# HW Multi-factor Models

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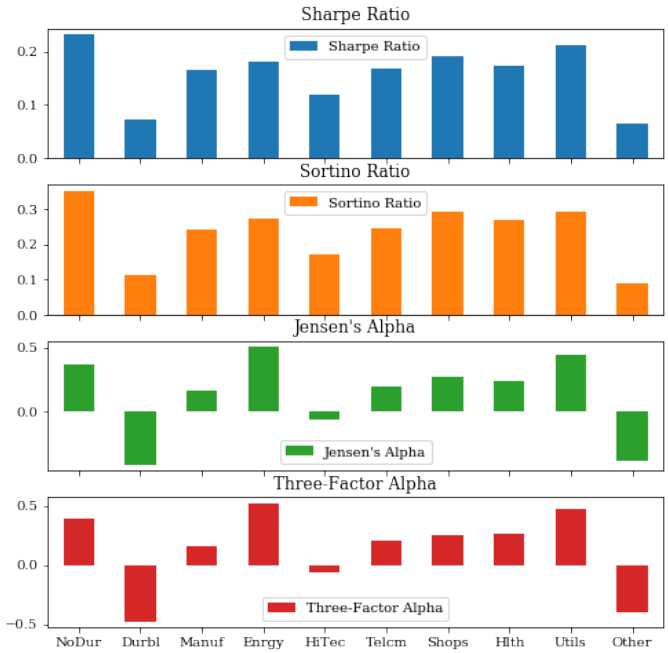
## 1 Performance Measurement

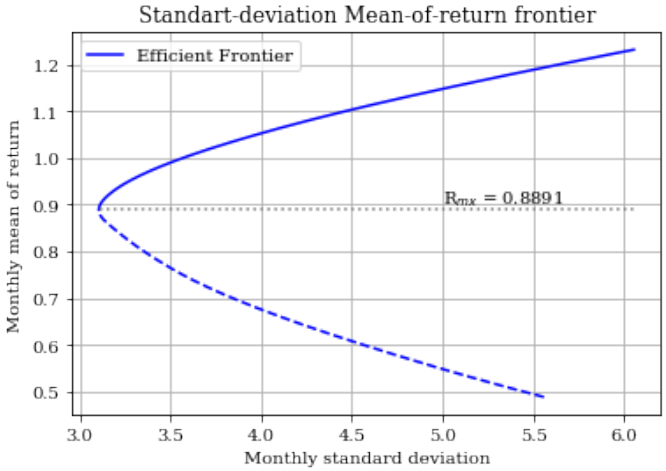
Sharpe ratio measures the risk premium per unit of total risk;
Sortino Ratio measures the risk premium per unit of downside risk;
Jensen's Alpha measures the pricing error of CAPM;
Three-factor Alpha measures the pricing error of three-factor model.



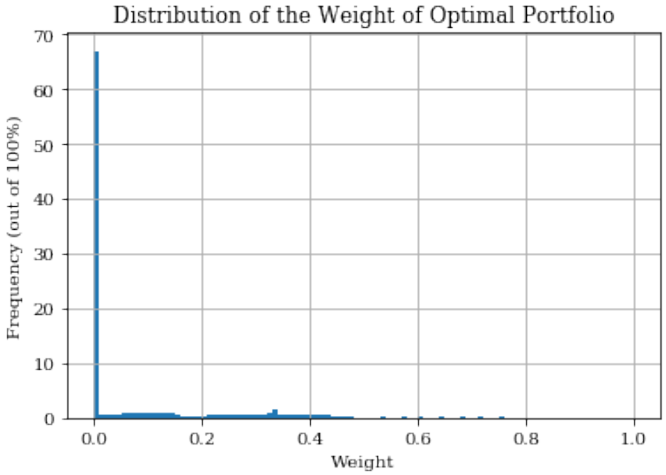
# 2 Minimum-Variance Frontier Revisited

## 2.1 Calculate efficient frontier via scipy.optimize.minimize

Before we apply Monte Carlo method, we firstly use scipy.optimize.minimize to find out the frontier portfolio weight.

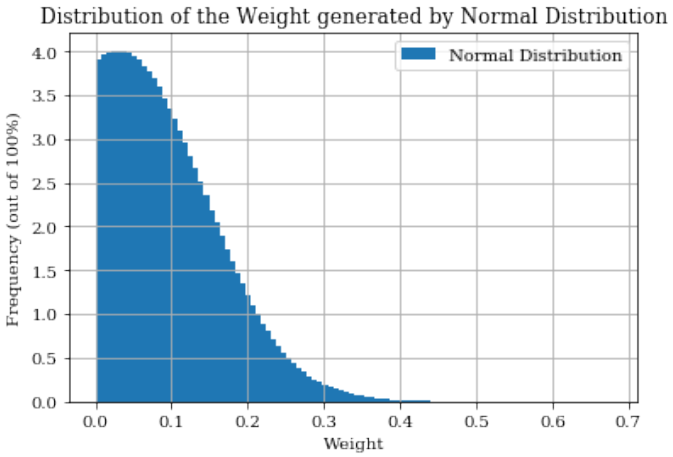



We can find that weight of optimal portfolio consists of a large proportion of extremely small values.

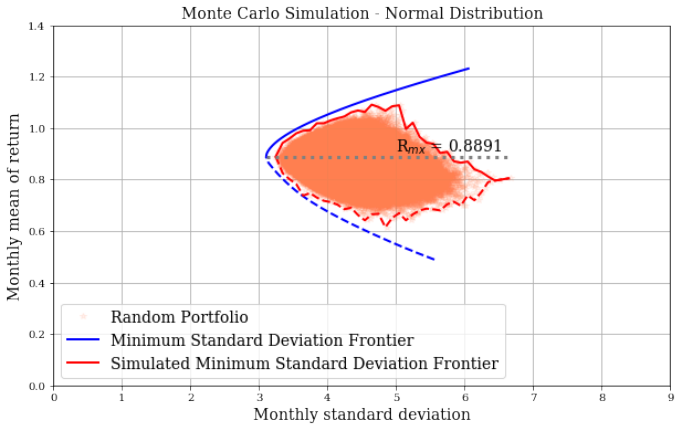


## 2.2 Simulate efficient frontier via random weight generated by normal distribution

Weight generated from normal distribution are not very likely to located on the optimal portfolio, because it doesn't countain enough proportion of extremely small weights.

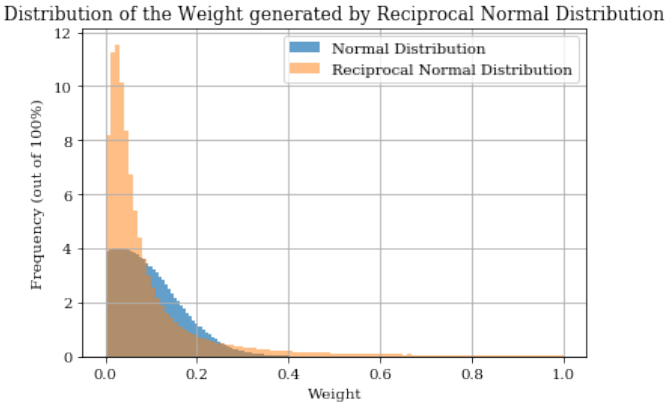



No surprise, the simulation fails to be perfectly located on the frontier.

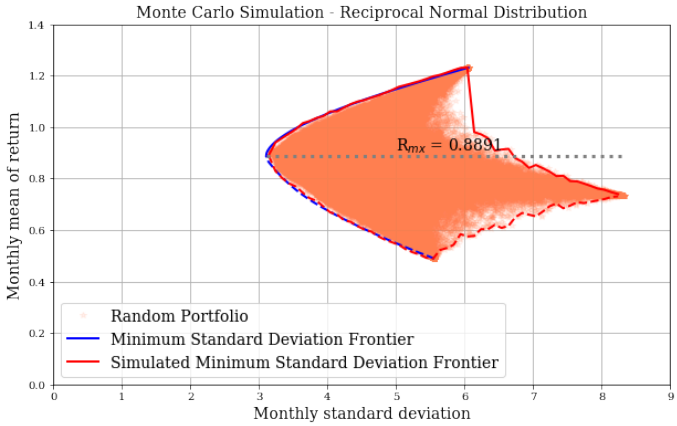


### 2.3 Simulate efficient frontier via random weight generated by reciprocal normal distribution

Reciprocal of normal distribution can generate more extreme values than the original one.

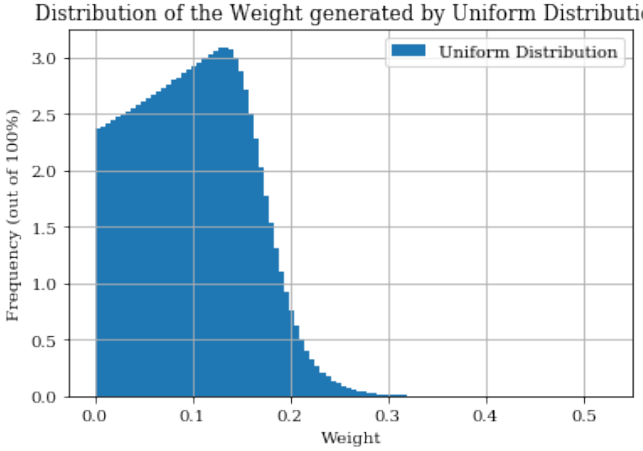


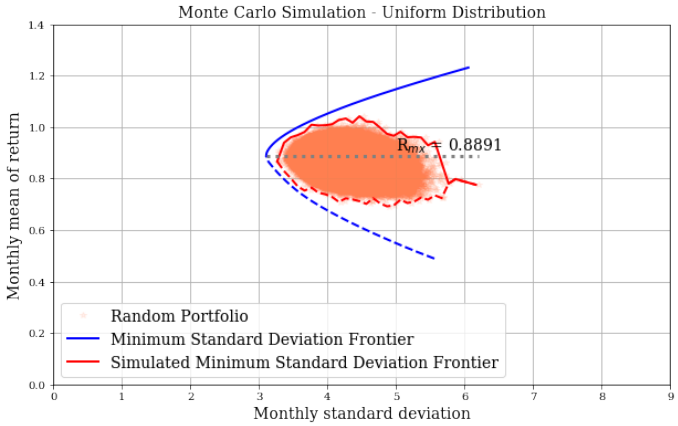

This time, the simulation is perfectly located on the frontier.

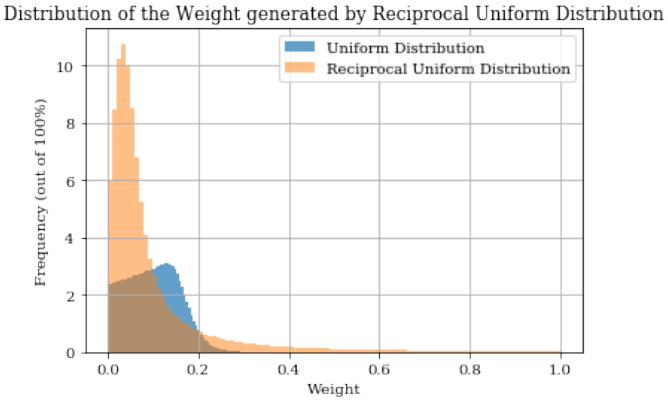


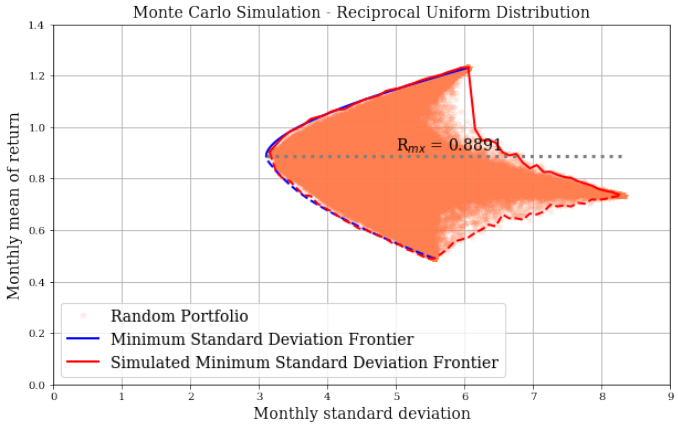

# 3 Complementary Work : Uniform Distribution

We can find out than reciprocal of uniform distribution can performs equally good as that of normal distribution.


Distribution of the Weight generated by Uniform Distribution
Uniform Distribution
Frequency (out of 100%)
Weight
0.0
0.5
1.0
1.5
2.0
2.5
3.0
0.0
0.1
0.2
0.3
0.4
0.5


Monte Carlo Simulation - Uniform Distribution
$R_{mx}$ = 0.8891
Random Portfolio
Minimum Standard Deviation Frontier
Simulated Minimum Standard Deviation Frontier
Monthly mean of return
Monthly standard deviation


Distribution of the Weight generated by Reciprocal Uniform Distribution
Uniform Distribution
Reciprocal Uniform Distribution
Frequency (out of 100%)
Weight


Monte Carlo Simulation - Reciprocal Uniform Distribution
Monthly mean of return
Monthly standard deviation
$R_{mx}$ = 0.8891
Random Portfolio
Minimum Standard Deviation Frontier
Simulated Minimum Standard Deviation Frontier
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
0
1
2
3
4
5
6
7
8
9