451 Portfolio Optimization: Programming Assignment 2

Prepared by Albert Lee

July 27, 2025

Background

With the new president administration, we've seen a seismic shift in how the government procure goods and services. Through contract reviews, contract cancellations, and executive orders, the federal landscape has changed. There's also been an emergent in new companies that have traditionally had limited business with the federal Government. Many of the traditional defense contractors have even started announcing partnerships or saying they're going to more of a "outcome based" contracting which the new administration prefers. The administration has even gone as far as start re-writing the FAR (Federal Acquisition Regulation), announce Anything as a Service within the DoD, and consolidating procurement within the government.

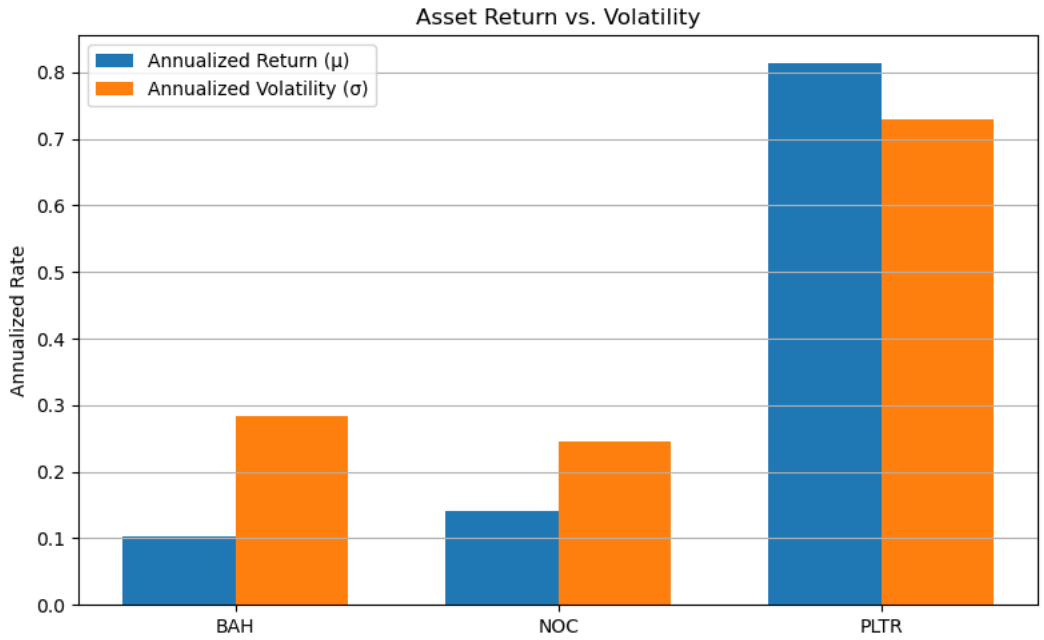
Due to all the changes within the federal procurement space, I wanted to see how potentially fund managers who have exposure to federal contractors may potentially change their portfolio mix based on the recent volatility within the industry. For the three companies stock, I chose 1) Booz Allen Hamilton (BAH), 2) Northrop Grumman (NOC), and 3) Palantir (PLTR). Booz Allen Hamilton is a $12B+ professional services federal contractor that has had recent contract cancellation and has had their company reviewed by GSA. Northrop Grumman is a defense manufacturer that recently gained a huge publicity due to it's B2 stealth bomber. The last company is Palantir whose stock has doubled since the beginning of the year but also has recently gained momentum in leading the federal contracting space in a new category as "defense tech".

Dataset

The dataset used for the modeling was based on yfinance python library and the historical close prices for BAH, NOC, and PLTR from 1/1/2020 to 06/30/2025. These assets were good candidates since their returns and volatility differed quite a bit from each other.

Asset Summary Statistics:

Ticker	Mean Daily Return	Annualized Return	Annualized Volatility
BAH	0.0004	0.1034	0.2841
NOC	0.0006	0.1419	0.2451
PLTR	0.0032	0.8145	0.7298



BAH and NOC had relatively low volatility compared to the current VIX index of $14.93 as of Friday, 7/25/25 while Palantir had the highest volatility. Even though Palantir had the highest volatility, it also saw the highest annualized return of ~81.5%. BAH and NOC had ~10.3% and ~14.2% annualized returns respectively.

Monte Carlo Model

For the portfolio optimization model, I use a Monte Carlo model based on expected annual returns and volatilities (standard deviations). To generate a model, the following steps were performed:

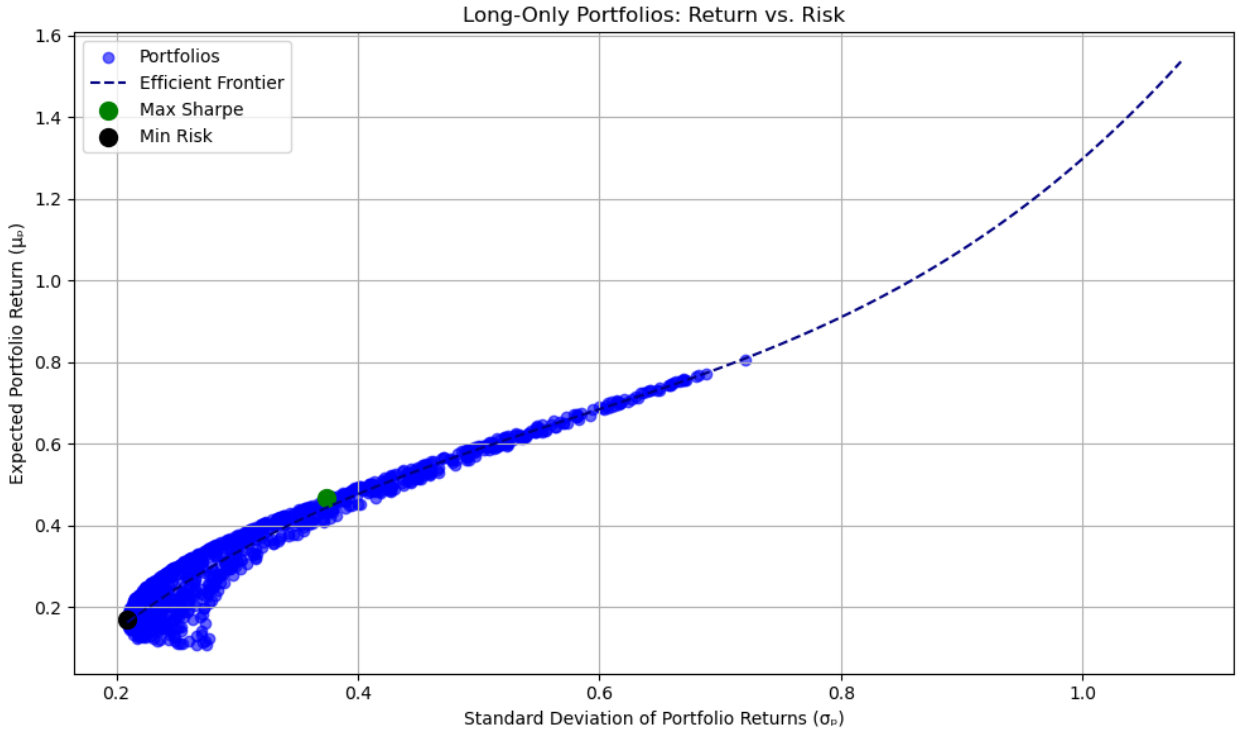
- Calculate expected annual return vector (mu) and covariance matrix (cov).
- Using 1,000 simulations (combination of portfolio asset weights) and a set of parameters: max leverage of 2.0 and risk free rate of 3% to test two categories:
    - Long-only positions (no short-selling)
    - Long-Short (shorts are okay)
- Each simulated portfolio comes up with a expected return and a risk (standard deviation)
- Create loops to simulate 3-asset long-only portfolios where the weights equal to 1. The loop will calculate and store each portfolio's return and risk while simultaneously creating a dataset for maximizing Sharpe Ratio.
    - Sharpe Ratio is a measure of an investment's risk adjusted performance by calculating its return against a risk-free asset.

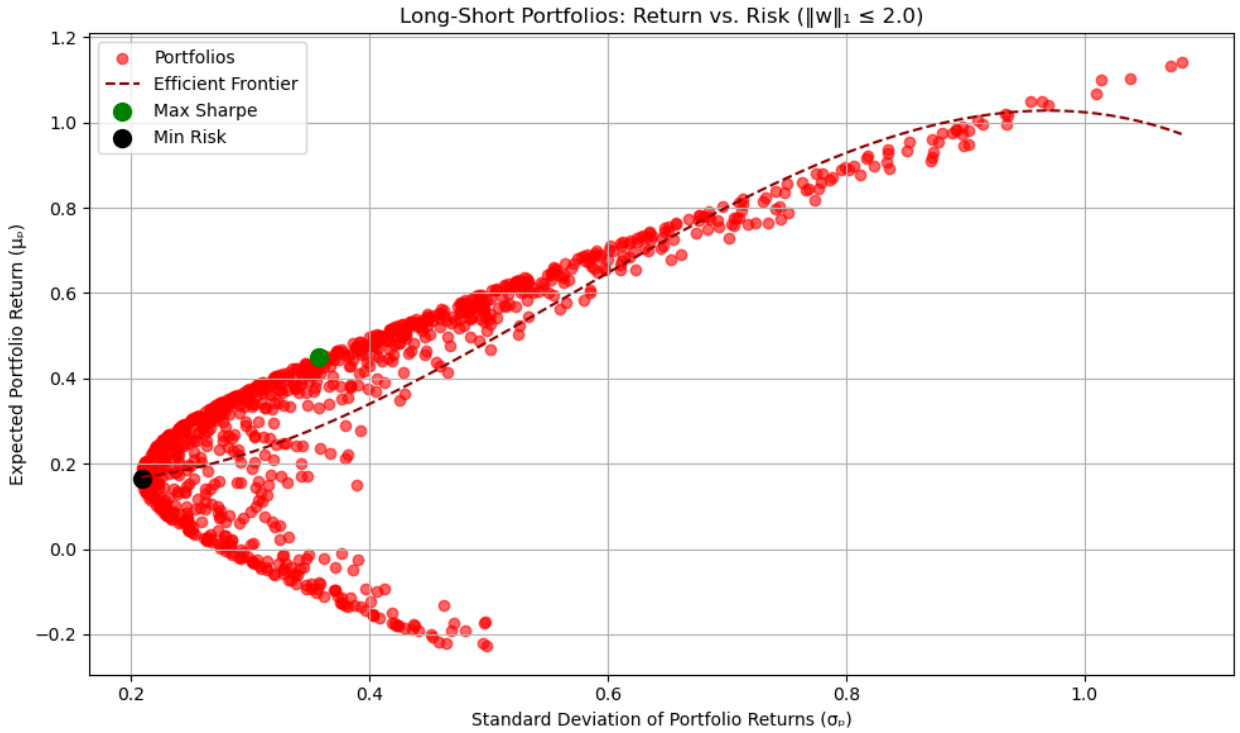
Sharpe Ratio = (Rx – Rf) / StdDev Rx

- Another loop was created except this time it allows for negative values (or short positions) but the portfolio weights still have to equal to 1.

- After the loops and the simulated results into vectorized calculations for plotting and indexing.
- The Sharpe ratio is now calculated for each simulated portfolio and then locates the portfolios with the highest Sharpe Ratio and the lowest volatility (minimum risk).
- The last and final piece before plotting is calculating the efficient frontier curve. The efficient frontier curve is a set of optimal portfolios that offer the highest expected return for a level of risk.

Model output:





Results and Conclusion

The blue dots in the first plot are all the simulated portfolio where each dot represents a generated long-only portfolio for the 3 assets. The green dot is the max Sharpe portfolio providing the most efficient portfolio which would equate to the highest return per unit of risk. The black dot represents the minimum risk portfolio providing the least risky portfolio but as you can see the returns decreases. The dashed line is the efficient frontier.

The second plot is the same except the red dots represent each simulated portfolio where shorts are okay within the portfolio (negative values).

Looking at the model and these 2 charts, it would seem the optimal portfolio weighting would be as followed:

Optimal Portfolio Weights:

Ticker	Long-Only (Max Sharpe)	Long-Only (Min Risk)	Long-Short (Max Sharpe)	Long-Short (Min Risk)
BAH	0.0070	0.3506	-0.0546	0.3868
NOC	0.5107	0.5899	0.6013	0.5561
PLTR	0.4823	0.0595	0.4533	0.05272

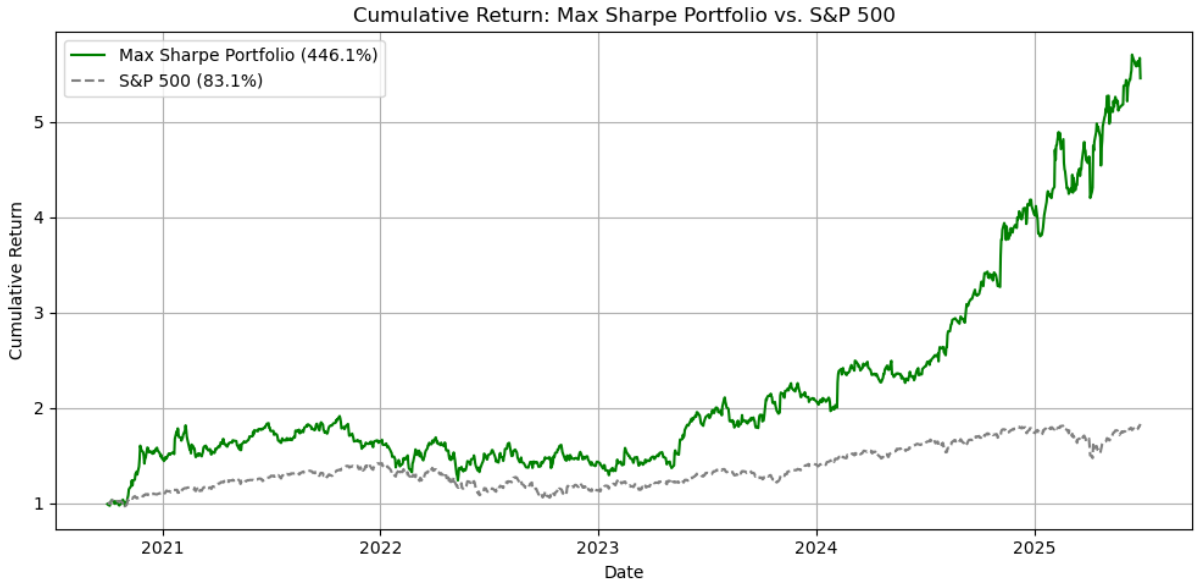
If we were only holding a long-only portfolio position, Northrop Grumman and Palantir would hold a 51% and 48% weighting respectively while Booz Allen Hamilton would have less than 1%. If Long-Short positions were allowed, and we were trying to maximize our returns then we would short Booz Allen Hamilton stock while increasing holdings in Northrop Grumman and Palantir.

Using stochastic Programming approximation for portfolio optimization, I am getting similar weightings based on the max Sharpe ratio:

```
Max Sharpe Portfolio Weights:
BAH: 0.0029
NOC: 0.5937
PLTR: 0.4035
Expected Return: 0.4024
Volatility: 0.3170
Sharpe Ratio: 1.1748
```

The optimization resulted in BAH with less than 1%, NOC with 59%, and PLTR with 40% weighting. According to Rebecca Bainbridge of Forbes Advisor, generally a Sharpe ratio of 1-2 is good. The volatility of 0.3170 is also not far off from the VIX index either which helps reduce the overall risk to the portfolio.

While it's ideal to see the portfolio optimization, I think one of the most important aspects for investors would be how the portfolio's cumulative return compares against S&P 500. To do that, I did a back testing based on the optimal weights within the portfolio and found that the portfolio yielded cumulative returns of 446.1% compared to the S&P 500 cumulative returns of 83.1%. This would mean the portfolio would have gained $44,610 vs. $8,310. With the recent changes in federal procurement, it does seem that the companies aligning more towards the new administration procurement strategy is being rewarded and the Monte Carlo portfolio optimization model proves that out.



References

14, A., Baldridge, R., & Forbes Advisor Forbes Advisor is a trusted destination for unbiased personal finance advice. (n.d.). *Understanding the Sharpe ratio*. Nasdaq. https://www.nasdaq.com/articles/understanding-the-sharpe-ratio

Abhirakshit. (2024, April 17). *Portfolio optimisation and Backtesting: A novel approach*. Medium. https://medium.com/@abhirakshit/portfolio-optimisation-and-backtesting-a-novel-approach-ccfe56747467

Cboe volatility index (^VIX) charts, Data & News - Yahoo Finance. (n.d.-a). https://finance.yahoo.com/quote/%5EVIX/

Fernando, J. (n.d.). *Sharpe ratio: Definition, formula, and examples*. Investopedia. https://www.investopedia.com/terms/s/sharperatio.asp

The Future of Federal Procurement: Key Executive Orders aim to reshape acquisition across civilian and defense agencies. Dentons. (n.d.). https://www.dentons.com/en/insights/alerts/2025/april/11/the-future-of-federal-procurement

Ganti, A. (n.d.). *Efficient frontier: What it is and how investors use it*. Investopedia. https://www.investopedia.com/terms/e/efficientfrontier.asp

Palantir Technologies Inc. (PLTR) stock price, news, Quote & History - Yahoo Finance. (n.d.-b). https://finance.yahoo.com/quote/PLTR/

Sharpe ratio. Corporate Finance Institute. (2024, March 4). https://corporatefinanceinstitute.com/resources/career-map/sell-side/risk-management/sharpe-ratio-definition-formula/

The United States Government. (2025a, April 15). *Restoring common sense to federal procurement*. The White House. https://www.whitehouse.gov/presidential-actions/2025/04/restoring-common-sense-to-federal-procurement/

The United States Government. (2025b, April 16). *White House Announces Revolutionary Federal Procurement Overhaul*. The White House. https://www.whitehouse.gov/briefings-statements/2025/04/white-house-announces-revolutionary-federal-procurement-overhaul/