Assignment 3
Ashutosh Ekade, Gabriel de La Noua, Peilin Liu, Yilu Chen

1. Equal-weighted portfolio

weights = [0.2, 0.2, 0.2, 0.2, 0.2]
The mean of the equal-weighted portfolio is 6.00%.
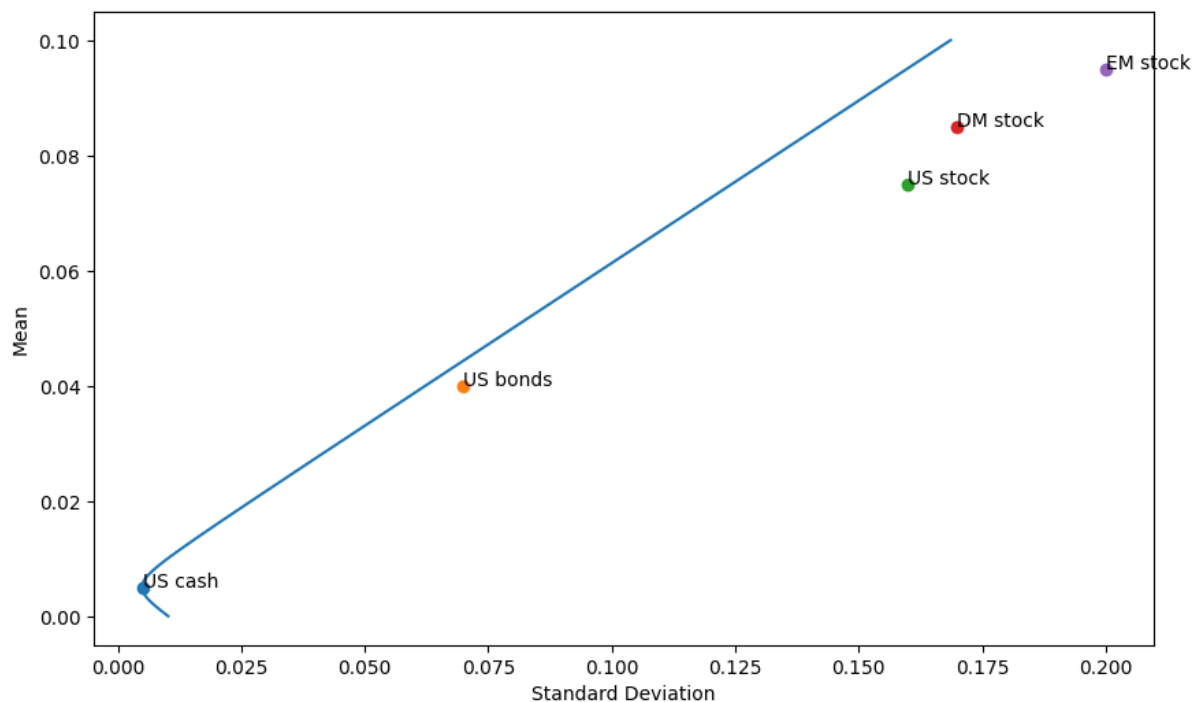The standard deviation of the equal-weighted portfolio is 10.70%

2. GMV constraint

Portfolio weights:

US cash	US bonds	US stocks	DM stocks	EM stocks
-0.16	0.82	0.15	0.13	0.06

The standard deviation of the above portfolio is 9.78%.
US bonds dominate this portfolio with a weight of 82%. So, the portfolio is not very well diversified.

3. Minimum Variance Frontier

Mean: 2%, Standard Deviation: 0.0269, Weights: [0.68 0.23 0.02 0.06 0.01]
Mean: 3%, Standard Deviation: 0.0445, Weights: [0.47 0.38 0.04 0.09 0.02]
Mean: 4%, Standard Deviation: 0.0622, Weights: [0.26 0.53 0.05 0.13 0.03]
Mean: 5%, Standard Deviation: 0.0799, Weights: [0.05 0.69 0.07 0.15 0.041]
Mean: 6%, Standard Deviation: 0.0976, Weights: [-0.163 0.839 0.085 0.187 0.053]
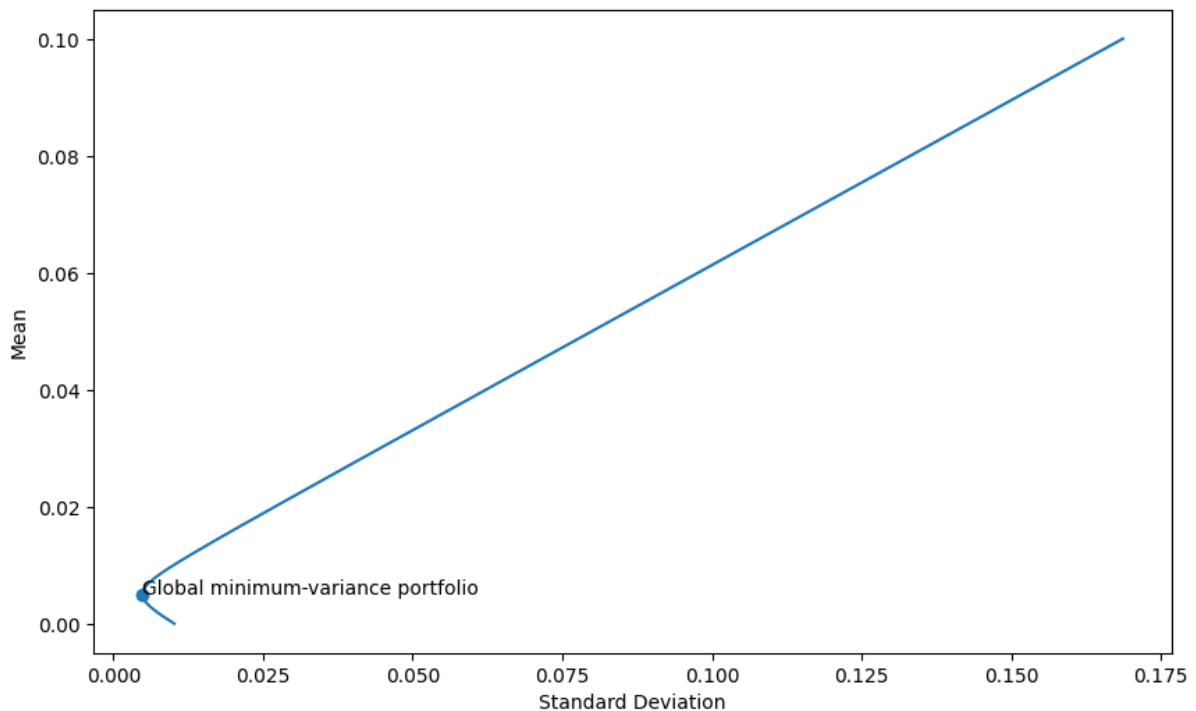Mean: 7%, Standard Deviation: 0.1154, Weights: [-0.375 0.992 0.101 0.218 0.064]

4. Global MV Portfolio

The global minimum variance portfolio has weights: (US cash, US bonds, US stocks, DM stocks & EM stocks) = [0.99 0.   -0.01 0.04 -0.03]
The mean of the global minimum-variance portfolio is 0.005
The standard deviation of the global minimum-variance portfolio is 0.0049

5. Short sale constraint

Since there is a short sell constraint for the same target mean, the standard deviations sometimes are larger than before, and there may not even exist an efficient combination because there are more constraints for the optimisation process.

Mean: 0.02, Standard Deviation: 0.0269, Weights: [0.683 0.226 0.025 0.059 0.007]
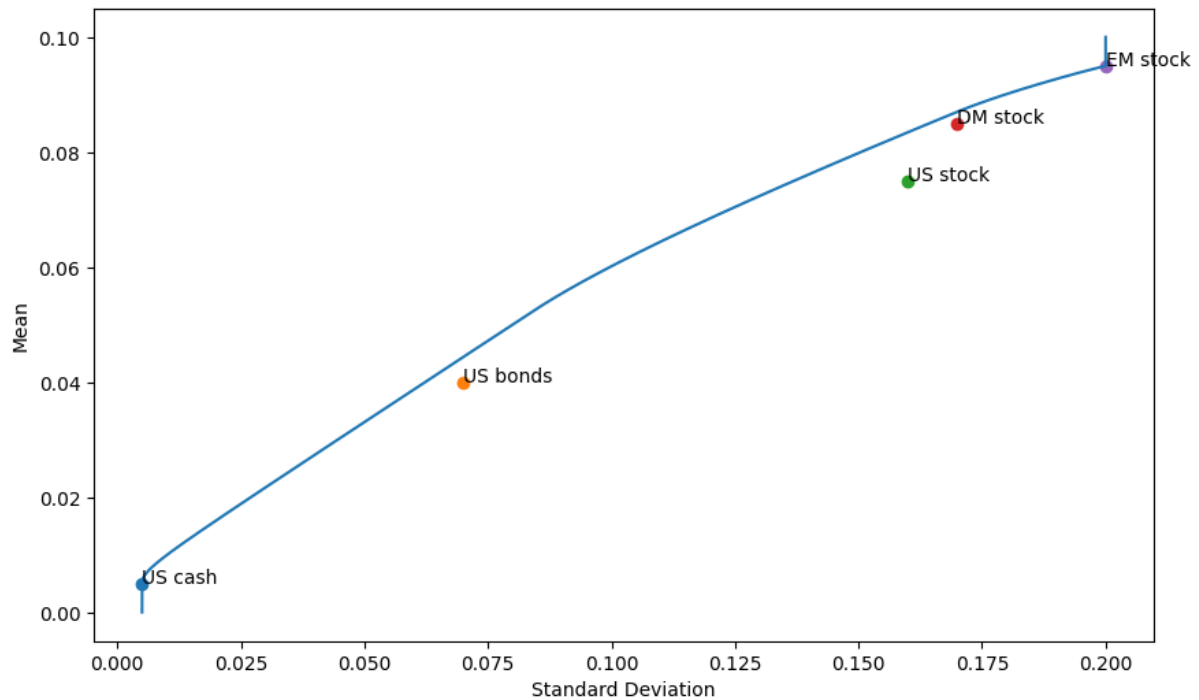Mean: 0.03, Standard Deviation: 0.0445, Weights: [0.47 0.383 0.041 0.086 0.021]
Mean: 0.04, Standard Deviation: 0.0622, Weights: [0.259 0.533 0.054 0.124 0.029]
Mean: 0.05, Standard Deviation: 0.0799, Weights: [0.048 0.686 0.07 0.155 0.041]
Mean: 0.06, Standard Deviation: 0.0995, Weights: [0   0.559 0.114 0.195 0.131]
Mean: 0.07, Standard Deviation: 0.1237, Weights: [0   0.351 0.17 0.23 0.249]

6. Changing mean assumptions

Portfolio weights of US cash, US bonds, US stock, DM stock, and EM stock are [-0.12 0.79 0.26 -0.11 0.19]

The standard deviation of the portfolio is 0.0964

From the difference in the weights, we can see that the new portfolio is to buy more US stock, and the position of DM stock changes to long from short. It makes sense since we have changed the mean assumptions by adding 0.5% to US stocks and subtracting 0.5% to DM stocks. The standard deviation of the new portfolio is lower than before, which is because firstly, the portfolio shorts less US cash and secondly, the weight of US stock plus the weight of DM stock is lower than before, and the mean and variance of the two are similar, so there is more long-short hedging.