Portfolio Return Simulations

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In this application, the user can select up to three stocks and assign them a weight w_i to create a portfolio. As a comparison, the performance of the SPDR S&P 500 ETF Trust (https://finance.yahoo.com/quote/SPY/) will always be referenced, and it can also be added to the portfolio with a desired weight.

The application will generate a Monte Carlo simulation of each of the selected stocks (those in which $w_i \neq 0$), and according to the weightings of each one, it will calculate a portfolio return. The portfolio return is calculated as the weighted average of the returns of each stock separately, i.e., $r_p = w^T R$ where w^T is the transposed vector of weights and R is the vector of returns of each stock. The return of each stock is simply calculated as $p_T/p_0 - p_0$ where p_T is the stock's final price at the end of the period, and p_0 is the initial price. The period is selected as desired by the user. It is recommended to be at least five years.

Annual returns are used as the base unit of measurement in the Monte Carlo simulation. They are calculated from empirical data obtained from stock prices between December 2021 and October 2022. These returns are then used as random samples with replacements to calculate the simulated stock prices independently as many times as necessary to complete the m-year price time series the user requires.

Note: The sample period indicated above includes the short-lived bear market of 2022, which impacted various indices worldwide due to central bank interest rate hikes. For this reason, it is worth considering that these simulations are obtained from a difficult period for capital markets.

Additionally, the application allows you to start with an initial investment amount and indicate an annual amount of savings, which will be invested each year in the portfolio according to the weightings provided by the user.

The challenge

The application allows the user to set the following challenge: Find a portfolio that beats the returns of the S&P500 ETF for a given period.

We know beating the S&P500 is possible with passive stock management, but this comes at a cost. The cost has to take on more risk, as measured by a higher variance of possible portfolio returns compared to the S&P500. However, is it possible, despite this higher risk, to obtain a better return than the S&P500 and still have a lower probability of portfolio loss than the S&P500?

An example

When starting the application, some stocks and default values are provided by default so the user can generate a simulation immediately. Figure 1 shows a possible result. Since these are simulations, we will not have the same results no matter how many times we simulate with the same parameters.

Portfolio Returns Estimations

The application estimates a distribution of year-returns of the a portfolio (not-ajusted by inflation) of SPDR-S&P 500 ETF Trust, and three companies using empirical data of annual returns between December 2021 and October 2022.

Enter Stock 1 Ticker:

V

Enter Stock 2 Ticker:

MSFT

Enter Stock 3 Ticker:

AAPL

Weight for S&P500 :

0

Weight for Stock 1:

0,33

Weight for Stock 2:

0,33

Weight for Stock 3:

0,34

Initial Investment:

1

Annual savings:

0

Years of savings:

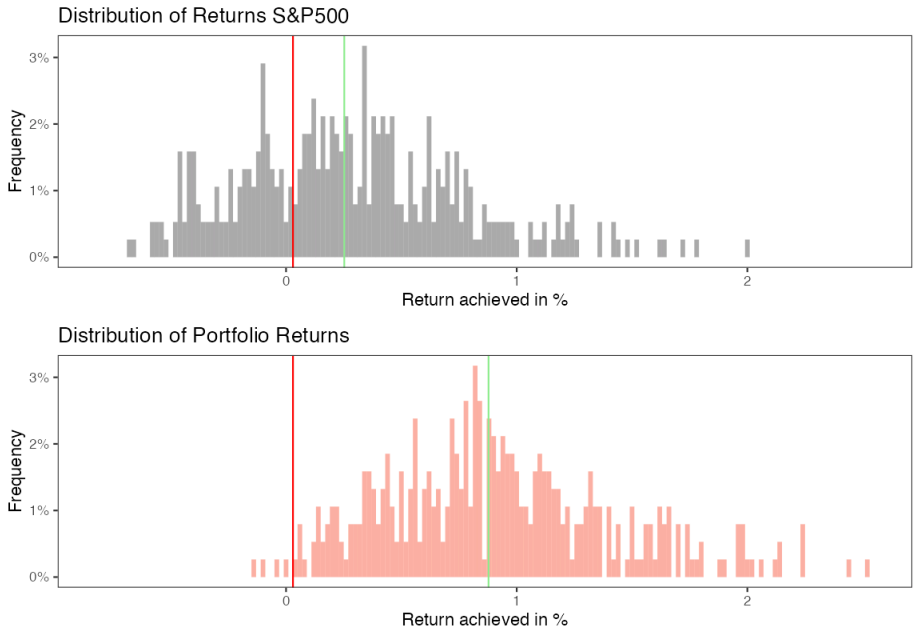
20

Minimum return required:

0,03

Calculate Portfolio Return

Indication: The red line indicates the Minimum Return Required, the green line indicates the Median of the Returns.

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Median returns S&P500 and Portfolio.    : 0.25  vs  0.88
Stand. Dev. returns S&P500 and Portfolio: 0.49  vs  0.5
Final value S&P500 and Portfolio        : 1.25  vs  1.88
Probability of losing money             : 0.22  vs  0.01
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Figure 1

Portfolio simulation with an initial investment of $1, without additional annual reinvestments, 33% in Visa (V), 33% in Microsoft (MSFT), and 34% in Apple (AAPL). No investments are included in the ETF; it is only used as a reference. The investment horizon is 20 years.

The most informative part of the simulation is the return distributions obtained from many simulations (to be exact, 800 simulations are done; this is a parameter that we cannot change in the application). For each simulation, the achieved returns of the S&P500 and the portfolio for the years indicated by the user are calculated. These returns are plotted in the histogram, representing the returns' distribution. Both distributions (of the S&P500 and the portfolio) are on the same scale, so they are comparable.

We can see that the portfolio's return distribution has higher returns than the S&P500 alone. The green lines indicate the mean returns, which for the S&P500 is 25%, while that of the portfolio is 88%. Interestingly, we see that the standard deviations of both distributions are very similar (49% and 50% respectively). In other words, not only do we achieve a better return with the portfolio, but we also do so with a minimal increase in risk. If we calculate the probability of losing money, we see that with the portfolio, it is only 1%, while with the S&P500, it is 22%! (All this information appears in the table below the graphs).

Can you find another portfolio that improves these results even more?

Note: Be sure to include the correct company tickers and that the sum of the weights always adds up to 1.