Combining CML Line to determine the Optimal Market Portfolio without Unsystematic Risk

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Introduction

According to relevant studies, asset allocation contributes more than 90% to portfolio performance. On the one hand, in a semi-strong efficient market environment, the information, profitability and size of the investment target, the characteristics of the investment variety and special time-varying factors have an impact on investment returns, so **CAL (Capital Allocation Line)** can play a role in reducing risk and increasing returns.

Based on the search for the optimal portfolio that can achieve the target return using the **EF (Effective Frontier)**. We find that with this approach, the final resulting portfolio weights are different because each investor's expected return is different. This often leads to investors being subject to unsystematic risk.

Therefore, we intend to find the maximized Sharpe ratio of this portfolio by introducing risk-free assets (cash) to construct CML.

Since there are an infinite number of EFs for each kind of investor, there are an infinite number of **OPTIMAL CALs**. By assuming that all investors are homogeneous and will only invest in two types of assets, risk-free and market portfolio, i.e., the same expectations for the future, it is simplified to one EF. At this point the **OPTIMAL CAL** is called **CML (Capital Market Line)** and has only 1 line.

The portfolio found by this method is also called **Market portfolio**, and the corresponding point is the point where the CML is tangent to the. At this point, the portfolio's unsystematic risk has been completely diversified, leaving only systematic risk.

Method

We collected stock data of the top 5 companies in each of the four sectors for the past year. The plan is to analyze and compare the portfolios of the four sectors in order to filter out the sectors with the highest Sharpe ratios. The higher the Sharpe ratio, the higher the return per unit of risk taken by the portfolio.

When there are no risk-free assets in the portfolio, in other words, when the portfolio is fully invested,

the effective boundary is the curve, which corresponds to the red line in the figure above. Therefore, there exists a unique risk and return that maximizes the Sharpe ratio. If the portfolio is allowed to invest in risk-free assets, a part of the red effective boundary line will be replaced by the CML, thus giving the effective boundary of the portfolio with risk-free investments (blue line). All points on the straight blue line have the same Sharpe ratio.

At this point we assume that the investor invests all the money in the portfolio and finds the market portfolio for each sector.

Results

Sharp ratio of four sectors	
Healthcare	0.7701
Retail	0.6106
Auto	0.9618
Cryptocurrencies	0.8382

Based on the results, we decided to select the auto sector to invest in.

At this point, the stock portfolio weights corresponding to the market portfolio of the auto sector are as follows:

Stock Weights	
Tesla, Inc. (TSLA)	0.0000
Bentley Systems, Incorporated (BSY)	0.2837
Ford Motor Company (F)	0.2953
Honda Motor Co., Ltd. (HMC)	0.0648
Toyota Motor Corporation (TM)	0.3561

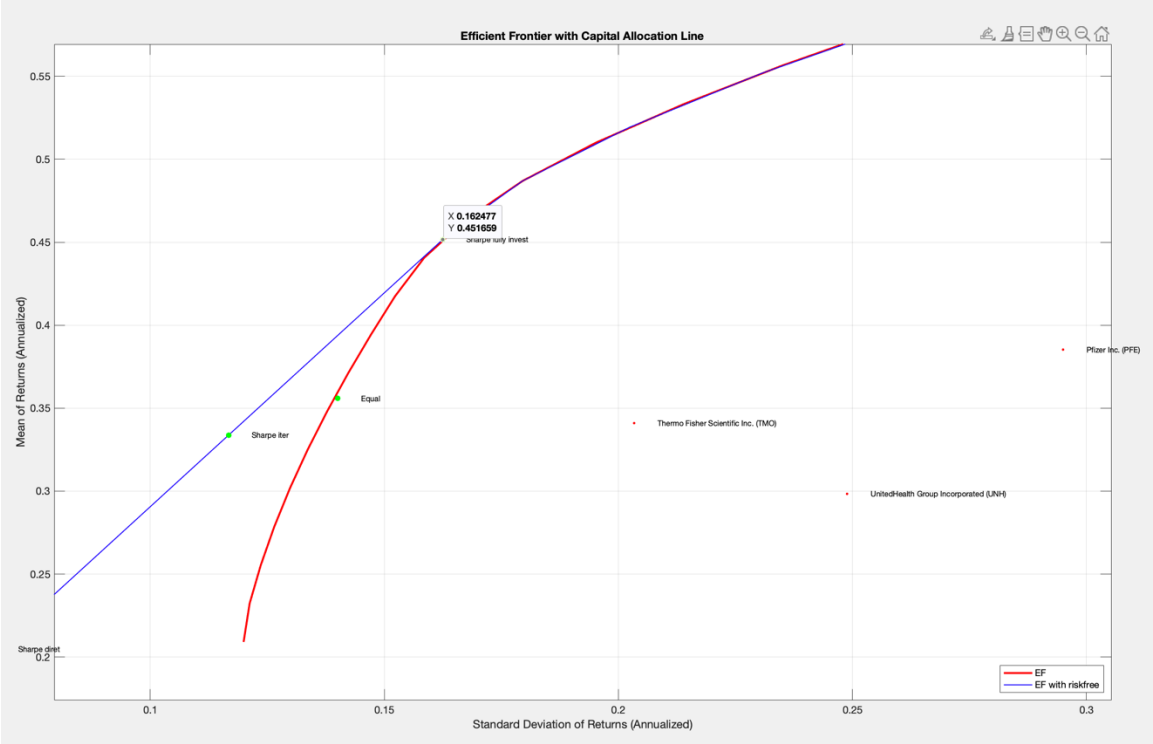
Conclusion

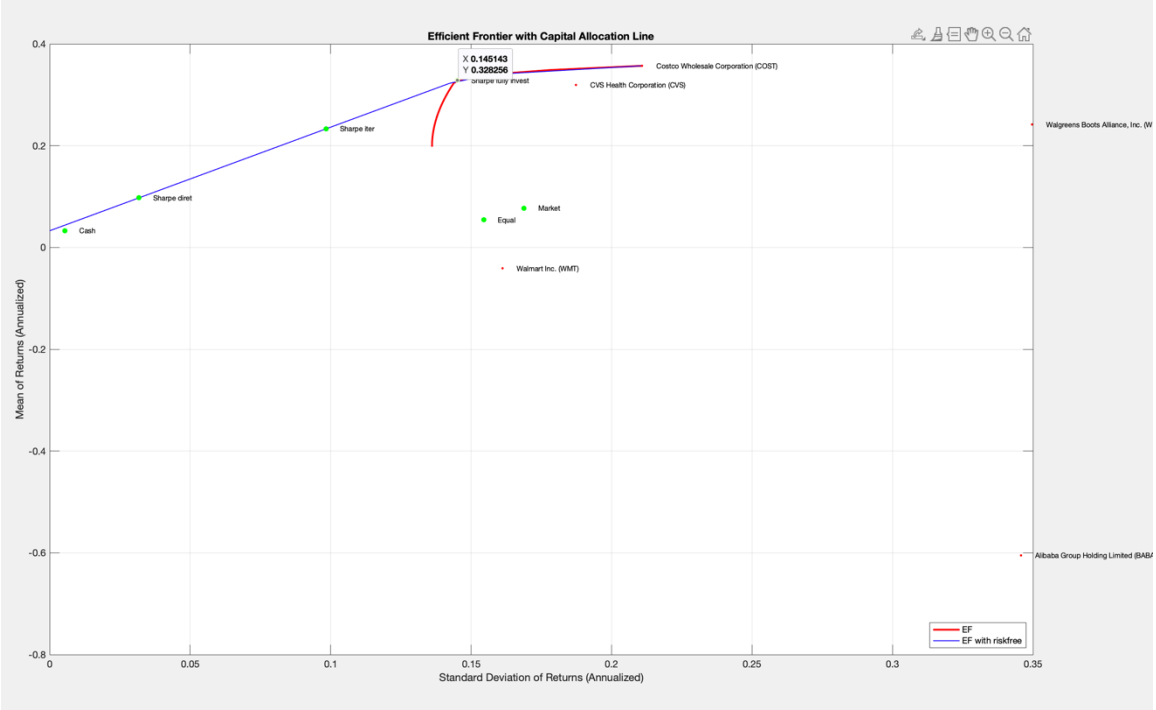
With the introduction of CML lines we are able to effectively eliminate the impact of unsystematic risk on investors. In addition, investors are not necessarily limited to the Market portfolio, but they can also change their investment approach according to their own investment needs. When investors emphasize safety, they increase their holdings of risk-free assets; when they emphasize return, they increase their holdings of market portfolio, and the corresponding portfolio points move on the CML. In our study in this paper, we find the largest sharp ratio in the auto sector among the four sectors. We then assume that investors put all their money into the Market portfolio and finally calculate the weight of each stock in

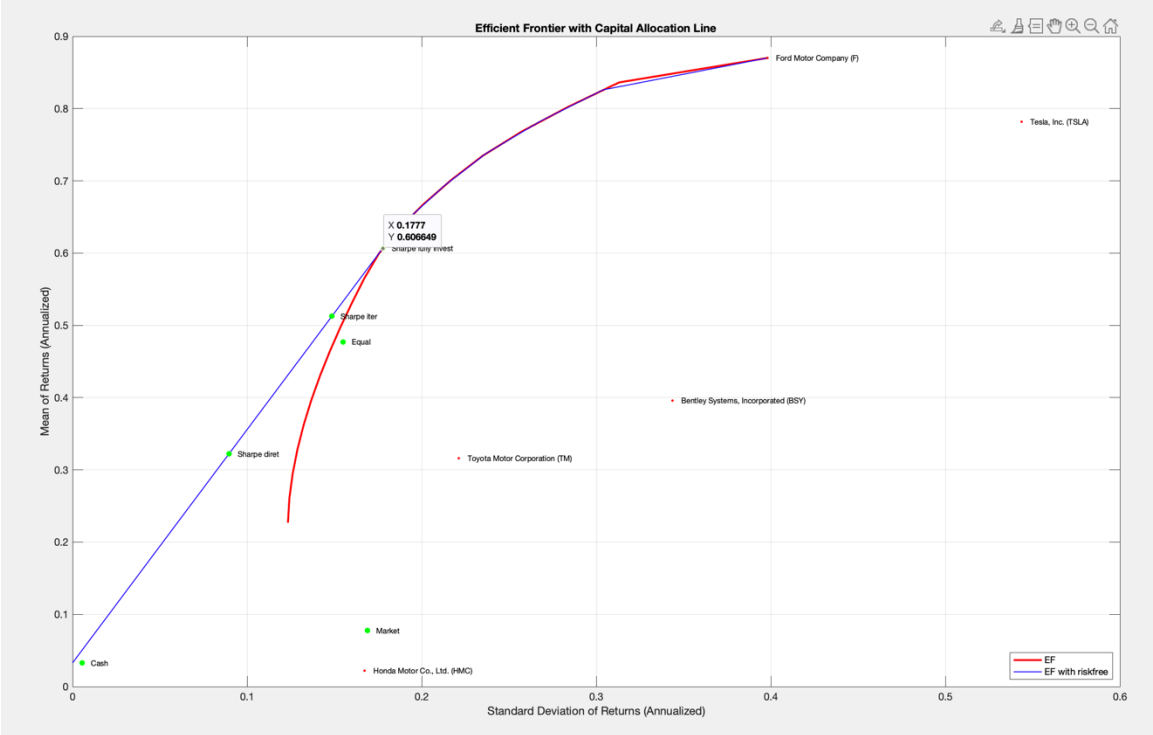
the Auto sector portfolio.

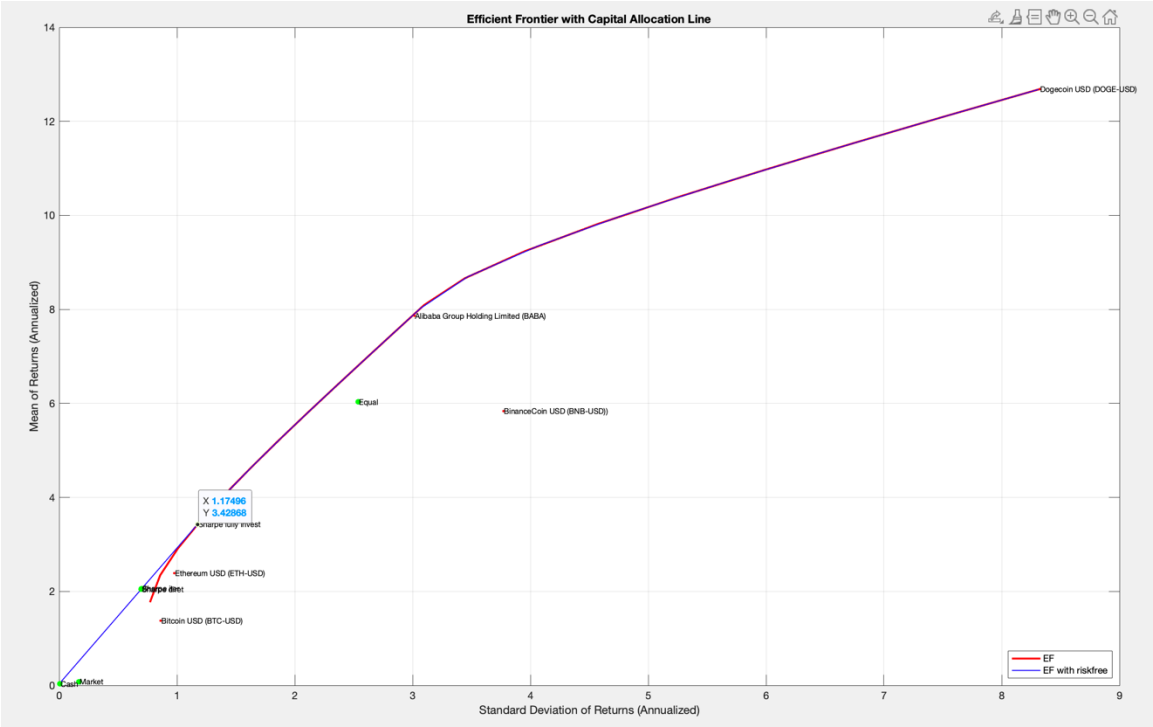
Appendix

Plot




Efficient Frontier with Capital Allocation Line
X 0.145143
Y 0.328256
Costco Wholesale Corporation (COST)
CVS Health Corporation (CVS)
Walgreens Boots Alliance, Inc. (W
Sharpe iter
Sharpe diret
Market
Equal
Cash
Walmart Inc. (WMT)
Alibaba Group Holding Limited (BABA
EF
EF with riskfree
Mean of Returns (Annualized)
Standard Deviation of Returns (Annualized)
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35


Efficient Frontier with Capital Allocation Line
X 0.1777
Y 0.606649
Ford Motor Company (F)
Tesla, Inc. (TSLA)
Sharpe iter
Equal
Bentley Systems, Incorporated (BSY)
Sharpe diret
Toyota Motor Corporation (TM)
Market
Cash
Honda Motor Co., Ltd. (HMC)
EF
EF with riskfree
Mean of Returns (Annualized)
Standard Deviation of Returns (Annualized)
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
0.1
0.2
0.3
0.4
0.5
0.6


Efficient Frontier with Capital Allocation Line
Mean of Returns (Annualized)
Standard Deviation of Returns (Annualized)
Dogecoin USD (DOGE-USD)
Alibaba Group Holding Limited (BABA)
Equal
BinanceCoin USD (BNB-USD))
X 1.17496
Y 3.42868
Ethereum USD (ETH-USD)
Bitcoin USD (BTC-USD)
Cash
Market
EF
EF with riskfree

Code

```
load BlueChipStockMoments

mret = MarketMean;
mrsk = sqrt(MarketVar);
cret = CashMean;
crsk = sqrt(CashVar);

data = xlsread('Stock_data.xlsx','data','B17:F28')
[~,names] = xlsread('Stock_data.xlsx','data','B16:F16')
C = cov(data)
R = mean(data)


p = Portfolio('AssetList', names, 'RiskFreeRate', CashMean);
p = setAssetMoments(p, R', C);

p = setInitPort(p, 1/p.NumAssets);
[ersk, eret] = estimatePortMoments(p, p.InitPort);

p = setDefaultConstraints(p);
pwgt = estimateFrontier(p, 20);
[prsk, pret] = estimatePortMoments(p, pwgt);
pwgtshpr_fully = estimateMaxSharpeRatio(p,'Method','direct');
[riskshpr_fully, retshpr_fully] = estimatePortMoments(p,pwgtshpr_fully);

q = setBudget(p, 0, 1);
qwgt = estimateFrontier(q, 20);
[qrsk, qret] = estimatePortMoments(q, qwgt);


%PLOT--------------------------------------------------------------------
pwgtshpr_direct = estimateMaxSharpeRatio(q,'Method','direct');
pwgtshpr_iter = estimateMaxSharpeRatio(q,'Method','iterative');
[riskshpr_diret, retshpr_diret] = estimatePortMoments(q,pwgtshpr_direct);
[riskshpr_iter, retshpr_iter] = estimatePortMoments(q,pwgtshpr_iter);

clf;
portfolioexamples_plot('Efficient Frontier with Capital Allocation Line', ...
                {'line', prsk, pret, {'EF'}, '-r', 2}, ...
                {'line', qrsk, qret, {'EF with riskfree'}, '-b', 1}, ...
                {'scatter', [mrsk, crsk, ersk, riskshpr_fully, riskshpr_diret, riskshpr_iter], ...
    [mret, cret, eret, retshpr_fully , retshpr_diret, retshpr_iter], ...
    {'Market', 'Cash', 'Equal','Sharpe fully invest', 'Sharpe diret','Sharpe iter'}}, ...
                {'scatter', sqrt(diag(C)), R', names, '.r'});

Sharpratio = (retshpr_fully - cret) / (riskshpr_fully - crsk)
```