**MIE1622H  
Computational Finance and Risk Management**

**Assignment 1**

**Mean-Variance Portfolio Selection Strategies**

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**1.0 Introduction**

The objective of this assignment is to compare different portfolio investment strategies which include: 1. “Buy and hold” strategy

2. “Equally weighted” (also known as “1/n”) portfolio strategy

3. “Minimum variance” portfolio strategy

4. “Maximum Sharpe ratio” portfolio strategy

There are in total of 20 stocks that need to be analyzed. The stock price data is saved on the ​Daily\_closing\_prices.csv​, which includes the 20 stocks’ closing prices from 2014 to 2016. There are 12 holding periods, and each of the holding periods is assumed to last for two months. Each trading has a transaction cost that is caused by the difference between the stock’s selling and bidding prices, and the amount of that cost will be based on 0.5% of the trading volume. In each function, there are four steps to build the strategy function.

1. Computing the current asset value.

2. Computing the new portfolio positions of each stock.

3. Computing the transaction cost.

4. Computing the current cash account (the cash account has to be greater than 0).

Final, there is a correction loop to detect if the cash flow is negative. When cash is negative, we increase the purchase of every stock.

**2.0 Implementation of Investment Strategies**

2.1 Buy and Hold Strategy

The buy and hold strategy is the simplest strategy that requires the user to hold the initial portfolio for the entire two years. The portfolio positions will be constant and transaction costs will not be generated.

2.2 Equally Weighted Strategy

“Equally weighted” (also known as “1/n”) portfolio strategy: asset weights are selected as weight = 1/n, where n is the 20 in this problem. The trading logic of this strategy is to keep the weight as a constant 1/20. If one stock gets profit (weight increases) during a holding period, its revenue will be used to purchase other stocks which have lost their values during the same period. The weakness of this algorithm is a large amount transaction fee will be generated.

The Minimum Variance strategy is to compute the minimum variance portfolio for each period and re-balance it accordingly. The minimized variance weight of the portfolio is fixed, and it will be calculated by the CPLEX API from IBM.

2.4 Maximum Sharpe Ratio Strategy

The Maximum Sharpe Ratio strategy is to compute the maximizes Sharpe Ratio for each period and re-balance accordingly. The strategy also calculated by CPLEX API from IBM

**3.0 Result Analysis**

3.1 value of portfolio

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| Initial portfolio value = $ 1000002.12  Period 1: start date 1/2/2015, end date 2/27/2015  Strategy "Buy and Hold", value begin = $ 1000002.12, value end = $ 1043785.08  Strategy "Equally Weighted Portfolio", value begin = $ 992880.88, value end = $ 1020038.79  Strategy "Mininum Variance Portfolio", value begin = $ 991454.43, value end = $ 1016159.03  Strategy "Maximum Sharpe Ratio Portfolio", value begin = $ 990052.34, value end = $ 1007863.43  Period 2: start date 3/2/2015, end date 4/30/2015  Strategy "Buy and Hold", value begin = $ 1045234.09, value end = $ 1069877.19  Strategy "Equally Weighted Portfolio", value begin = $ 1030724.21, value end = $ 1011178.46  Strategy "Mininum Variance Portfolio", value begin = $ 1023391.23, value end = $ 1014243.70  Strategy "Maximum Sharpe Ratio Portfolio", value begin = $ 1017318.17, value end = $ 1056079.92  Period 3: start date 5/1/2015, end date 6/30/2015  Strategy "Buy and Hold", value begin = $ 1085647.24, value end = $ 1027659.63  Strategy "Equally Weighted Portfolio", value begin = $ 1021173.57, value end = $ 987397.06  Strategy "Mininum Variance Portfolio", value begin = $ 1009285.31, value end = $ 970176.58  Strategy "Maximum Sharpe Ratio Portfolio", value begin = $ 1057391.72, value end = $ 1015502.13  Period 4: start date 7/1/2015, end date 8/31/2015  Strategy "Buy and Hold", value begin = $ 1035245.91, value end = $ 947793.98  Strategy "Equally Weighted Portfolio", value begin = $ 991273.32, value end = $ 934221.34  Strategy "Mininum Variance Portfolio", value begin = $ 972750.92, value end = $ 932853.80  Strategy "Maximum Sharpe Ratio Portfolio", value begin = $ 1011242.32, value end = $ 925455.92  Period 5: start date 9/1/2015, end date 10/30/2015  Strategy "Buy and Hold", value begin = $ 912055.56, value end = $ 1027307.87  Strategy "Equally Weighted Portfolio", value begin = $ 904423.24, value end = $ 1022625.20  Strategy "Mininum Variance Portfolio", value begin = $ 900915.56, value end = $ 941172.59  Strategy "Maximum Sharpe Ratio Portfolio", value begin = $ 880468.67, value end = $ 1099329.15  Period 6: start date 11/2/2015, end date 12/31/2015  Strategy "Buy and Hold", value begin = $ 1039856.20, value end = $ 1003328.46  Strategy "Equally Weighted Portfolio", value begin = $ 1039583.58, value end = $ 1035026.26  Strategy "Mininum Variance Portfolio", value begin = $ 945675.27, value end = $ 960203.02  Strategy "Maximum Sharpe Ratio Portfolio", value begin = $ 1102394.20, value end = $ 1216833.73  Period 7: start date 1/4/2016, end date 2/29/2016  Strategy "Buy and Hold", value begin = $ 994608.85, value end = $ 970570.87  Strategy "Equally Weighted Portfolio", value begin = $ 1014670.87, value end = $ 954289.07  Strategy "Mininum Variance Portfolio", value begin = $ 949370.41, value end = $ 944913.93  Strategy "Maximum Sharpe Ratio Portfolio", value begin = $ 1175755.97, value end = $ 1007792.91  Period 8: start date 3/1/2016, end date 4/29/2016  Strategy "Buy and Hold", value begin = $ 999683.25, value end = $ 975547.52  Strategy "Equally Weighted Portfolio", value begin = $ 982277.17, value end = $ 1052404.73  Strategy "Mininum Variance Portfolio", value begin = $ 956495.37, value end = $ 989239.47  Strategy "Maximum Sharpe Ratio Portfolio", value begin = $ 1031199.45, value end = $ 1003031.96  Period 9: start date 5/2/2016, end date 6/30/2016  Strategy "Buy and Hold", value begin = $ 982170.01, value end = $ 1000838.49  Strategy "Equally Weighted Portfolio", value begin = $ 1065731.48, value end = $ 1107472.49  Strategy "Mininum Variance Portfolio", value begin = $ 993717.23, value end = $ 1063046.75  Strategy "Maximum Sharpe Ratio Portfolio", value begin = $ 1006883.97, value end = $ 1094813.58  Period 10: start date 7/1/2016, end date 8/31/2016  Strategy "Buy and Hold", value begin = $ 1003605.67, value end = $ 1067751.34  Strategy "Equally Weighted Portfolio", value begin = $ 1118569.25, value end = $ 1224442.50  Strategy "Mininum Variance Portfolio", value begin = $ 1063341.49, value end = $ 1049350.83  Strategy "Maximum Sharpe Ratio Portfolio", value begin = $ 1094233.78, value end = $ 1115730.66  Period 11: start date 9/1/2016, end date 10/31/2016  Strategy "Buy and Hold", value begin = $ 1073361.15, value end = $ 1090939.15  Strategy "Equally Weighted Portfolio", value begin = $ 1226278.26, value end = $ 1224856.53  Strategy "Mininum Variance Portfolio", value begin = $ 1045773.05, value end = $ 1020324.47  Strategy "Maximum Sharpe Ratio Portfolio", value begin = $ 1114511.56, value end = $ 1177537.74  Period 12: start date 11/1/2016, end date 12/30/2016  Strategy "Buy and Hold", value begin = $ 1077523.53, value end = $ 1173675.24  Strategy "Equally Weighted Portfolio", value begin = $ 1211179.55, value end = $ 1349048.35  Strategy "Mininum Variance Portfolio", value begin = $ 1006897.18, value end = $ 1120976.00  Strategy "Maximum Sharpe Ratio Portfolio", value begin = $ 1157455.31, value end = $ 1535893.12 |

A screenshot of a cell phone

Description automatically generated

As can be seen from the result, Strategy ‘Maximum Sharpe Ratio’ will generate the largest value $1535893 after 12 holding periods, and the ‘Buy and Hold’ strategy has the least return only $ 1173675.24 Therefore, the ‘Maximum Sharpe Ratio’ Strategy is the best to be used for this dataset. As shown from the graph, the ‘Buy and Hold Strategy’, as well as the ‘Max Sharpe Ratio Strategy’ is generating almost similar returns during approximate the first 160 days. The reason could be the price of each stock increase or decrease as the same trend. Then, the value of the ‘Max Sharpe Ratio’ will experience a dramatical rising. However, all strategy values will reach their local minimum around the 290th days, which may be caused by an economic depressions. In the end, the ‘Max Sharpe Ratio Strategy’ will generate the most profit, whereas the ‘Buy and Hold’ becomes the least value strategy due to its conservatism.

3.2 dynamic changes in portfolio allocations (Minimize Variance)

A close up of a map

Description automatically generated

As shown from the graph, the ‘Minimum Variance Strategy’ barely holds the portfolios. It will purchase the stock at a period, and then sell it at the next. The highest weight of stock is MSFT. From period 4 to period 9, this strategy choose to hold due to its stability. To get minimum variance, this strategy select more than 70 percent of value into a stock. Reducing the variance also means reduce the risk, therefore, it can be used to do long term investment.

3.2 dynamic changes in portfolio allocations (Maximize Sharpe Ratio)

A close up of a map

Description automatically generated

As the graph represents, this strategy is also barely holding the stocks. However, this strategy will choose a main stock to hold for a period, and then sell them all, and choose another dominant stock. It also will not purchase too many stocks at the same time. But here, we add the risk-free rate 2.5% will also be taken into account by this strategy. This risk-free rate is already high than some returns of stock.

In conclusion, this strategy is safer and more conservative to optimize portfolio. And I will choose Maximum Sharpe Ratio managing your own portfolio

**4.0 Possible Improvement**

4.1 Improvement Strategy

The improvement of the strategy will be based on the combination of ‘Equally Weighted Strategy’ and ‘Buy and Hold Strategy’. The idea is to adjust the portfolios with the equally weighted at first. So we only need to pay a transaction fee, and save fee to get more profit from stocks. When comparing with Hold and Buy, and equally weighted strategy, the end value has been improved a lot. But it still lower than Maximum Sharpe Ratio. We can see this from 4.2 Result.

**4.2 Result:**A screenshot of a cell phone

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A screenshot of a map

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**4.3 Can you suggest any improvements of the trading strategies that you have implemented?**

By using ‘Maximum Sharpe Ratio Strategy’, the value will be terminated at around $1.5M, which is 50 percent more than original portfolio value. However, as can be seen from the results, around 260 days, loss and high risk were still existing due to economic depression. Besides, the risk free rate should reduce during depression period. In real world, the best strategy should maximize the return and minimize the risk(variance). Therefore, efficient frontier may be a good strategy to implement for portfolio management.

Additional, the user can choose different portfolio strategy during different periods such as choose “Max Sharpe Ratio Strategy’ to operate during the early periods then hold the portfolio as cash during depression period. As a result, the final value of the portfolio can be further improved.

**5.0 Conclusions**

In conclusion, by comparing and analyzing the different portfolio strategy, the most appropriate strategy to be implemented for this data set is the ‘Maximum Sharpe Ratio Strategy’, and the ‘Hold and Buy Strategy’ generate the least of the portfolio value. Besides, the different variations strategy that has been tested will also generate a substantial net value, whereas it still can be advanced compared to ‘Hold and Buy Strategy’ and ‘equally weighted’. Finally, for this model and dataset, the ‘Maximum Sharpe Ratio Strategy’ is recommended.