Assignment 2

Portfolio Optimization: A Monte Carlo Study

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Problem Description

This project focuses on optimizing a portfolio composed of four large-cap stocks: Salesforce (CRM), Cisco Systems (CSCO), Tesla (TSLA), and Lululemon Athletica (LULU). These equities were selected based on their strong market capitalization and relatively lower volatility levels, as indicated by their lower implied volatility (VIX-related) scores.

The objective is to construct an optimal portfolio that balances risk and return, taking into account the investor's risk tolerance. The expected returns and standard deviations (as proxies for risk) for each of the four large-cap stocks are as follows:

	Annual Return	**Annualized Std Dev**
CRM	20.50%	34.82%
CSCO	14.89%	25.04%
LULU	21.08%	39.76%
TSLA	46.06%	58.23%

12-Month Rolling Correlation Matrix (as of 2025-07-2025)

Ticker	**CRM**	**CSCO**	**LULU**	**TSLA**
CRM	1.00	0.53	0.31	0.47
CSCO	0.53	1.00	0.33	0.41
LULU	0.31	0.33	1.00	0.27
TSLA	0.47	0.41	0.27	1.00

Monte Carlo Methods

I used a Monte Carlo simulation to evaluate the optimal portfolio allocation by taking the following steps:

1) Generated over 10,000 random sets of portfolio weights across the four large-cap stocks for a unique allocation.
2) Each allocation then generated an expected annual return and annualized volatility based on historical daily returns over the last 10 years.
3) Volatility and expected return were plotted to reflect the best combination.
4) There are suggested portfolios that generated negative returns if there was an overallocation leading to unbalanced volatility.

Results and Conclusion

Figure 1 illustrates the return–risk trade-offs across different portfolio strategies that includes short positions and those that do not have short positions. Portfolios that include short positions achieved returns above 0.60, compared to a cap of 0.55 for long-only strategies, showing that taking on more risk can lead to higher reward. That said, allowing shorts also introduces greater downside, with losses that exceed those seen in long-only portfolios.

Based on Figure 2, the optimal portfolio is where the Sharpe ratio is maximized relative to risk and is marked by the red star. In both figures, on the left side, we see the boundary of long-only positions, representing portfolios with lower risk and more conservative returns. As we move toward the upper right, portfolios with higher risk tolerance begin to show higher potential returns, especially when short positions are allowed.

The key takeaway from the study is the following:

There has to be a tradeoff between risk and return to reach the optimal allocation across equities. To achieve higher total returns, the investor must invest in both long and short positions.

Figure 1: Portfolio Strategies (Long vs Short Positions)

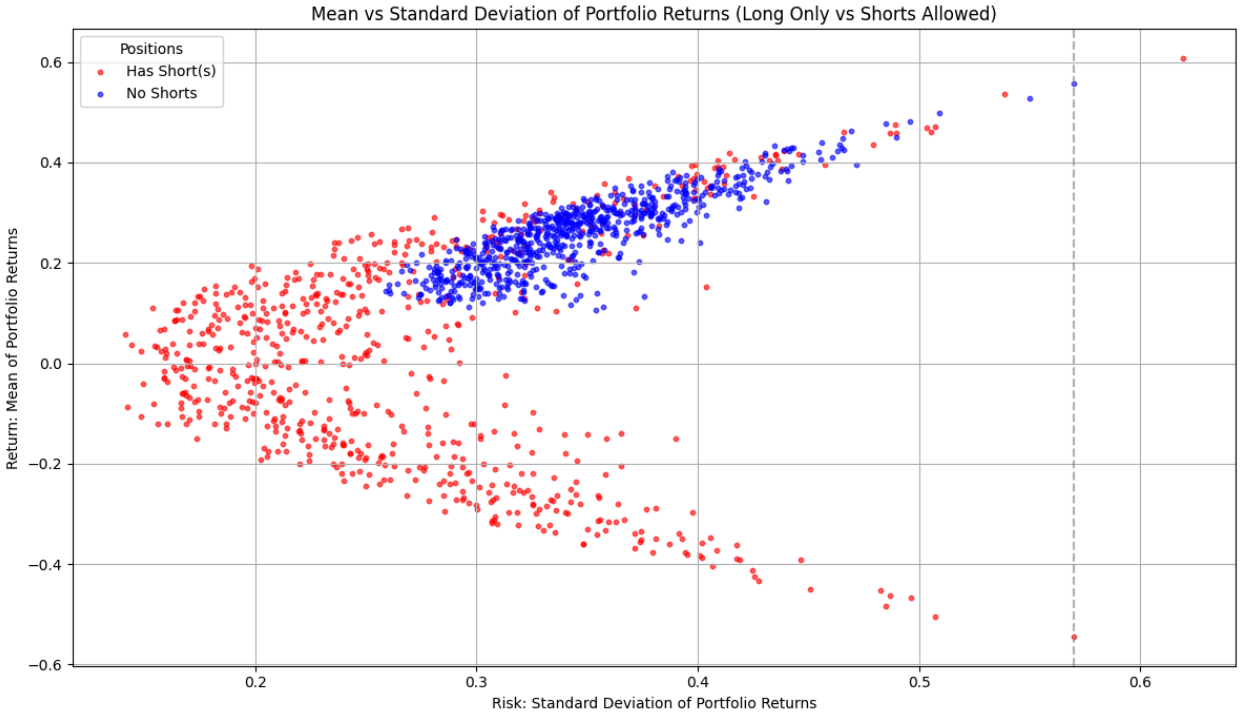
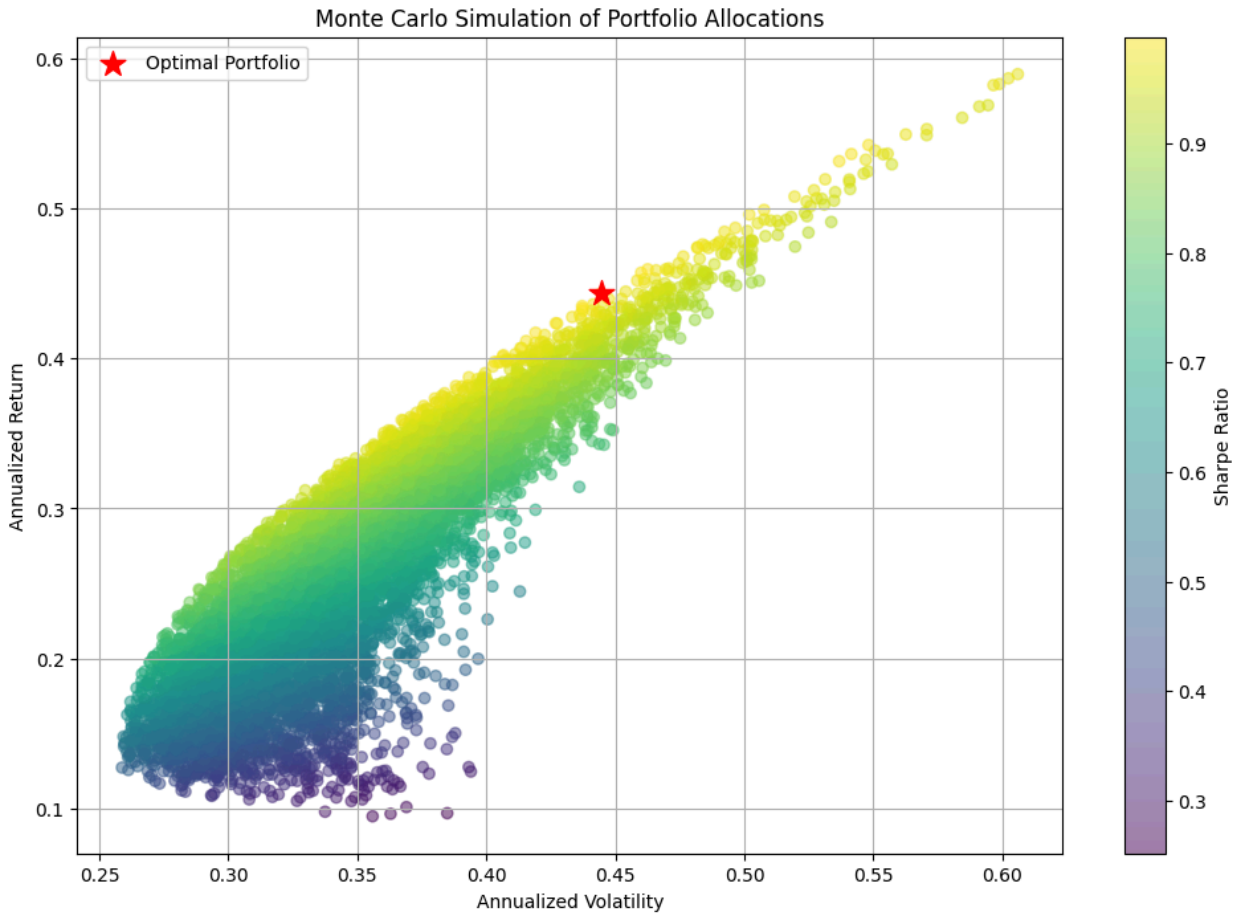


Figure 2: Optimal Portfolio Based on Monte Carlo Simulation of Portfolio Allocations



References

Miller, Dr. Tom. “Portfolio Optimization: A Monte Carlo Study.” 2025.

Ribeiro, Diogo. “Monte Carlo Simulations in Macroeconomic Modeling.” *Diogo Ribeiro*, accessed July 27, 2025. **https://diogoribeiro7.github.io/macroeconomics/simulation%20methods/quantitative%20finance/monte_carlo_simulations_macroeconomic_modeling/**