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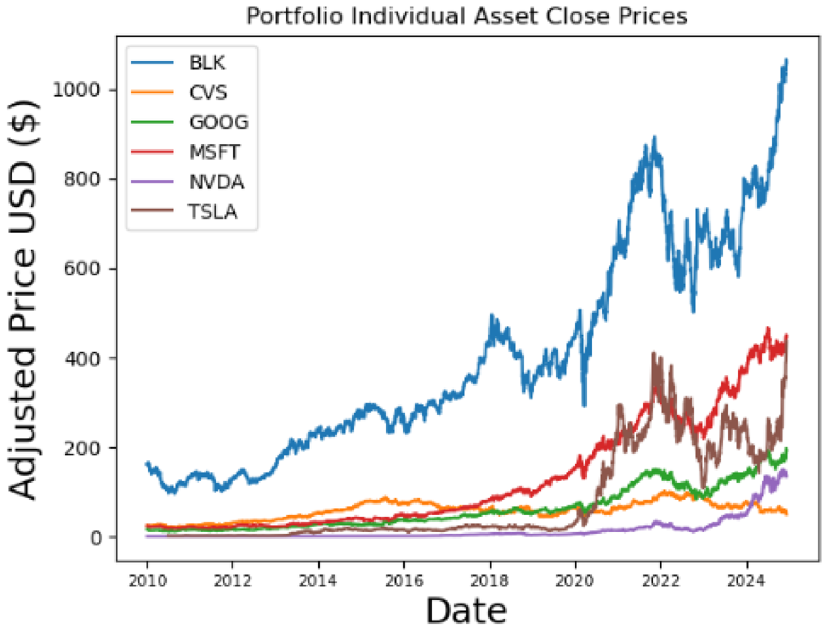
AMS 325 Final Project Report

For the AMS 325 Final Project, Isaar Chadha and I worked on a Quantitative Finance themed Portfolio Optimization Algorithm. Our motivation was our personal interests in finance, and how we can apply mathematical techniques through code to find a methodical and numerical method to investing and making calculated data-driven decisions. We used Python as our programming language of choice, and wrote the code in Jupyter Notebooks. Our primary objectives were to create a user-friendly program that collects information from the user (how many stocks they want in their portfolio, what are the stocks, what time frame of stock data do they want to consider in the model), and returns the optimal weightages of each stock, the Efficient Frontier and optimal Sharpe Ratio Combinations, portfolio risk and returns, the plot of each stock price over time, and Monte Carlo simulation of the portfolio and some sample statistics (after the user inputs starting portfolio value, number of Monte Carlo simulations to run, and how many days into the future do they want to predict returns). We used some of the commonly used packages in AMS 325 in our analysis including pandas, numpy, matplotlib, along with others, and all of the financial data we pulled from yahoo finance (yfinance). The main mathematical work done involved matrix operations, implementing covariance matrices and standard deviations for volatility, implementing Monte Carlo simulations, and using the SLSQP (nonlinear numerical optimization method) to maximize the Sharpe Ratio of our algorithm. Isaar and I both watched Quantitative Finance videos and projects on Youtube while also reading pages on Modern Portfolio Theory to get a broader understanding of how we wanted to properly implement mathematical procedures in our portfolio optimization, and we worked on the code at the same time and constantly ran, debugged, and rewrote code many times before getting the finished product. Here are some examples of the graphics observed in the output of our code, where the inputs are 6 stocks in the portfolio (CVS, BLK, NVDA, GOOG, TSLA, MSFT) in the time period 2010-01-01 to 2024-12-16 with initial portfolio value of 10,000, 100 Monte Carlo Simulations, and projected portfolio value 100 days in the future:

Stock prices over time frame



Optimal Weights & Efficient Frontier

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Optimal Weights for Maximum Sharpe Ratio:
CVS: 0.00%
BLK: 0.00%
NVDA: 7.81%
GOOG: 29.88%
TSLA: 39.81%
MSFT: 22.50%
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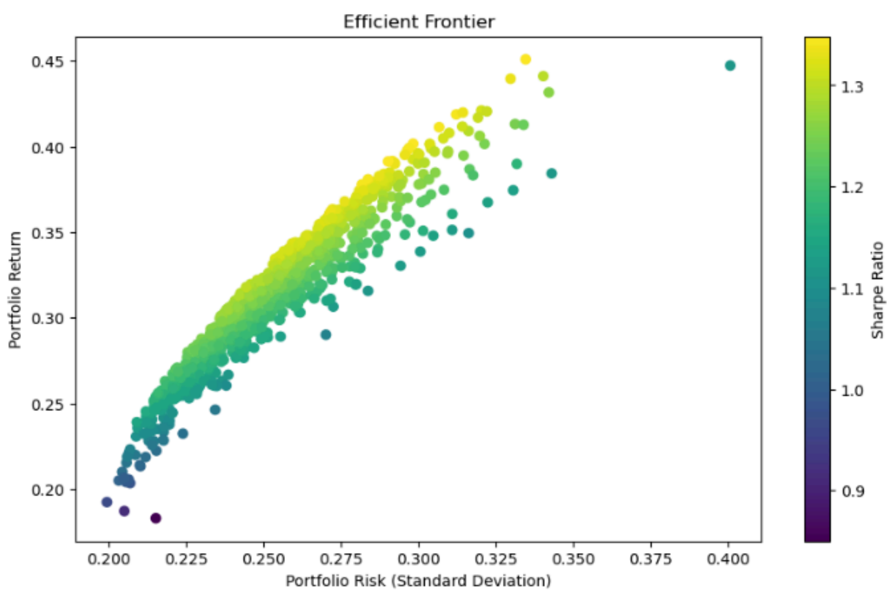

Monte Carlo Simulation

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Enter the initial portfolio value:  10000
Enter the number of Monte Carlo simulations:  100
Enter the number of days to simulate:  100
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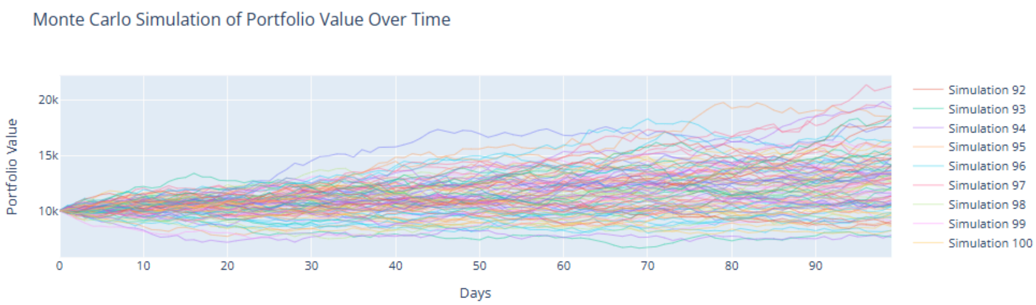


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Ending Mean Value: $12720.52
Ending Standard Deviation: $2760.62
0th Percentile: $7631.82
10th Percentile: $9393.23
20th Percentile: $10487.25
30th Percentile: $10943.20
40th Percentile: $11875.61
50th Percentile: $12736.84
60th Percentile: $13260.94
70th Percentile: $13730.22
80th Percentile: $14733.83
90th Percentile: $16132.46
100th Percentile: $21229.23
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Overall, this project was very challenging but equally rewarding. There were a lot of errors, bugs, and unexplainable outputs, but tweaking our approach for the formatting of the code and the way we carried out the analysis along with the end product made the many hours put in worth it. There was a lot of data retrieval, cleaning, and manipulation - and applying mathematical techniques through coding in the interesting world of finance to create a prototype to solve a problem commonly encountered at Investment Banks and Hedge Funds was very interesting. We can further see the emphasis on why it is important to diversify a portfolio, how there's so many ways to measure risk and return along with how to optimize a portfolio (we chose Sharpe Ratio optimization but there are many other approaches), and how to tackle the uncertainty of using past data as a basis for predicting future prices (and how so much research needs to be done to study what prior time window is optimal if at all, and how can qualitative events in the economy be measured quantitatively and predicted + captured by a model). The overall project was very interesting and enjoyable, and I enjoyed implementing math learned from linear algebra, calculus, and probability into my dream career of finance through code - and this class was beyond valuable in helping me increase my skill set and curiosity for experimenting and solving such real world problems in a coding and quantitative nature.