16
Strategy "Robust Optimization Portfolio", value begin = $ 539326.47, value end = $ 495775.68

Period 4: start date 7/1/2008, end date 8/29/2008
Strategy "Buy and Hold", value begin = $ 487307.50, value end = $ 485687.69
Strategy "Equally Weighted Portfolio", value begin = $ 446375.12, value end = $ 452441.20
Strategy "Minimum Variance Portfolio", value begin = $ 495025.60, value end = $ 497990.64
Strategy "Maximum Sharpe Ratio Portfolio", value begin = $ 438446.25, value end = $ 436984.42
Strategy "Equal Risk Contributions Portfolio", value begin = $ 459954.28, value end = $ 463368.24
Strategy "Leveraged Equal Risk Contributions Portfolio", value begin = $ 354577.94, value end = $ 359887.06
Strategy "Robust Optimization Portfolio", value begin = $ 495025.62, value end = $ 497990.92

Period 5: start date 9/2/2008, end date 10/31/2008
Strategy "Buy and Hold", value begin = $ 478985.24, value end = $ 369998.60
Strategy "Equally Weighted Portfolio", value begin = $ 451414.27, value end = $ 316446.39
Strategy "Minimum Variance Portfolio", value begin = $ 486785.34, value end = $ 374053.66
Strategy "Maximum Sharpe Ratio Portfolio", value begin = $ 424337.41, value end = $ 294405.11
Strategy "Equal Risk Contributions Portfolio", value begin = $ 460998.80, value end = $ 333833.61
Strategy "Leveraged Equal Risk Contributions Portfolio", value begin = $ 356906.19, value end = $ 159448.75
Strategy "Robust Optimization Portfolio", value begin = $ 486785.59, value end = $ 374053.90

Period 6: start date 11/3/2008, end date 12/31/2008
Strategy "Buy and Hold", value begin = $ 372792.12, value end = $ 338021.03
Strategy "Equally Weighted Portfolio", value begin = $ 315106.64, value end = $ 276774.54
Strategy "Minimum Variance Portfolio", value begin = $ 374336.22, value end = $ 335801.10
Strategy "Maximum Sharpe Ratio Portfolio", value begin = $ 296608.47, value end = $ 255878.66
Strategy "Equal Risk Contributions Portfolio", value begin = $ 333031.90, value end = $ 294589.15
Strategy "Leveraged Equal Risk Contributions Portfolio", value begin = $ 158691.18, value end = $ 121954.55
Strategy "Robust Optimization Portfolio", value begin = $ 375036.01, value end = $ 344347.56

Period 7: start date 1/2/2009, end date 2/27/2009
Strategy "Buy and Hold", value begin = $ 351630.52, value end = $ 325694.94
Strategy "Equally Weighted Portfolio", value begin = $ 288243.64, value end = $ 254234.00
Strategy "Minimum Variance Portfolio", value begin = $ 345576.52, value end = $ 325413.72
Strategy "Maximum Sharpe Ratio Portfolio", value begin = $ 255031.69, value end = $ 209681.48
Strategy "Equal Risk Contributions Portfolio", value begin = $ 306371.94, value end = $ 271207.75
Strategy "Leveraged Equal Risk Contributions Portfolio", value begin = $ 126302.10, value end = $ 97223.63
Strategy "Robust Optimization Portfolio", value begin = $ 354836.90, value end = $ 334138.54

Period 8: start date 3/2/2009, end date 4/30/2009

Strategy "Buy and Hold", value begin = $ 316048.57, value end = $ 392525.73
Strategy "Equally Weighted Portfolio", value begin = $ 243222.09, value end = $ 375123.52
Strategy "Minimum Variance Portfolio", value begin = $ 312607.81, value end = $ 424279.53
Strategy "Maximum Sharpe Ratio Portfolio", value begin = $ 199554.83, value end = $ 280582.43
Strategy "Equal Risk Contributions Portfolio", value begin = $ 260428.21, value end = $ 381407.31
Strategy "Leveraged Equal Risk Contributions Portfolio", value begin = $ 93120.56, value end = $ 179820.29
Strategy "Robust Optimization Portfolio", value begin = $ 320989.92, value end = $ 435652.33

Period 9: start date 5/1/2009, end date 6/30/2009
Strategy "Buy and Hold", value begin = $ 394998.62, value end = $ 426991.87
Strategy "Equally Weighted Portfolio", value begin = $ 374383.95, value end = $ 412969.83
Strategy "Minimum Variance Portfolio", value begin = $ 420849.92, value end = $ 426525.41
Strategy "Maximum Sharpe Ratio Portfolio", value begin = $ 271805.72, value end = $ 295452.87
Strategy "Equal Risk Contributions Portfolio", value begin = $ 380368.25, value end = $ 409228.65
Strategy "Leveraged Equal Risk Contributions Portfolio", value begin = $ 178069.78, value end = $ 205178.16
Strategy "Robust Optimization Portfolio", value begin = $ 432130.95, value end = $ 437958.37

Period 10: start date 7/1/2009, end date 8/31/2009
Strategy "Buy and Hold", value begin = $ 429930.17, value end = $ 467013.68
Strategy "Equally Weighted Portfolio", value begin = $ 413921.49, value end = $ 463222.11
Strategy "Minimum Variance Portfolio", value begin = $ 425126.01, value end = $ 449976.15
Strategy "Maximum Sharpe Ratio Portfolio", value begin = $ 290893.70, value end = $ 287882.73
Strategy "Equal Risk Contributions Portfolio", value begin = $ 409928.72, value end = $ 449136.47
Strategy "Leveraged Equal Risk Contributions Portfolio", value begin = $ 204826.99, value end = $ 244108.45
Strategy "Robust Optimization Portfolio", value begin = $ 436520.97, value end = $ 462025.05

Period 11: start date 9/1/2009, end date 10/30/2009
Strategy "Buy and Hold", value begin = $ 457407.27, value end = $ 489396.95
Strategy "Equally Weighted Portfolio", value begin = $ 448200.07, value end = $ 480463.07
Strategy "Minimum Variance Portfolio", value begin = $ 438810.09, value end = $ 462205.99
Strategy "Maximum Sharpe Ratio Portfolio", value begin = $ 272285.12, value end = $ 275142.41
Strategy "Equal Risk Contributions Portfolio", value begin = $ 436269.00, value end = $ 467073.90
Strategy "Leveraged Equal Risk Contributions Portfolio", value begin = $ 236156.29, value end = $ 269619.02
Strategy "Robust Optimization Portfolio", value begin = $ 450560.07, value end = $ 474575.92

Period 12: start date 11/2/2009, end date 12/31/2009
Strategy "Buy and Hold", value begin = $ 490582.55, value end = $ 542246.05
Strategy "Equally Weighted Portfolio", value begin = $ 482152.25, value end = $ 551899.38
Strategy "Minimum Variance Portfolio", value begin = $ 458504.89, value end = $ 513595.76
Strategy "Maximum Sharpe Ratio Portfolio", value begin = $ 273870.74, value end = $ 310135.30
Strategy "Equal Risk Contributions Portfolio", value begin = $ 467539.04, value end = $ 523169.73
Strategy "Leveraged Equal Risk Contributions Portfolio", value begin = $ 268857.39, value end = $ 333041.13
Strategy "Robust Optimization Portfolio", value begin = $ 470776.25, value end = $ 527335.69
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