Portfolio Optimization and Management (BAF625)

Homework 1

Provided data on KLMS includes stock returns of the 100 largest stocks (as of 2021) from 1990 to 2021. Use the data to answer the following questions. You need to submit an excel file with all outputs and figures, as well as the Python code you wrote to generate results. Our TA prepared an appendix file with a guideline for Python codes and data descriptions for your reference.

1. Compute the vector of the mean (μ) and covariance matrix (Σ) using all data. Assume that there is no risk-free asset, but short-selling is allowed. (case #2 in our lecture note)

    a. Use the parameters to **derive** the mean-variance frontier using the standard deviation for measuring risk. **Plot** the mean-variance frontier. (x: standard deviation, y: expected return) **Indicate** the global minimum portfolio (GMVP) on the plot.

    b. Let S&P 500 index be the Benchmark. Then, **derive** the portfolio weight that minimizes portfolio risk while matching the Benchmark expected return. **Report** the portfolio weight in an excel file. And **report** the portfolio weights on 3M CO (22592), Bank of America Corp (59408), Advanced Micro Devices Inc (61241), Apple Inc (14593), and McDonalds Corp (43449).

    c. **Compute** the annualized excess returns, annualized volatility (standard deviation), and annualized Sharpe ratio of the optimal and the S&P 500 portfolios. (Check annualized Sharpe ratio from https://web.stanford.edu/~wfsharpe/ws/wi_perf.htm#:~:text=The%20annualized%20Sharpe%20Ratio%20is,the%20square%20root%20of%2012.)

	Optimal Portfolio (Case 2)	S&P 500
Excess Return (%)		
Volatility (%)		
Sharpe Ratio		

    d. **Plot** the cumulated performance of the optimal portfolio and the S&P 500 portfolio. (x: time, y: cumulative return.) **Discuss** the difference in the performance of those two portfolios. (MV case2, Benchmark)

2. Assume that there is a risk-free asset, and short-selling is allowed. (case #1 in our lecture note)

   a. **Derive** the mean-variance frontier. **Report** the slope of the mean-variance frontier. Then, **plot** the mean-variance frontier together with the mean-variance frontier in MV case2 in question (1.a).

   b. **Derive** the portfolio weight that minimizes portfolio risk, matching S&P 500 expected return. **Report** the portfolio weight in an excel file. **Report** the portfolio weights on 3M CO (22592), Bank of America Corp (59408), Advanced Micro Devices Inc (61241), Apple Inc (14593), and McDonalds Corp (43449). **What** is the weight of a risk-free asset?

   c. **Compute** the annualized excess returns, annualized volatility, and annualized Sharpe ratio of the optimal and the S&P 500 portfolios. Then, **compare** the results to the results from MV case2 and Benchmark**. How** different are the results?

	Optimal Portfolio (Case1)	S&P 500
Excess Return (%)		
Volatility (%)		
Sharpe Ratio		

   d. **Plot** the cumulated performance of the optimal portfolio with the figure in question (1.d). Then, **discuss** the difference in the performance of those three portfolios. (MV case1, MV case2, and Benchmark)

3. Assume that there is a risk-free asset, but short-selling is not allowed. (case #3 in our lecture note)

    a. **Derive** the mean-variance frontier. **Report** the slope of the mean-variance frontier. Then, **plot** the mean-variance together with the mean-variance frontier in MV case1 in question (2.a). **Which** one has a higher slope, and **what** is its meaning?

    b. **Derive** the portfolio weight that minimizes portfolio risk, matching S&P 500 expected return. **Report** the portfolio weight in an excel file. **Report** the portfolio weights on 3M CO (22592), Bank of America Corp (59408), Advanced Micro Devices Inc (61241), Apple Inc (14593), and McDonalds Corp (43449). **What** is the weight of a risk-free asset?

    c. **Compute** the annualized excess returns, annualized volatility, and annualized Sharpe ratio of the optimal and the S&P 500 portfolios. Then, **compare** the results to MV case1, MV case2, and Benchmark**. How** different are the results?

	Optimal Portfolio (Case3)	S&P 500
Excess Return (%)		
Volatility (%)		
Sharpe Ratio		

    d. **Plot** the cumulated performance of the optimal portfolio with the figure in question (2.d). Then, **discuss** the difference in the performance of those four portfolios. (MV case1, MV case2, MV case3, Benchmark)

4. Assume that there is no risk-free asset, and short-selling is not allowed. (case #4 in our lecture note)

   a. **Derive** the mean-variance frontier. Then, **plot** the mean-variance frontier together with the mean-variance frontiers from MV case1, MV case2, MV case3, Benchmark in questions (1.a), (2.a), and (3.a). **Explain** the differences in the plotted frontiers. **Do** the efficient frontiers expand with lesser constraints?

   b. **Derive** the portfolio weight that minimizes portfolio risk, matching S&P 500 expected return. Report the portfolio weight in an excel file. **Report** the portfolio weights on 3M CO (22592), Bank of America Corp (59408), Advanced Micro Devices Inc (61241), Apple Inc (14593), and McDonalds Corp (43449).

   c. **Compute** the annualized excess returns, annualized volatility, and annualized Sharpe ratio of the optimal and the S&P 500 portfolios. Then, **compare** the results to MV case1, MV case2, MV case3, and Benchmark. **How** different are the results?

	Optimal Portfolio (Case4)	S&P 500
Excess Return (%)		
Volatility (%)		
Sharpe Ratio		

   d. **Plot** the cumulated performance of the optimal portfolio with the figure in question (3.d). Then, **discuss** the difference in the performance of those five portfolios. (MV case1, MV case2, MV case3, MV case4, Benchmark)

5. Let's check how portfolio optimization performance depends on the number of stocks in a portfolio and the correlation of returns among stocks.

    a. Randomly **choose** 10 stocks. **Plot** the mean-variance frontiers for Case 1 (with the MV frontier in the question (2.a)) and Case 2 (with the MV frontier in the question (1.a)). **Compare** annualized Sharpe ratio to the answers in (2.c) and (1.c).

    b. Let's construct a portfolio C with only stocks in the Money sector (19 stocks with flag_sector=1 in the provided data). We also construct a portfolio D with 19 stocks in diverse industries (19 stocks with flag_sector=0 in the provided data). **First, plot** the mean-variance frontiers of C and D portfolios in the case of MV case 2. **Next, plot** the mean-variance frontiers of C and D portfolios in the case of MV case 1. **Whose** Sharpe ratio is higher? **Why**?