Final Report

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Contents

1 Data Collection

1.1 Data Sources

The trading history data is collected from MYQUANT [1] and the table of ETFs in Shanghai Stock Exchange comes from the official fund list of Shanghai Stock Exchange [2].

1.2 Data Details

The frequency researched in this study is daily frequency. Assuming the slippage in trading could be neglected. Therefore, this study directly uses open to calculate **log return** (all the following results, like average returns and standard deviations, are based on log return). The data is split into insample data (from 2022/09/01 to 2024/09/01) and outsample data (from 2024/09/02 to 2024/11/29).

1.3 Trading Assets Selection

The rule of selection:

- It should be an ETF of an industry.
- It should be traded everyday.
- It should have an acceptable trading amount in the insample data (from 2022/09/01 to 2024/09/01).

The selected results are following:

	Symbol	Name
1	512480	Semiconductor ETF
2	512880	Securities ETF
3	512010	Pharmaceutical ETF
4	515790	Photovoltaic ETF
5	512690	Wine ETF
6	512660	Military ETF
7	512800	Bank ETF
8	512200	Real estate ETF
9	516160	New energy ETF
10	512980	Media ETF
11	515170	Food and beverage ETF
12	516510	Cloud computing ETF

Table 1: Selected ETFs

[1] `https://www.myquant.cn/`
[2] `https://etf.sse.com.cn/fundlist/`

2 MVE Portfolio Construction

The construction of the Mean-Variance Efficient (MVE) portfolio involves optimizing the portfolio weights to maximize the portfolio's Sharpe Ratio, subject to the constraint that the weights sum to one and all weights are nonegative. This study solves the following optimization problem to construct the MVE portfolio:

$$\min_{\mathbf{w}} \quad -\frac{\mathbf{w}^\top \mu^e}{\sqrt{\mathbf{w}^\top \mathbf{\Sigma} \mathbf{w}}}$$

where:

- $\mathbf{w}$ is the vector of portfolio weights,
- $\mathbf{\Sigma}$ is the covariance matrix of asset returns.

Subject to:

$$\sum_{i=1}^{n} w_i = 1 \quad \text{(portfolio weights sum to 1)}$$

$$w_i \geq 0 \quad \text{for all}\, i \quad \text{(non-negative weights)}$$

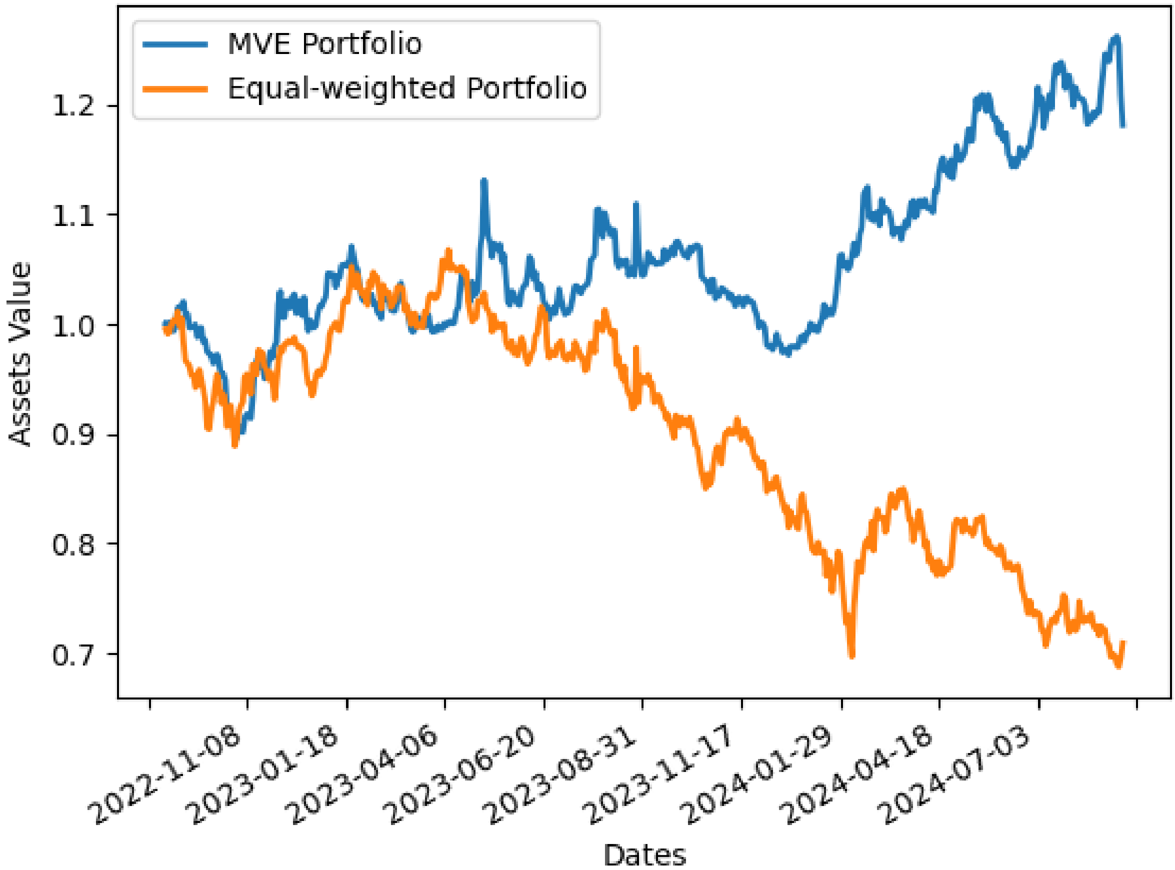

Figure 1: Comparison of Asset Value Over Time: MVE vs Equal-weighted Portfolio

The resulting MVE portfolio is designed to have the greatest Sharpe Ratio based on the covariance matrix and expected return of the selected assets.

In contrast, the equal-weighted portfolio assigns the same weight to each asset, which means each asset receives $\frac{1}{12}$ of the total portfolio weight. This simple method does not consider the correlations between assets, and as a result, it may expose the portfolio to higher risk.

The average return of MVE portfolio is $3.431 * 10^{-4}$, the standard deviation of it is $1.001 * 10^{-2}$, and the Sharpe Ratio of it is $5.443 * 10^{-1}$, while average return of equal-weighted portfolio is $-7.093 * 10^{-4}$, the standard deviation of it is $1.234 * 10^{-2}$, and the Sharpe Ratio of it is $-9.122 * 10^{-1}$. The MVE portfolio has a higher mean return and a comparable standard deviation compared to the equal-weighted portfolio, indicating that it is slightly less risky while achieving a higher return.

3 Black-Litterman Model

Black-Litterman is a variation of MVE that utilizes posterior mean and covariance.

$$\min_{\mathbf{w}} \quad -\frac{\mathbf{w}^\top \mu_{BL}^e}{\sqrt{\mathbf{w}^\top \mathbf{\Sigma}_{BL} \mathbf{w}}}$$

where:

- $\mu_{BL}^e = ((\tau\mathbf{\Sigma})^{-1} + \mathbf{P}^\top \Omega^{-1} \mathbf{P}^\top)^{-1}((\tau\mathbf{\Sigma})^{-1}\pi + \mathbf{P}^\top \mathbf{\Omega}^{-1} q)$
- $\mathbf{\Sigma}_{BL}^e = \mathbf{\Sigma} + ((\tau\mathbf{\Sigma})^{-1} + \mathbf{P}^\top \Omega^{-1} \mathbf{P}^\top)^{-1}$
- π is the prior mean of return, this study takes the return of previous 3 months.
- $\tau\mathbf{\Sigma}$ is the prior covariance matrix of asset returns. In this study, I choose $\tau = 0.05$ since these ETFs has fallen for one and a half years, making me believe something is going to change.
- $\mathbf{P}$ and $\mathbf{q}$ are two parts of views, they have the relationship of $\mathbf{P}\mu^e = \mathbf{q} + \mathbf{e}$ where μ^e is the excessive return.
- $\mathbf{\Omega}$ is the uncertainty of views.

Subject to:

$$\sum_{i=1}^{n} w_i = 1 \quad \text{(portfolio weights sum to 1)}$$

$$w_i \geq 0 \quad \text{for all}\, i \quad \text{(non-negative weights)}$$

This study stands on the point of 2024/09/02, providing the following views:

- Semiconductor ETF: With the improvement of sales, the whole indusrty get into a high-speed way of development [3] (although the report is slightly in the outsample period, the data in that report is about the first half of that year, which is accessible at insample period). Thus, the view of this study is the expected excessive return of this ETF will be 1.5%. The uncertainty of it is relatively small, $(0.1)^2$.

[3] https://pdf.dfcfw.com/pdf/H3_AP202409041639734913_1.pdf?1725470001000.pdf

- Securities ETF: Based on this report [4], the business of securities declined. Moreover, a new [5] that a employee of a famous securities company committed suicide. I believe the following 3 months will be hard for them. Since there is another indusrty about finance, the bank, which performs acceptable based on a report from KPMG [6]. I would like to use the relative view: Bank ETF will outperforms Securities ETF by 2% and the uncertainty of it is $(0.15)^2$.

- Pharmaceutical ETF: Based on this report [7], this indusrty suffered before August. Thus, my view is it will have an expected return of -0.5% with uncertainty of $(0.3)^2$.

- Wine ETF: The economy of China was not so good these months, so I believe people will spend more money on food and beverage rather than wine. My view is the Food and beverage ETF will overperform Wine ETF by 2% with uncertainty of $(0.2)^2$.

- Military ETF: The world was disordered these months. So, I believe the expected excessive return of it will be 2% with uncertainty of $(0.1)^2$.

- Real estate ETF: Citizens were pessimistic to this indusrty, so I believe the expected excessive return of it will be -1% with uncertainty of $(0.1)^2$.

- Photovoltaic ETF and New energy ETF: The government of China released an announcement [8] to promote the development of new energy. So, I I believe the expected excessive return of them will be 1% with uncertainty of $(0.2)^2$.

- Media ETF: Based on this report [9], I believe the expected excessive return of it will be 1% with uncertainty of $(0.25)^2$.

- Cloud computing ETF: This indusrty was not as popular as Semiconductor indusrty these months. I believe it will underperform Semiconductor ETF by 1% with uncertainty of $(0.2)^2$.

Based on these views, $\mathbf{P}$, $\mathbf{q}$ and $\mathbf{\Omega}$ can be represented as:

$$\mathbf{P} = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & -1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ -1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix}$$

[4] https://finance.sina.com.cn/roll/2024-09-04/doc-incmzfqe9437706.shtml
[5] https://news.qq.com/rain/a/20240703A06XKC00
[6] https://news.qq.com/rain/a/20240613A0609S00
[7] https://bydrug.pharmcube.com/report/detail/238ace0747a843b8a104ff67ffd561ce
[8] https://www.gov.cn/zhengce/202408/content_6971115.htm
[9] https://www.hangyan.co/reports/3447246469789124565

$$\mathbf{q} = \begin{bmatrix} 0.015 \\ 0.02 \\ -0.005 \\ 0.02 \\ 0.02 \\ -0.01 \\ 0.01 \\ 0.01 \\ 0.01 \\ -0.01 \end{bmatrix}$$

$$\mathbf{\Omega} = \begin{bmatrix} 0.1^2 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0.15^2 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0.3^2 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0.2^2 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0.1^2 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0.1^2 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 0.2^2 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0.2^2 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0.25^2 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0.2^2 \end{bmatrix}$$

4 Out-of-Sample Portfolio Evaluation

The following is some general metrics about these three portfolios:

- MVE: mean is 3.119×10^{-3}, standard deviation is 2.295×10^{-2}, and Sharpe Ratio is 2.157.
- Equal-weighted: mean is 4.476×10^{-3}, standard deviation is 3.203×10^{-2}, and Sharpe Ratio is 2.219.
- Black-Litterman (BL): mean is 4.237×10^{-3}, standard deviation is 2.684×10^{-2}, and Sharpe Ratio is 2.506.

For detailed analysis, we can see MVE and Black Litterman Model perform consistently better than equal-weighted portfolio before the red dashed line. After the red dashed line (a bull market generated by a series of policies), the equal-weighted portfolio outperforms MVE portfolio for diversity. However, Black Litterman Model still performs well for my views. For the MVE portfolio, we can see if the market have changed, this kind of portfolio will suffer for its bad covariance estimation. Although Black Litterman Model has the help from views, it τ is too low, it will suffer too when market changes. For the equal-weighted portfolio, it will benefit from diversity when market changes. However, if the market does not change a lot, the benefits of estimated covariance matrix will emerge and make other two methods dominate it.

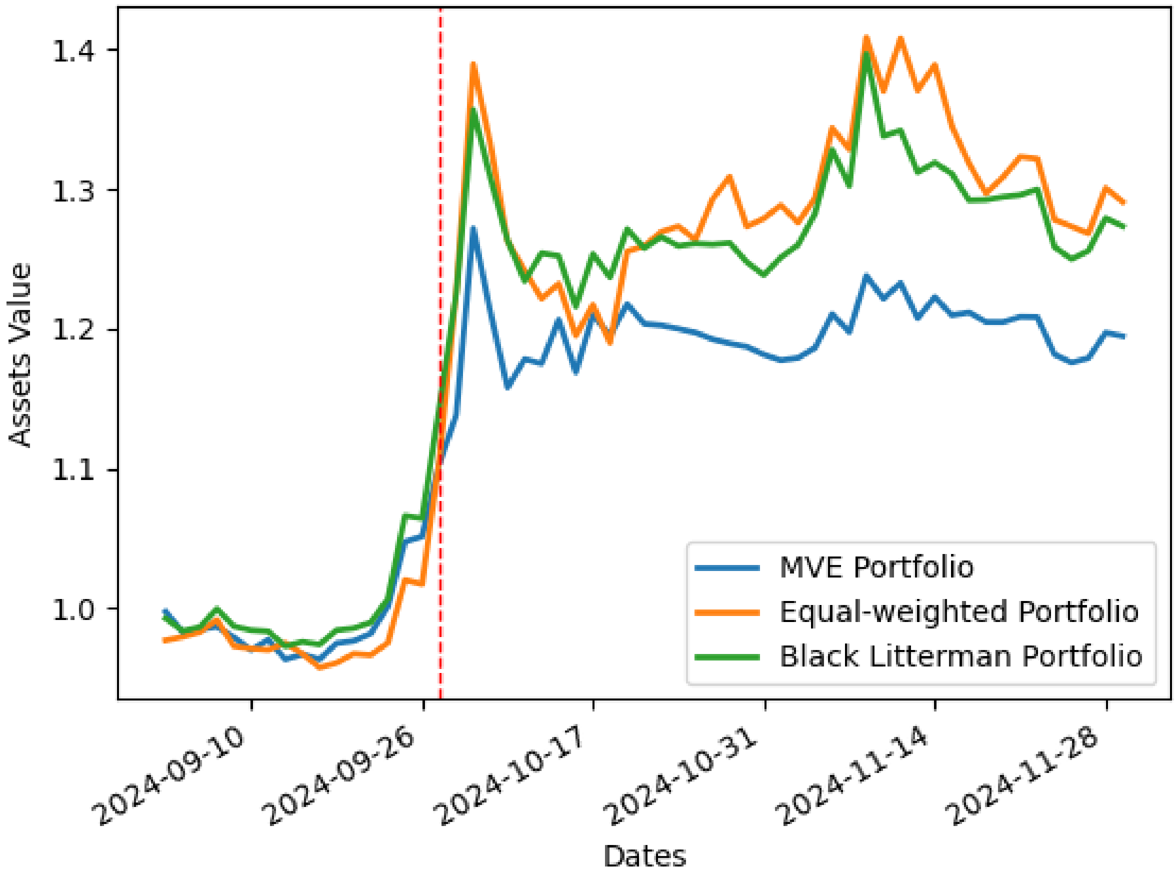

Figure 2: Outsample Performance of Black Litterman Model, MVE Portfolio, and Equal-weighted Portfolio