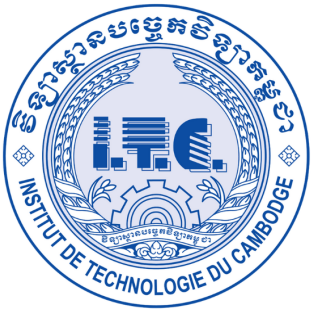

Monte Carlo Simulation in Finance Field

Numerical Analysis

I3-AMS-B

3rd year, 2nd Semester Bachelor of Applied Mathematics and Statistics

Institute of Technology of Cambodia

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Abstract
The Monte Carlo Simulation is used to estimate the probability of a certain income. As such, it is widely used by investors and financial analysis to evaluate the probable success of investments they are considering. A Monte Carlo Simulation in investing is based on historical price data on the assets being evaluated. One such uncertainty in finance and investment is volatility. Volatility will create situations where investors might have an expected return on an investment but due to the volatile nature of markets, that expectation may overshoot or undershoot anticipated returns.
Keywords: Monte Carlo

I. Monte Carlo VaR Overview

Monte Carlo Simulation can be traced back to the early 20th century. In 1901, the French mathematician Émile Borel published a paper on the use of random numbers to solve problems in probability theory. Borel's work was later extended by the American mathematician John Von Neumann, who developed the first Monte Carlo Simulation in 1946.

The name of Monte Carlo comes from the city of Monte Carlo in Monaco, which is known for its casinos. The popular usage of Monte Carlo Simulation is similar to the way that random numbers are used in gambling.

Monte Carlo Simulation is a mathematical technique that uses repeated random sampling to solve problems that would be difficult or impossible to solve using other analytical methods. It is often used in finance, engineering, and other fields to model uncertainty and to calculate probabilities.

- Finance: Monte Carlo Simulation is used to estimate the risk of financial investments. For example, a Monte Carlo Simulation could be used to estimate the probability of a stock losing money over a certain period of time.
- Engineering: Monte Carlo Simulation is used to calculate the expected value of complex systems. For example, a Monte Carlo Simulation could be used to calculate the expected lifespan of a bridge.
- Natural Sciences: Monte Carlo Simulation is used to determine the probability of natural disasters. For example, it could be used to calculate the probability of an earthquake occurring in a certain area.
- Business: Monte Carlo Simulation is used to design new products or processes. For example, it could be used to determine the optimal price for a new product.

II. Our Mission

A Monte Carlo simulation is performed by running many thousands or even tens of thousands of calculations or simulations with inputs taken at random from a predetermined distribution having a specific std deviation. This allows analysts to make probability statements such as "we expect that in 99% of cases the return over 10 years will be at least 50%" or "there is a 5% chance that this investment will lose money in the next 3 months".

III. Algorithms

Imagine you have $100,000 to invest in an ETF and you plan to retire in 30 year's time. How much would you expect to have in your retirement account assuming you can achieve 9.5% growth each year.

In theory, it is quite easy to perform the Monte Carlo Simulation. The way the method works is by following these steps:

1. Assign a random value to the variable, for which we cannot calculate the probabilities;
2. Calculate the model with this random value for the assumption;
3. Record the result;
4. Change the random value for the variable;
5. Recalculate and re-iterate for hundreds, or even thousands of times;
6. Average out the result

During each iteration of the simulation, we select random values from the distribution population of each variable.

The result of the Monte Carlo Simulation is a probability distribution, or an array of sorts, of all possible outcomes from our model. It provides a more comprehensive outlook on what may happen and how likely it is to happen.

In this project, Monte Carlo Simulation of a retirement account.

Step1: Numpy library is being used to generate a random sequence of annual growth rate

Step 2: There are 4 arguments which are the initial investment, the annual growth rate, the number of simulations and the number of years. In range of number of time Simulation, loop the each year of the investment value which is calculated by Normally Distributed with a Mean of 0.095 and a Standard Deviation of 0.15

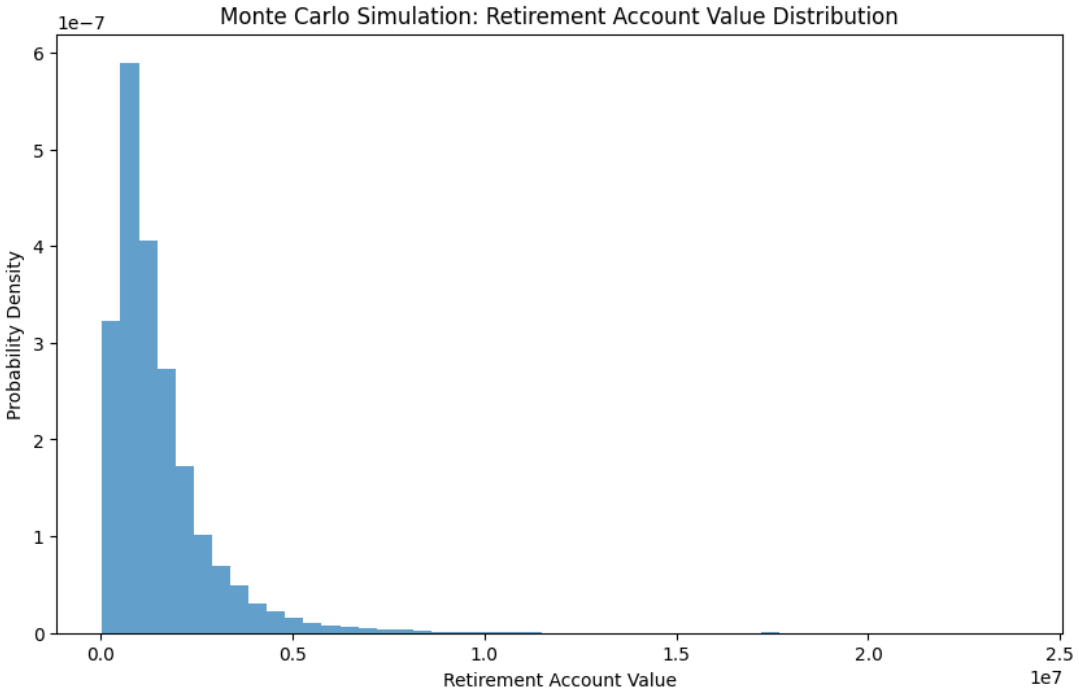
Step3: Then, this Simulation runs for 30 years and generates 10,000 different scenarios.

Step4: Last, the final value of the retirement account in each scenario is calculated by multiplying initial investment by the sequence of annual growth rates. Those final values of the investment are appended to the list of results. We will get the list of the expected value of the retirement account.

IV. Result

```python
import numpy as np

def monte_carlo_simulation(initial_investment, annual_growth_rate, num_simulations, num_years):
    results = []

    for _ in range(num_simulations):
        investment_value = initial_investment

        for _ in range(num_years):
            investment_value *= (1 + np.random.normal(annual_growth_rate, 0.15))

        results.append(investment_value)

    return results

initial_investment = 100000
annual_growth_rate = 0.095
num_simulations = 10000
num_years = 30

simulation_results = monte_carlo_simulation(initial_investment, annual_growth_rate, num_simulations, num_years)

expected_value = np.mean(simulation_results)
print("Expected retirement account value:", expected_value)
```

The output of the result is `1532330.7013146123`.



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