Riding the Wave: Navigating Decision-Making in the Sea of Uncertainty

Trevor Squires

Last Updated: December 11, 2023

1 Introduction

In the intricate landscape of decision-making, particularly in the realm of data science and financial planning, the allure of deterministic models can be strong. The simplicity and clarity they provide seem like a beacon, promising a path to optimal outcomes. However, reality is rarely as straightforward as these models would have us believe. The world is imbued with randomness, variability, and unpredictability, factors that wield considerable influence on the outcomes of our decisions. In a world that thrives on the unexpected, the role of randomness becomes a pivotal element in the decision-making process. Reality, after all, is a series of unpredictable events, a dynamic interplay of countless variables that refuse to conform to the neat equations of deterministic models. Embracing randomness is not an admission of defeat against this chaos; rather, it's an acknowledgment of the very essence of life.

The consequences of overlooking randomness are profound. Imagine relying solely on deterministic models – optimizing for events that never truly materialize. The risk lies in the stark disparity between the deterministic ideal and the unpredictable reality. Ignoring randomness may lead us down a path where decisions optimized in the deterministic sense fall short in the face of real-world variability. By failing to account for the inherent uncertainty, decisions crafted in the realm of deterministic models may not only prove suboptimal but also leave us vulnerable to unforeseen challenges.

Here, we delve into the imperative need for embracing randomness in decision-making processes, emphasizing its significance through a case study centered around retirement planning. While conventional wisdom often hinges on deterministic projections and average values, the nuances of uncertainty can significantly alter the landscape, leading to outcomes starkly different from what simplistic models might predict. Specifically, a prevalent belief holds that as long as withdrawals from a retirement account remain beneath the historical average return, financial security is assured. However, reality introduces a complex interplay of stochastic elements, where the rate of return fluctuates unpredictably year after year. To make informed and robust financial decisions, it becomes paramount to move beyond the realm of averages and grapple with the inherent randomness that underlies these financial dynamics.

Our case study centers on a simulation designed to evaluate the success rate in different simple environments. As we embark on this exploration, we seek to underscore the value of incorporating randomness into decision-making frameworks. By acknowledging and modeling the inherent uncertainties, we can fortify our capacity to make decisions that are not only optimal but also resilient in the face of the unpredictable nature of the world.

2 Simulating Retirement

To delve into the intricacies of modeling randomness in retirement planning, let's consider a simplified scenario. Picture this: you're on the brink of retirement, armed with a nest egg stashed away in a retirement account. Historical data tells us that reliable funds, like the S&P 500, have boasted average yearly returns of nearly 10%. So, the straightforward argument would be to withdraw less than 10% of your initial capital annually, and you're golden, right? Not quite. This logic overlooks the twists and turns of market returns, failing to consider deviations from historical averages. While the market may generally yield reasonable returns over extended periods, unforeseen fluctuations can pose a threat to long-term financial well-being. To capture this unpredictability, we'll simulate retirement periods by drawing annual return rates from a distribution, creating a more realistic financial landscape.

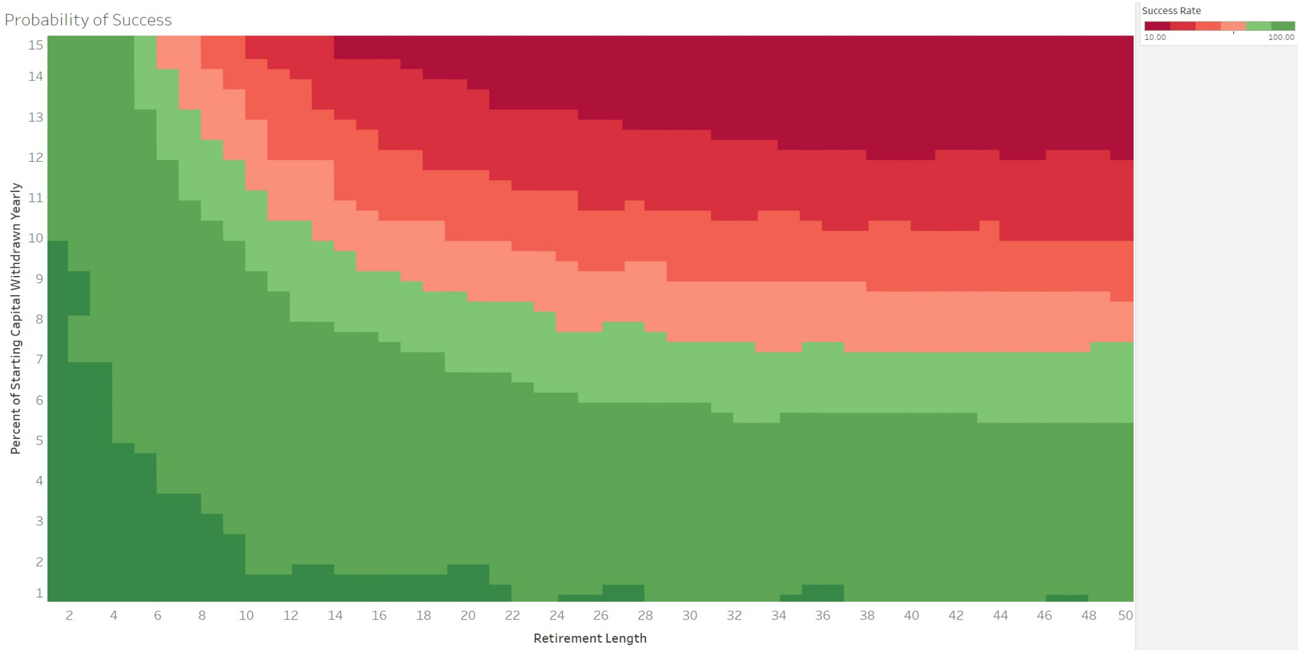

Figure 1: Financial Retirement Success Rates

2.1 Simulation Assumptions

Let's delve into the specifics of our simulation. At the commencement of retirement, we kick things off with an initial investment of M_0 in a chosen fund. The annual growth of this fund follows a normal distribution with a mean μ and standard deviation σ derived from historical performances. Using the last 20 years of the S&P 500 as a reference, we estimate the compound annual growth rate to be around 9.8% or 1.098 represented as a multiplier, with a standard deviation of approximately 0.18.

Each year, we start with an amount M_t invested in the account, intending to withdraw $M_0 r$ during the year. Here, r represents the extraction rate. The end-of-year balance is determined by the equation:

$$M_{t+1} = (M_t - M_0 r) g_t$$

where g_t is sampled from the aforementioned normal distribution. In essence, we withdraw our yearly amount at the beginning of the year and observe the growth to calculate our end-of-year balance. This process repeats for T years, and if $M_T \geq 0$, we consider the retirement successfully completed.

2.2 Simulation Parameters

To evaluate the retirement process under various conditions, we conduct 10,000 simulations for each combination of extraction rate r and retirement length l. The success rate, indicating the number of successful trials divided by 10,000, provides insights into the viability of different parameter settings. Our study encompasses a broad spectrum of scenarios, simulating all pairs (r, l) where r ranges from 1% to 15% in steps of size 0.25 and l spans from 1 to 50 years in steps of size 1. This exhaustive exploration allows us to discern patterns and make informed decisions in the face of financial uncertainty.

3 Results

The results of our experimentation can be found in Figure 3

To start, let's evaluate the effectiveness of our naive strategy. If we direct our attention to results where r is near 10%, we see that although we see higher success rates for smaller lengths of retirement ($l < 15$), we are far from guaranteed success for most reasonable lengths between 10 and 30. In particular, retirement lengths above 25 will see only a 50% chance of success under this strategy. This is precisely the value of modeling randomness. Without it, we would have drastically overestimated our chance of success under various circumstances.

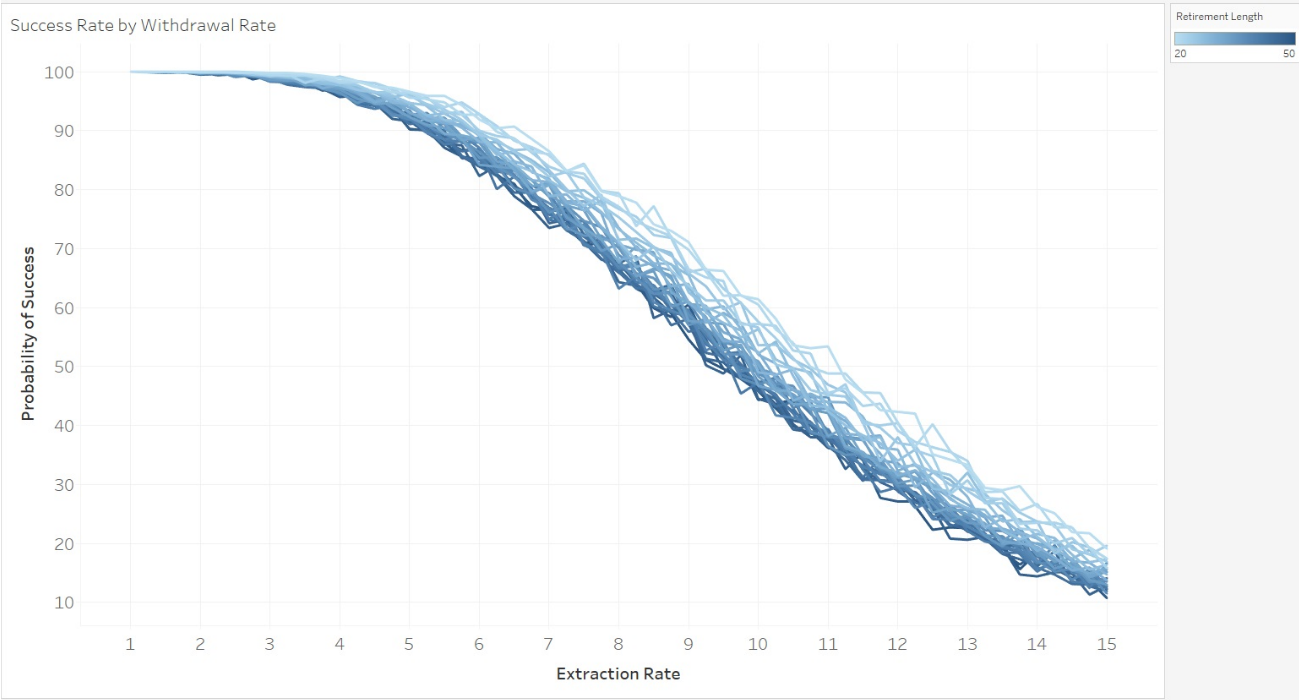

Figure 2: Success Rate by Rate of Withdrawal

When we model the variability of the problem, we can more accurately assess the situation. Note that in Figure 3, after reaching a retirement length of $10 - 20$ years, the remaining variability in success rate is predominately described by the withdrawal rate. This is highlighted again in Figure 3. Indeed, each curve of different retirement lengths has similar probabilities with respect to the rate of extraction.

Nonetheless, what remains consistent in all the experiments is the undeniable truth: financial forecasts are not an exact science.

4 Conclusions

Our exploration into retirement planning through extensive simulations illuminates a fundamental truth: the indispensability of modeling randomness in decision-making. As we navigated the intricacies of financial landscapes, the stark disparity between deterministic models and the nuanced reality of our world became evident.

The naive reliance on deterministic projections initially painted a rosy picture, particularly when tethered to historical averages. However, beneath the surface, the absence of randomness led us astray, providing a false sense of security. The lesson learned extends beyond the confines of our specific experiment, resonating with a broader understanding of decision science.

In the realm of decision-making, particularly in finance, where future outcomes are inherently uncertain, the simplicity offered by deterministic models is an alluring mirage. The intricacies of life, like the unpredictable nature of market returns, defy the rigid structures of deterministic certainties. Our simulations underscore that embracing randomness is not merely a choice but a necessity.

Whether planning for retirement or navigating other facets of life, the acknowledgment of randomness is pivotal. It's a recognition that our future is not governed by fixed averages and predictable patterns alone. Life is an ever-changing interplay of variables, each introducing an element of unpredictability. To make informed decisions, we must incorporate randomness into our models, transcending the allure of simplicity for the pragmatic embrace of complexity.

In conclusion, our journey through financial simulations serves as a microcosm of a larger truth – the need to grapple with randomness is a universal imperative. This is not a concession to chaos but an acknowledgment of the dynamic richness that defines our existence. In embracing randomness, we empower ourselves to navigate the uncertainties of the world with a clarity that deterministic models alone cannot provide.