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## Monte Carlo Analysis



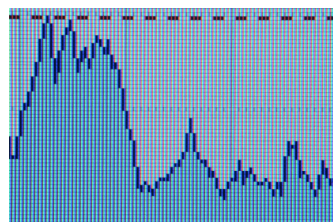
When you sit down with a financial professional to update your retirement plan, you're likely to encounter a Monte Carlo simulation, a financial forecasting method that has become popular in the last few years. Monte Carlo

simulations project and illustrate the probability that you'll reach your financial goals, and can help you make better-informed investment decisions.

### Estimating investment returns

All financial forecasts must account for variables like inflation rates and investment returns. The catch is that these variables have to be estimated, and the estimate used is critical to a forecast's results. For example, a forecast that assumes stocks will earn an average of 4% each year for the next 20 years will differ significantly from a forecast that assumes an average annual return of 8% over the same time period.

Estimating investment returns is particularly difficult. For example, the volatility of stock returns makes short-term projections almost meaningless. Multiple factors influence investment returns, including events such as natural disasters and terrorist attacks, which are unpredictable. So, it's important to understand how different forecasting



methods handle this inherent uncertainty.

### Basic forecasting methods

Straight-line forecasting methods assume a constant value for the projection period. For example, a straight-line forecast might show that a portfolio worth \$116,000 today would have a future value of approximately \$250,000 if the portfolio grows by an annual compounded return of 8% for the next 10 years. This projection is helpful, but it has a flaw: In the real world, returns aren't typically that consistent from year to year.

Forecasting methods that utilize "scenarios" provide a range of possible outcomes. Continuing with the 10-year example above, a "best-case scenario" might assume that your portfolio

will grow by an average 12% annual return and reach \$360,000. The "most-likely scenario" might assume an 8% return (for a \$250,000 value), and the "worst-case scenario" might use 4%, resulting in a final value of roughly \$171,000. Scenarios give you a better idea of the range of possible outcomes. However, they aren't very precise in estimating the likelihood of any specific result.

Forecasts that use Monte Carlo analysis are based on computer-generated simulations.

You may be familiar with simulations in other areas; for example, local weather forecasts are typically based on a computer analysis of national and regional weather data. Similarly, Monte Carlo financial simulations rely on computer models to replicate the behavior of economic variables, financial markets, and different investment asset classes.



### Why is a Monte Carlo simulation useful?

In contrast to more basic forecasting methods, a Monte Carlo simulation explicitly accounts for volatility, especially the volatility of investment returns. It enables you to see the spectrum of thousands of possible outcomes, taking into account not only the many variables involved, but also the range of potential values for each of those variables.

By attempting to replicate the uncertainty of the real world, a Monte Carlo simulation can actually provide a detailed illustration of how likely it is that a given investment strategy will meet your needs. For example, when it comes to retirement planning, a Monte Carlo simulation can help you answer specific questions, such as:

- Given a certain set of assumptions, what is the probability that you will run out of funds before age 85?
- If that probability is unacceptably high, how much additional money would you need to invest each year to decrease the probability to 10%?

### The mechanics of a Monte Carlo simulation

A Monte Carlo simulation typically involves hundreds or thousands of individual forecasts or "iterations," based on data that you provide (e.g., your portfolio, timeframes, and financial

goals). Each of these individual iterations draws a result based on the historical performance of each investment class included in the simulation.

Each asset class--small-cap stocks, corporate bonds, etc.--has an average (or mean) return for a given period. Standard deviation measures the statistical variation of the actual returns of that asset class around the average for that period. A higher standard deviation implies greater volatility. The returns for stocks have a higher standard deviation than the returns for U.S. Treasury bonds, for instance.

There are different types of Monte Carlo computational methods, but each generates a forecast that reflects the variable patterns of investment returns. Software modeling stock returns, for example, might produce a series of annual returns such as the following: Year 1: -7%; Year 2: -9%; Year 3: +16%, and so on. For a 10-year projection, a Monte Carlo simulation will produce a series of 10 randomly generated returns--one for each year in the forecast--based on the model's inputs. A separate series of random returns is generated for each iteration in the simulation.

#### Monte Carlo simulation output and use

Monte Carlo applications run multiple iterations; the combined iterations are considered a simulation. Each program has its own method of presenting results, but most provide numerical and graphical outputs. A graph of a Monte Carlo simulation might appear as a series of statistical "bands" around a calculated average.

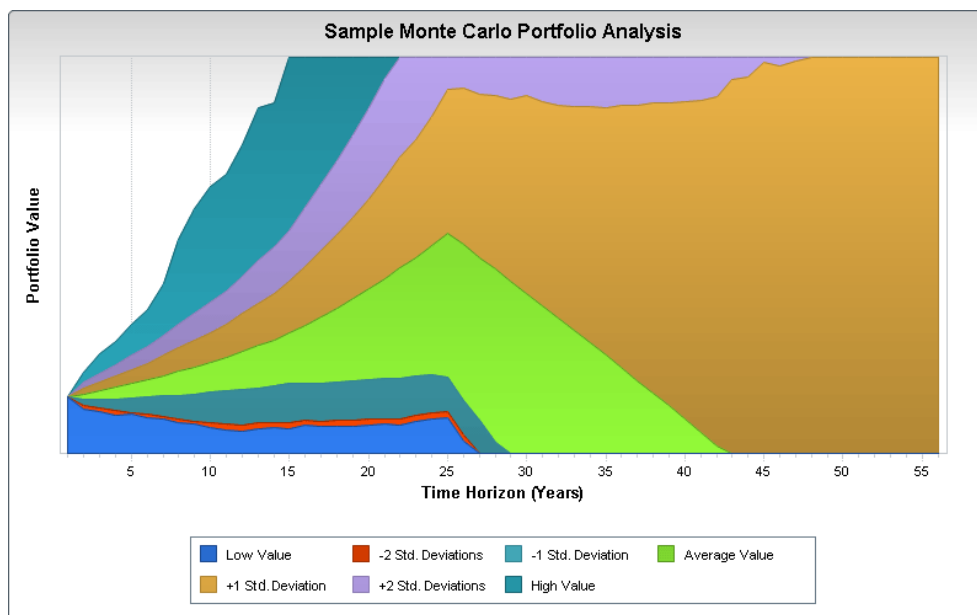
**Example:** Let's say a Monte Carlo simulation performs 1,000 iterations using your current retirement assumptions and investment strategy. Of those 1,000 iterations, 600 indicate that your assumptions will result in a successful outcome, while 400 iterations indicate that you will fall short of your goal. The

*simulation tells you that you have a 60% chance of successfully meeting your retirement goals.*

#### Pros and cons of Monte Carlo

A Monte Carlo simulation illustrates how your future finances might look based on the assumptions you provide. However, it could prove incorrect--that's the nature of a forecast. How many times have you left home without an umbrella because the local meteorologist said there was only a 30% chance of rain, only to be soaked in a downpour? It's the same with a Monte Carlo simulation. A Monte Carlo projection might show a very high probability that you'll achieve your financial goals, but it can't guarantee that outcome.

However, a Monte Carlo simulation is an important tool because it can illustrate how changes to your plan can affect the likelihood of achieving your goals. Combined with periodic progress reviews and plan updates, Monte Carlo forecasts can help you make better-informed investment decisions to keep your financial goals on track.



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