Monte Carlo Simulations – Details Matter

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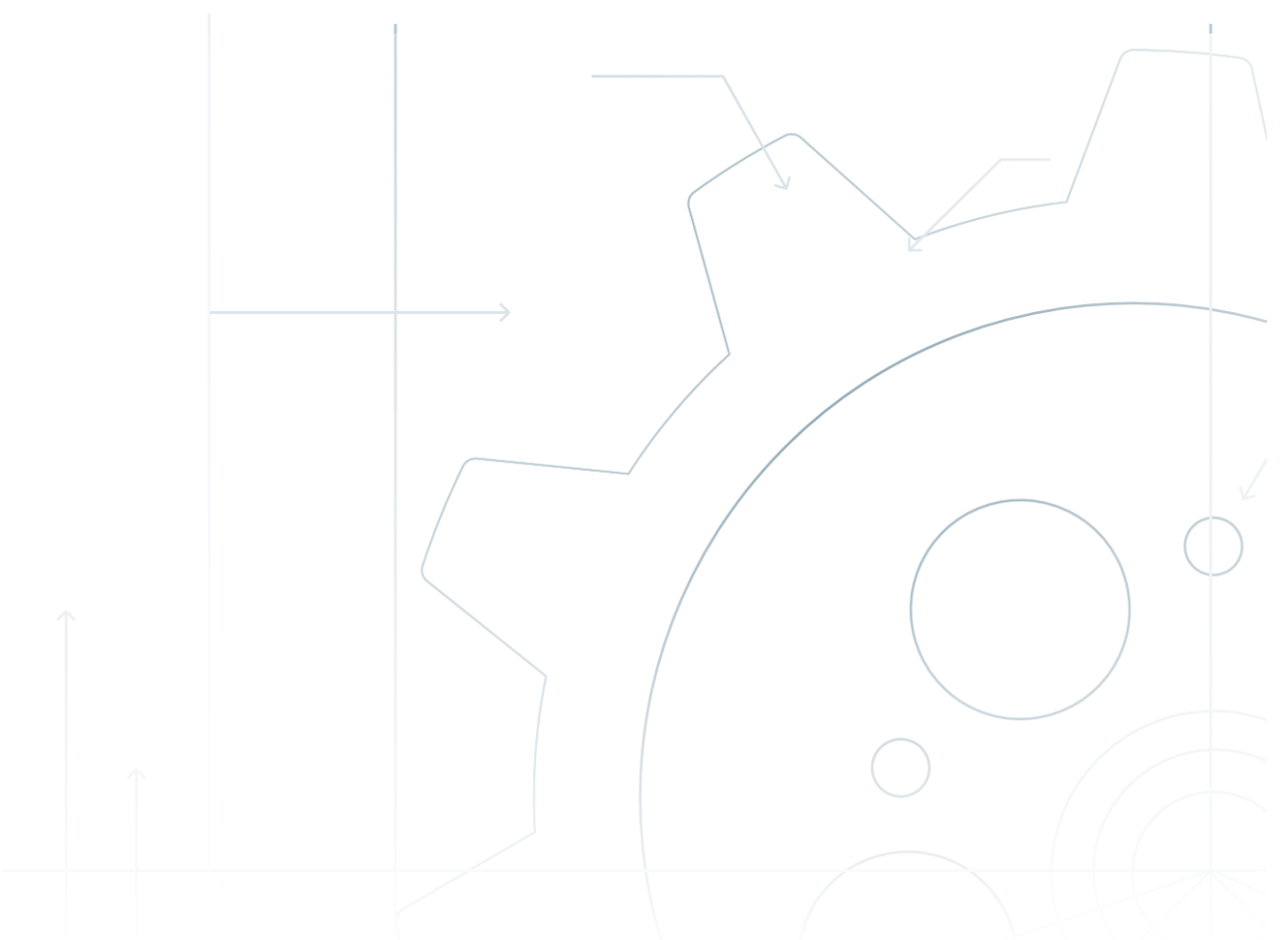

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Monte Carlo Simulations – Details Matter

Monte Carlo simulations are an important aspect of testing the viability of a client's financial plan. Unfortunately, the Monte Carlo engines in standard financial planning software are based on the overly-academic Random Walk[1] model that leads to unrealistic long-term volatility profiles at odds with historical data. The result is a distorted analysis of the client's financial plan with an artificially wide distribution of returns, calling into question the usefulness of the activity itself or potentially causing a client to change their financial plan and/or lifestyle unnecessarily. Fortunately, within Nebo, we correct for these flaws to provide a more realistic and useful assessment of a client's financial plan.

Random Walk versus Reality

Burton Malkiel in his famous (or infamous) 1973 book "A Random Walk Down Wall Street" popularized the Random Walk approach to markets. Unfortunately, once something becomes established in academia, correcting these errors is difficult and takes time. Reliance on academic theory has the patina of safety, but the devil has always been in the details. The Random Walk ignores the importance of valuations which are strongly correlated to future returns. Another crucial detail that the Random Walk model gets wrong is that it over-predicts long-horizon volatility for stocks and under-predicts long-horizon volatility for bonds, ignoring what we have observed in markets over the last 100 or so years as well as common-sense intuition about how valuations relate to expected future returns. This distorts the analysis of the financial plan and can lead to placing clients into inappropriate portfolios or causing them to change their plan and/or lifestyle. All due to an over-reliance on outdated and unrealistic Monte Carlo simulations.

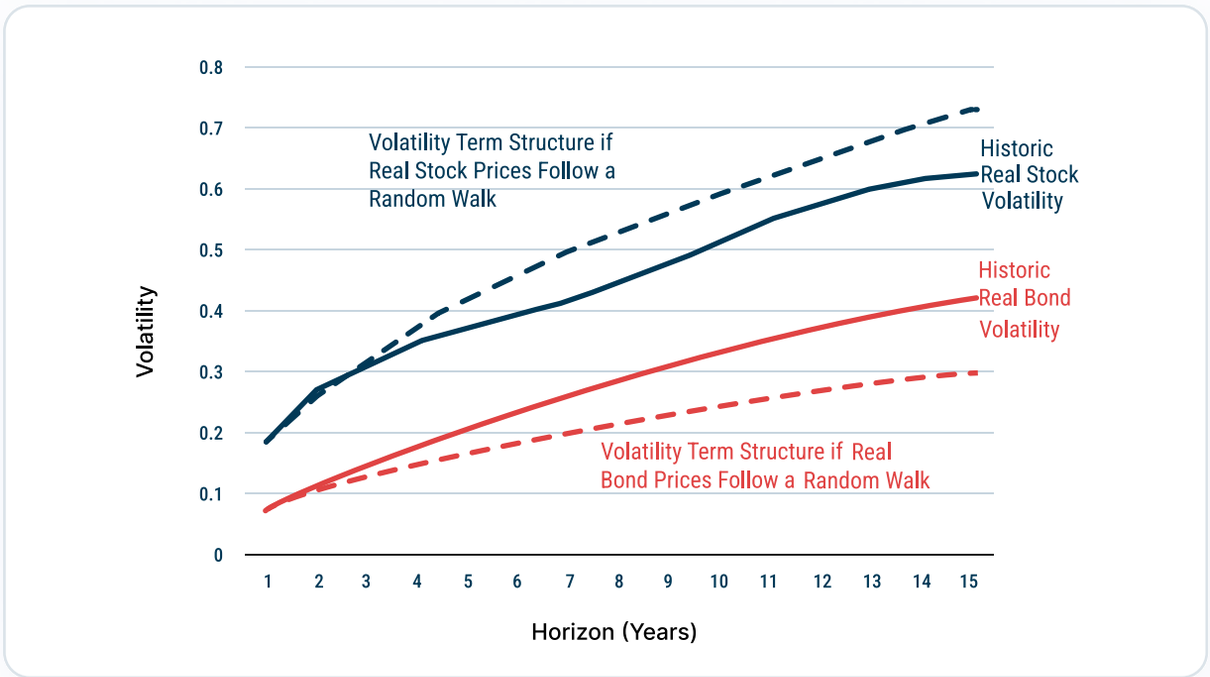
How Mean Reversion Impacts Monte Carlo Simulations

Standard financial planning tools assume asset prices follow a "Random Walk." The dashed lines in Graphic 1 illustrate how the volatility of real returns for stocks and bonds changes with horizon given a random walk assumption – the classic "square root of time" signature. The problem is that the empirical volatility based on the past century of US market data, which is shown in the solid lines, is inconsistent with the Random Walk model.[2] Clearly, real bond volatility rises more rapidly with horizon than predicted by the Random Walk. By contrast, real stock volatility rises less rapidly with horizon than predicted by the Random Walk. In other words, the Random Walk underestimates the long run volatility of bonds and overestimates the long run volatility of stocks.

1 The "Random Walk" assumes asset prices have no memory, i.e., their return in one period is completely independent of their return in another.

2 This finding is by no means unique to the US financial markets. The basic pattern exists across the stock and bond markets where we have real return data going back far enough to be able to reasonably calculate 15-year return volatilities.

Graphic 1



What is going on here? We believe this is related to the forces of mean reversion. For stocks, if you have a loss in one period your expected return for the next period increases.[3] Similarly, a very strong gain in one period portends lower expected returns in the next. This overall effect reduces volatility relative to the Random Walk method which assumes returns in one period are independent of the next.[4]

With bonds, as is typically the case, it is more complicated. First, it is not Mean Reversion per se that is the driving force, but the related concept that expected returns change over time. Second, since what we care about are real returns, inflation plays a crucial role. When you have unanticipated inflation, like we did in 2022, bonds deliver a loss in real terms which is a permanent impairment of capital, i.e., a loss you will never get back. This lowers your expected return for that bond. Similarly, inflation that is lower than anticipated delivers a positive real return increasing the overall expected return of the bond. The forces here in bonds are the opposite of what we see in stocks – your forecast error and subsequent expected return are positively correlated (whereas with equities they are negatively correlated), and importantly these forces cause your expected returns to change. The Random Walk[5] completely ignores this reality.

3 This assumes fundamentals do not change materially, which has generally been the case. Historically the volatility of stock returns has been far higher than the volatility of their underlying fundamentals, as described in Robert Shiller's "The Volatility of Stock Market Prices" Science, 235 (January 1987) pp 33-37 among other articles.

4 The implication of the Random Walk's "no memory" orientation is that the variance of multi-period returns scale linearly with your investment horizon whereas Mean Reversion's variance will scale less quickly.

5 Further reading can be found here: Investing for Retirement II: Modeling Your Assets

The Practical Implications: A Case Study

As investors, Mean Reversion and how it impacts returns and portfolios has been part of our DNA since GMO was founded in 1977. Applying this understanding to Monte Carlo simulations has a significant impact on their ability to accurately assess the viability of financial plans.

To illustrate, we consider a 60-year-old with 5 years to retirement at age 65, and longevity of 91. The goal here is to contrast Nebo's mean-reversion based Monte Carlo simulation with a traditional Random Walk Monte Carlo simulation. In this case we use identical glide paths based on the same expected returns,[6] volatilities and correlations used by our fictional ACME Advisors. These glide paths are constructed using Nebo's multiperiod shortfall optimization based on the common sense notion that risk, rather being a synonym for volatility, is "not having the money you need, when you need it." This allows us to isolate the impact of how each method models the volatility term structure.

The results of the Monte Carlo simulations are shown in Table 1. The results in the left column (MR) are based on the Nebo Monte Carlo engine, and the results in the right column (RW) are based on Random Walk Monte Carlo simulations

Table 1

MEAN REVERSION VERSUS RANDOM WALK

The impact of using a flawed Monte Carlo analysis

Long Term	Mean Reversion	Random Walk
Prob of success (Wealth > 0) at age 91	86%	78%
Median Weath at age 91 (current dolars)	$ 474.769	$ 467,794
95th percentile at age 91 (current dolars)	$ 1.969.364	$ 2,773,182
5th precentile at age 91 (current dollars)	$ (198,511)	$ (316,871)
Avg. Median Wealth in Retirement (current dolars)	$ 541.135	$ 540,605

Short Term	Mean Reversion	Random Walk
1 Year Drawdown (Bottom 5th percentile)	$ 137,359	136,889
1 Year Drawdown (Bottom 1st percentie)	$ 193,847	$ 189,965
1 Year Weath Volatilty	17%	$ 17%

To start, notice at the bottom of the table that there is not much difference between the volatility profiles at short horizons. This is not a surprise because, as is clear from Graphic 1, the volatilities at one year match. This result emphasizes that the impact of how you model the volatility term structure has an increasingly dramatic effect as horizon increases.

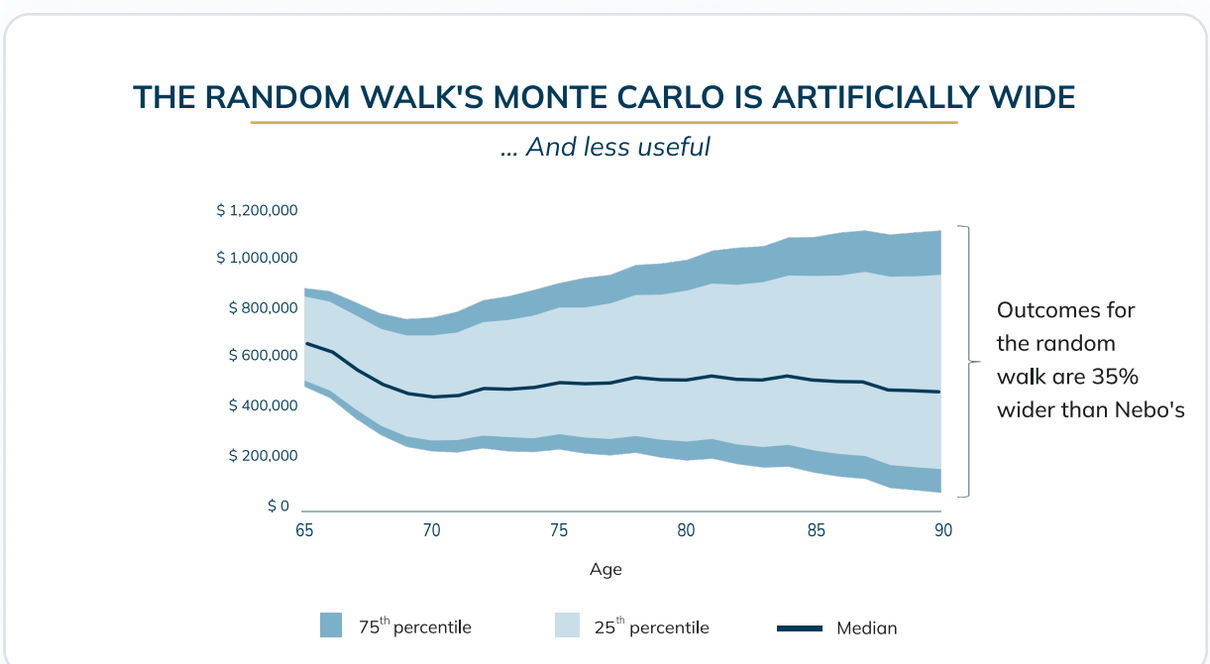
6 Here we are using constant expected returns, which means that the current expected return is equal to the long run average. This isolates the impact of model in g the term structure of volatility differently than what is assumed in the Random Walk.

The long horizon results are shown in the top part of Table 1. Here we see that the choice of whether or not to assume mean reversion in the volatility term structure for our Monte Carlo has a significant impact on the analysis of this financial plan. The probability of success in MR (mean reversion) is 86% versus 78% in RW (random walk). Generally, an 80% probability of success is considered the unofficial threshold of acceptability. A client could easily look at RW and a 78% probability and conclude that was too close for comfort. The result would be either a change in their portfolio, making it more aggressive than it would need to be, or a change to their financial plan/lifestyle. Either way, taking more risk than needed or changing your lifestyle unnecessarily all because of a flawed analysis is certainly not the right answer.

Further, the tails of the distribution for RW are significantly wider (and we would argue, less realistic). The 95th percentile for RW is 41% larger than MR. If the client were younger and needed to expand the time horizon to fifty or sixty years, the gap would only increase through time. Similarly, at the 5th percentile, RW is 60% below MR. Even though these Monte Carlos are analyzing the same exact plan with the same returns, how you model those assets has a significant impact on the analysis of the plan.

To dig a bit deeper into the long horizon results, Graphic 2 illustrates the 75th and 25th percentiles and how the interquartile range expands through time.

Graphic 2



After 25 years, when the client is age 90, the RW distribution is 35% wider than MR. Not quite wide enough to drive a truck through but wide enough to cause you to question your reliance on the flawed RW glide path as many advisors do. Nebo corrects for these flaws and provides advisors with a more reliable Monte Carlo engine helping them have greater confidence in their client's financial plan.

The Details Matter

Advisors are in a difficult position. Trying to navigate complex clients – with all of their behavioral biases developed over thousands of years – while simultaneously dealing with chaotic financial markets is incredibly difficult. This makes having the right tools to build portfolios and analyze financial plans even more critical.

Nebo deals with these complexities by framing risk, not as volatility, but in terms that clients actually care about: having the financial resources they need, when they need them. Nebo builds portfolios that seek to minimize shortfall relative to the client's investment goals and gives advisors the tools to help them frame meaningful choices and tradeoffs for clients. A crucial aspect of this type of analysis is the choice of Monte Carlo simulation engine. The right choice – the Nebo choice – ensures that you are using the most appropriate and realistic tools available.

To learn more, visit **www.nebo-gmo.com.**

Disclaimer: The views expressed are the views of Matt Kadnar, Martin Tarlie and Ben Inker through the period ending June 2023 and are subject to change at any time based on market and other conditions. This is not an offer or solicitation for the purchase or sale of any security and should not be construed as such. References to specific securities and issuers are for illustrative purposes only and are not intended to be, and should not be interpreted as. recommendations to purchase or sell such securities.

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Mr. Kadnar is a member of GMO's Asset Allocation team, a partner of the firm and serves as the Nebo sales lead. Prior to joining GMO in 2004, he was an investments specialist and consultant relations manager at Putnam Investments. Previously, he served as in-house counsel for LPL Financial Services and as a senior associate at Melick & Porter, LLP. Mr. Kadnar earned his bachelor's degree from Boston College majoring in Finance and Philosophy and a JD from St. Louis University School of Law. He is a CFA charterholder.

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Dr. Tarlie is a member of GMO's Asset Allocation team and serves as the Nebo product lead. Prior to re-joining GMO in 2018, he was a managing director at QMA. He previously worked on GMO's Global Equity team from 2007 to 2014. Prior to that he worked at Breakwater Trading and at Marlin Capital Corp as a fundamental equity analyst and the director of research. Dr. Tarlie earned his B.S. in Physics from the University of Michigan, his Ph.D. in Theoretical Condensed Matter Physics from the University of Illinois at Urbana-Champaign, and his MBA from the University of Chicago. He was also a Postdoctoral Research Fellow at the James Franck Institute at the University of Chicago and is a CFA charterholder.

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Mr. Inker is co-head of GMO's Asset Allocation team, a member of the GMO Board of Directors, and a partner of the firm. He joined GMO in 1992 following the completion of his bachelor's degree in Economics from Yale University. In his years at GMO, Mr. Inker has served as an analyst for the Quantitative Equity and Asset Allocation teams, as a portfolio manager of several equity and asset allocation portfolios, as co-head of International Quantitative Equities, and as CIO of Quantitative Developed Equities. He is a CFA charterholder.