Monte Carlo Simulation for Stock Price & Portfolio Price Prediction

Introduction

This project implements a Monte Carlo simulation to model the future stock price of Nvidia (NVDA) and a portfolio of five stocks. The Monte Carlo method is a powerful tool for estimating future prices by simulating random paths based on historical data and key parameters such as expected return and volatility. This simulation provides a range of potential outcomes for stock prices, enabling better risk assessment and informed decision-making.

Additionally, the project calculates the 5% Value at Risk (VaR), which quantifies the potential downside risk with a 5% probability. VaR is an essential metric for evaluating the risk of loss in investments, making it a vital tool for portfolio management.

Monte Carlo Simulation: Uses and Applications

Monte Carlo simulations have several applications in finance, including:

- **Pricing of derivatives**: Simulating future prices to estimate the fair value of options and other financial products.
- **Risk management**: Assessing the probability of extreme price movements and the risk of significant financial losses.
- **Portfolio optimization**: Generating different asset combinations to maximize returns and minimize risk.

In this project, we apply the Monte Carlo simulation for both a single stock and a diversified portfolio of five stocks, allowing us to explore the range of possible price paths and potential risk.

Formula Used

The Monte Carlo simulation for stock prices is based on the following equation:

$$S_t = S_0 \cdot \exp\left(\left(\mu - \frac{\sigma^2}{2}\right)\Delta t + \sigma \cdot \epsilon \cdot \sqrt{\Delta t}\right)$$

Where:

- StS_tSt = Stock price at time ttt
- S0S_0S0 = Initial stock price (current price)

- μ\muμ = Expected return based on historical data
- σ\sigmaσ = Volatility, measured as the standard deviation of returns
- Δt\Delta tΔt = Time increment (1 day)
- ϵ\epsilonϵ = Random value from a standard normal distribution

This equation incorporates both the deterministic price movement (drift) and the randomness (volatility), allowing us to simulate different future price scenarios.

Parameters

- **Initial Price (S0S_0S0)**: The last observed price for Nvidia (or any stock in the portfolio).
- **Expected Return (μ\muμ)**: The mean of historical returns, annualized.
- **Volatility (σ\sigmaσ)**: The annualized standard deviation of returns, representing the stock's fluctuation.
- **Number of Simulations**: 1000 simulations are run to generate different possible outcomes.
- **Time Horizon**: 252 trading days (1 year).

Getting the Data from Historical Prices

Historical adjusted closing prices for Nvidia are used to calculate daily returns as follows:

$$R_t = \frac{P_t}{P_{t-1}} - 1$$

Where RtR_tRt is the daily return at time ttt, and PtP_tPt is the adjusted closing price at time ttt. The mean and standard deviation of the returns provide the expected return (μ\muμ) and volatility (σ\sigmaσ).

Value at Risk (VaR)

The 5% Value at Risk (VaR) measures the potential loss in a stock or portfolio with a 5% chance over a specific time frame. In this simulation, the 5% VaR represents the maximum potential loss with 95% confidence.

For example, if the VaR is negative (e.g., -29.75%), it means there is a 5% probability that the stock could lose 29.75% or more of its value within a year. This is crucial for risk management and helps investors understand potential downside risk in worst-case scenarios.

Monte Carlo Simulation for a Portfolio

Beyond simulating a single stock, we also applied Monte Carlo simulations to a portfolio of five different stocks. The portfolio simulation follows the same process as for individual stocks but aggregates the simulated returns for all the stocks. This approach helps demonstrate the benefits of diversification—reducing risk through exposure to multiple assets.

Results and Interpretation

The Monte Carlo simulations provide a range of potential outcomes, visualized through price paths for Nvidia and the portfolio over a one-year period. From the results, we can observe the volatility in possible price movements and the risks associated with holding NVDA or a stock portfolio.

Key Findings:

1. **Monte Carlo Simulation**: The simulated price paths highlight how the stock price can fluctuate dramatically over a year, showing a range of possible outcomes.
2. **5% VaR**: The Value at Risk metric indicated that there is a 5% probability that Nvidia's stock price could fall by 29.75% or more within a year.
3. **Portfolio Simulation**: The portfolio simulations showed a reduced level of risk compared to individual stock simulations, reinforcing the concept of diversification.

Conclusion

This Monte Carlo simulation project successfully modeled the potential future stock prices of Nvidia and a portfolio of five stocks. The simulation offers valuable insights into risk management, providing investors with a probabilistic view of future price movements and the associated risks.

Key Takeaways:

- Monte Carlo simulations can generate a range of future price scenarios, helping to understand potential outcomes and risks.
- The 5% VaR quantifies downside risk, indicating the potential loss over a specific period.
- Portfolio simulations demonstrated the advantage of diversification in reducing risk.

Future Work:

- **Expanding Portfolio Simulations**: Future simulations could include more stocks, helping to observe the impact of further diversification.
- **Stress Testing**: Incorporating different economic scenarios, such as recessions or market crashes, could provide insights into how external factors affect stock price behavior.
- **Alternative Risk Metrics**: Exploring other risk measures such as Conditional VaR (CVaR) could provide additional perspectives on extreme risk.

This project demonstrates the practical application of Monte Carlo simulations in financial analysis, showcasing both the power and limitations of these models in forecasting and risk management.