# Investment Planning Answer Book by Jay L. Shein, Q 12:1, What is Monte Carlo Simulation?

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Monte Carlo Simulation (MCS) is a statistical method that simulates probable outcomes by attempting to model real world situations. Monte Carlo Simulation is used across many different fields such as physics, business, and finance. MCS is used to simulate the uncertainty that may be extremely complex to reproduce mathematically. It answers the question about what is most probable to occur in the future. Monte Carlo Simulation can be used to model retirement planning and peer group analysis of money managers. It is also valuable for evaluating cash flows and variable rates of return investors may be subject to over a lifetime or specific time horizon. No one formula can model the range of possible outcomes when portfolios are not growing on a linear basis while also subject to spending withdrawals and contributions. MCS will not give an exact value of a portfolio at any specific time, but it will indicate the possible range of these values and the probability of that range.

# Investment Planning Answer Book by Jay L. Shein, Q 12:2, How does Monte Carlo Simulation work?

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Monte Carlo Simulation uses the concept of randomly drawing numbers. Random numbers can be generated by Monte Carlo software programs or even Excel. With MCS, the advisor is looking to draw from the various possible random ordering of returns over a period of time and model those possible outcomes with a log normal distribution. By calculating hundreds or even thousands of possible ordering of returns, the advisor and investor can evaluate whether an investment portfolio will last over the investor's lifetime based on the number of withdrawals and contributions.

A simple example of random number selection and ordering of returns is as follows.

**EXAMPLE 12-1**

Suppose there were only 21 possible return scenarios ranging from −10 percent per year to 10 percent per year. The following Table 1 is an example of three random draws over a ten year period.

**Table 1**

| *Year* | *Trial one* | *Trial two* | *Trial three* |
|---|---|---|---|
| 1 | 3 | 4 | 3 |
| 2 | 6 | 7 | 4 |
| 3 | −4 | 6 | 8 |
| 4 | 10 | −4 | −2 |
| 5 | −2 | 10 | −9 |
| 6 | 0 | 8 | 10 |
| 7 | −9 | 7 | 5 |
| 8 | 8 | −8 | −10 |
| 9 | 7 | 4 | 9 |
| 10 | 4 | 8 | 8 |

In Table 1, the ordering of returns is different for each trial. This is typical of what we might see with random number generation. With MCS, this random number generation typically would be performed a thousand or more times with each time producing a trial. The contribution and withdrawal stream in dollars would be used with each trial to determine how many times it was successful and how many times it failed. This would then allow the calculation of the probability of the objectives being met.

If the objective was to have sufficient funds so that the portfolio value was zero at the death of a particular investor, the Monte Carlo Simulation method would sum the amount of times the investor's assets lasted through their retirement stage and tally the number of times this did not hold true. If a simulation had more than zero dollars at the end of the period, that simulation would be considered a success, and if there was zero dollars or less which would indicate that more money is needed, that simulation would be deemed a failure. When the successful outcomes are tabulated and compared with the unsuccessful ones, the advisor can observe the chance of the assets lasting through the time period specified. For example, if there were 2,000 trials with 500 of them having zero dollars or less and 1,500 of them having more than zero dollars, then the chance of the portfolio lasting over the specified time period would be 75 percent.

# Investment Planning Answer Book by Jay L. Shein, Q 12:3, What is an example of the timing of the withdrawals from a portfolio that Monte Carlo Simulation (MCS) can help answer?

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The following Timing Risk Example demonstrates the negative and positive effects of the variability of returns over periods of time and how this can impact the terminal value of a portfolio. Returns Series #1 is actual returns of the S&P 500 from 1973-1982. Returns Series #2 is simply reversing the ordering of those returns. Returns Series #3 is explained in the chart. This example assumes a beginning portfolio of $1,100,000 with annual withdrawals of $100,000.

**EXAMPLE 12-2**

## TIMING RISK EXAMPLE

Each of these three return series have the same compound annual return.
**Series #1 & #2 are the same returns, but in the opposite order.**
**Series #3 assumes the exact same compound return each year as most traditional planning tools.**
*If you have no contributions or withdrawals, the* ***ending results are the same****. However, once you factor in additional savings or withdrawals (as in any financial plan),the series with the best or worst result is dependent on the order of returns and your unique inputs.*

| | |
|---|---|
| $ 1,100,000 | Starting portfolio value |
| $ (100,000) | Annual withdrawal |

| | Return Series #1 | | Return Series #2 | | Return Series #3 | |
|---|---|---|---|---|---|---|
| | | *Year End Value* | | *Year End Value* | | *Year End Value* |
| Starting Value: | | $ 1,100,000 | | $ 1,100,000 | | $ 1,100,000 |
| 1973 Year 1 | -14.7% | $ 838,300 | 21.4% | $ 1,235,400 | 6.7% | $ 1,073,700 |
| 1974 Year 2 | -26.5% | $ 516,151 | -4.9% | $ 1,074,865 | 6.7% | $ 1,045,638 |
| 1975 Year 3 | 37.2% | $ 608,158 | 32.4% | $ 1,323,122 | 6.7% | $ 1,015,696 |
| 1976 Year 4 | 23.8% | $ 652,900 | 18.4% | $ 1,466,576 | 6.7% | $ 983,747 |
| 1977 Year 5 | -7.2% | $ 505,891 | 6.6% | $ 1,463,370 | 6.7% | $ 949,658 |
| 1978 Year 6 | 6.6% | $ 439,280 | -7.2% | $ 1,258,008 | 6.7% | $ 913,285 |
| 1979Year 7 | 18.4% | $ 420,108 | 23.8% | $ 1,457,413 | 6.7% | $ 874,476 |
| 1980 Year 8 | 32.4% | $ 456,223 | 37.2% | $ 1,899,571 | 6.7% | $ 833,065 |
| 1981 Year 9 | -4.9% | $ 333,868 | -26.5% | $ 1,296,185 | 6.7% | $ 788,881 |
| **1982 Year 10** | 21.4% | **$ 305,316** | -14.7% | **$ 1,005,646** | 6.7% | **$ 741,736** |
| | | | | | | |
| Compound Return: | | 6.7% | | 6.7% | | 6.7% |
| Average Return: | | 8.7% | | 8.7% | | 6.7% |
| Standard Deviation: | | 21.3% | | 21.3% | | 0.0% |

**This could be termed the variance drain**

Monte Carlo Simulation tests hundreds or even thousands of these ordering of returns on a random basis. As can be seen by the Timing Risk Example, the ordering of returns can drastically affect the outcome when withdrawals from a portfolio are being made. The ordering of returns is much more important than the average return. Timing of contributions to a portfolio can also significantly affect the outcome of the portfolio value. In this Timing Risk Example, the risk would be exacerbated if the required annual withdrawals had to increase each year to compensate for increases in cost of living. Some investors may also want their portfolio beginning value purchasing power to be maintained which can make it much more difficult to reach their goal.

## Investment Planning Answer Book by Jay L. Shein, Q 12:4, What are some of the important inputs for Monte Carlo Simulation analysis?

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In order for Monte Carlo Simulation software to calculate the probabilities of expected outcome, some assumptions have to be made. Two of these assumptions are the expected return of the portfolio and the standard deviation of the portfolio. MCS is assuming a normal bell-shaped curve regarding the possible future returns. Assumption of a higher standard deviation will provide a wider range of possible outcomes in any one specific year. Typically, at least two standard deviations are assumed as the maximum range which would represent approximately 95 percent of the possible results. There is always a risk that some of the possibilities are not included when only two standard deviations are used.

## Investment Planning Answer Book by Jay L. Shein, Q 12:5, Should mortality risk be part of Monte Carlo Simulation (MCS)?

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Some advisors like to incorporate mortality risk into their MCS analysis for retirement planning scenarios. One of the unknowns when planning for retirement is a client's mortality. Each person has a different probability of living any specific length of time. When there are two people in the household that are part of the retirement planning process, the joint probability of any one of the two living longer than any one of them alone is greater. If mortality risk is incorporated, the analysis may be more accurate. However, some advisors may take a more conservative approach such as assuming that all parties live to at least the age of one hundred. Assuming too short of a life span may be disastrous in a retirement plan as the investors may outlive their money. Being too conservative and assuming investors will live to a very old age can reduce the present lifestyle for the investors as they may spend less in order to provide for the future. Modeling mortality risk may at least give a better idea of the potential future outcomes.

## Investment Planning Answer Book by Jay L. Shein, Q 12:6, What are the basic steps for the Monte Carlo Simulation (MCS) process?

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The basic steps in the MCS process are as follows:

- A series of variables are determined. These variables would include portfolio beginning value, asset allocation, the cash flows in and out of the portfolio, and the desired ending portfolio value.
- A probabilistic simulation with many different return series is calculated.
- With completion of each simulation, the returns are derived and the ending value of the portfolio is established.
- The process begins again from the beginning generating another unique set of returns for the next time period.
- The calculations continue for the required number of simulations.
- The probability of success is computed for all the simulations looking at how many times goals were accomplished.

## Investment Planning Answer Book by Jay L. Shein, Q 12:7, What are some of the different Monte Carlo Simulation methods?

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In the context of retirement planning, MCS is being used to project the range and average possible outcomes. The most typical methods of Monte Carlo Simulation include parametric, nonparametric, and economic models. The most commonly used is the parametric form. Other ways besides MCS that are used to project retirement planning outcomes include linear forecasting and short fall probability. Monte Carlo Simulation is used primarily because risk exists. MCS helps evaluate the tradeoffs between risk and return without the limitations inherent to a linear forecasting model. To perform a Monte Carlo Simulation, an average expected outcome which is a linear forecast must be determined. The parametric method puts a range around the expected return which is variable. Typically, a normal distribution is assumed. The mean and standard deviation would be the inputs with the standard deviation setting the variability for the range. With linear assumptions of returns for the whole time period, the investor is assuming that returns are the same each year. This will tend to provide a more positive view of the future although probably more unreliable. MCS should use as many variables as possible in order to provide the information for better decision making.

## Investment Planning Answer Book by Jay L. Shein, Q 12:8, How many trials should be used with a Monte Carlo Simulation?

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It is most likely best to use a minimum of one thousand trials. Advisors will probably find that increasing to two or three thousand trials will give them a more accurate probability distribution. Increasing the trials to four or five thousand will probably have an insignificant change in the outcomes. There is no hard and fast rule on how many trials should be run. Advisors can experiment with the number of trials with various client scenarios. More trials should be run when there are a greater number of variables that are a part of the calculation.

## Investment Planning Answer Book by Jay L. Shein, Q 12:9, What will Monte Carlo Simulation not do?

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Monte Carlo Simulation will not help improve an already dire investor's situation. It cannot overcome the volatility of the capital markets, it will not help an investor retire at an earlier age, it will not keep an investor from running out of money before he runs out of life, and it will not keep an investor from losing money.

# Investment Planning Answer Book by Jay L. Shein, Q 12:10, What is wrong with the deterministic forecasting models?

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Deterministic models, which are also known as linear forecasting models, can give advisors and investors a false sense of security. For instance, an advisor could use a linear forecasting model which would give a single ending portfolio value that shows that the investor meets their goals while a Monte Carlo Simulation might show that the investor only reaches their goals 60 percent of the time. Probabilistic models such as MCS can help fine tune cash flow and retirement planning. Deterministic models tend to overstate an investor's probability of succeeding and at the same time do not show how bad the results may be. In models that are linear, higher expected returns will always give a better outcome. With the linear model, an investor might include that investing in more stocks is more likely to give them a better result. But with a Monte Carlo approach, investing in higher risk assets may increase the upside potential and at the same time increase the probability of having no money left in the end. This tradeoff between risk and return can be demonstrated in the following manner. Most would agree that the expected return on stocks is higher than bonds even though that may not always be true. There is a potential cost to this risk return tradeoff. Hypothetically, over a long period of time, bonds may fall 1.25 percent below their expected return while stocks might fall 3.5 percent below their expected return. While increasing the allocation to stocks could increase the probability of higher returns, stocks have a greater uncertainty about the future returns; therefore, there is a much greater possibility of earning much less than expected on stocks.

# Investment Planning Answer Book by Jay L. Shein, Q 12:11, What might a Monte Carlo Simulation look like?

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A sample of what information might be gleaned from a Monte Carlo Simulation is as follows using these inputs:

- Starting portfolio value: $2,000,000.
- Expected returns: 7.8 percent.
- Standard deviation: 9.5 percent.
- Investor retires in current year.
- Retirement income stream increases 3 percent per year.
- Retirement income withdrawals are $100,000 per year for 30 years, adjusted for inflation at 3 percent per year.
- Assume a 95 percent confidence level.

Table 1 shows what the output might look like with the input assumptions. Like all Monte Carlo Simulations, they are hypothetical in nature and do not purport to be predictive of the future.

| ***Table 1*** | ***Year 1*** | ***Year 8*** | ***Year 15*** | ***Year 22*** | ***Year 30*** |
|---|---|---|---|---|---|
| Best Case Scenario | $2,586,000 | $4,986,000 | $8,274,000 | $14,254,000 | $24,968,000 |
| Expected Value | $2,048,000 | $2,356,000 | $2,644,000 | $2,844,000 | $2,592,000 |
| Worst Case Scenario | $1,640,000 | $988,000 | $300,000 | $0 | $0 |
| Chances of Assets Lasting | 100% | 100% | 99% | 89% | 71% |

The output from the simulation as contained in Table 1 indicates that the investor's objectives have a high probability of not lasting in later years. The probability of meeting their retirement goal from years 1-15 is extremely high. In subsequent years, the probability declines, and the investor may not meet their goals and could run out of money. The investor could deal with this in a multitude of ways such as the following: they could work longer before beginning retirement and save more, they could spend less in retirement, they could design a more aggressive portfolio with its attendant risks, and/or they could make a different assumption for inflation (where a lower assumption would improve their chances for success, and a higher inflation rate would decrease their chances for success). Different software programs or spreadsheets will give somewhat different outputs, but all of them will provide essentially the same information answering the following question in a hypothetical manner: Can the financial objectives of the investor be met?

## Investment Planning Answer Book by Jay L. Shein, Q 12:12, What are some of the limitations of the Monte Carlo Simulation outcomes?

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Monte Carlo Simulation gives an average outcome which is the one with the highest probability of being realized and a range of possible outcomes with smaller probabilities of being realized than the average. But like many statistics, caution should be taken when interpreting averages. For example, if it takes someone 60 minutes on average to get to work each day and she leaves for work exactly 60 minutes before she is required to arrive, she will be late half of the time. This shows how averages might be misleading.

Because MCS uses random returns, some critics argue that the results should not be relied upon too much. Because the future behavior of the markets may be different from the simulation or may not be representative of what the investor actually experiences over their lifetime, the validity and reliability of MCS has been brought into question. Other variables are that investors usually do not spend the amounts that they predict when they retire and tax laws change frequently over the investor's lifetime. Another limitation of MCS: the return distributions are assumed to be normal when they may not be. These and other possible unknown factors may not be accounted for in Monte Carlo Simulation.

Monte Carlo Simulation is trying to project the future which is not an easy task. No one knows the future, and past performance and predictions of expected future performance are unreliable and unknowable. MCS produces many outcomes and variables that can help investors make more informed decisions, but it does not help them make perfect decisions.