The Dynamic Implications of Sequence Risk on a Distribution Portfolio

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Executive Summary

- While a distribution portfolio's exposure to sequence risk changes over time, sequence risk never really goes away unless the withdrawal rate is constrained considerably.
- A practical method for advisers to measure this exposure to sequence risk is through evaluation of the *current* probability of failure rate.
- The fundamental withdrawal rate formula is portfolio value ($X) times a withdrawal rate (WR%) to equal the annual distribution amount ($Y). Therefore WR% = $Y / $X. Because sequence risk relates to the order of returns, especially negative returns, when the portfolio value ($X) decreases, the inverse relationship increases the withdrawal rate (WR%), which results in an increased probability of failure.
- The distribution period should be measured primarily from a fixed target end date rather than from the date of retirement (that is, based on life expectancy). This establishes a continuously reducing period of remaining years that reflects the distribution period likely to be experienced by retirees.
- This paper will discuss three methods advisers may use to evaluate the exposure of a portfolio to sequence risk:
  - Adjust WR% as market return trends suggest
  - Adjust portfolio allocation to mitigate exposure to negative market returns as market trends suggest
  - Start with a reduced WR% to reduce exposure to the impact of declining markets on the probability of failure
- Reliance on a single simulation to be accurate for a lengthy distribution period is not prudent. Rather, the current likelihood of failure should be reviewed regularly to ensure the withdrawal is still prudent.

Sequence risk, or the effect of returns on the probability of success for a distribution portfolio, is a timely issue. The stock market decline in 2008 left many retirees, and their advisers, questioning the long-term sustainability of their distribution portfolio. When markets drop and force a higher than sustainable withdrawal rate, advisers and their clients are left with many questions: How does one recognize and manage such inadvertent exposure? Is this exposure the same with different portfolio allocations? Is this exposure the same as the retiree ages? Does sequence risk ever really go away?

Unlike past research, which has suggested sequence risk only exists for a certain period, the authors contend that a "spectrum" of *exposure* to sequence risk exists, and that sequence risk is always present, regardless of how long distributions have been occurring. This paper will discuss this exposure to sequence risk and argue that sequence risk is *always* present to *some degree* when there are cash flows out of the portfolio. This paper will also demonstrate that the *degree* of exposure can be determined through evaluation of the current probability of failure of the portfolio's value being depleted during the remaining distribution period.

As a practical matter, sequence risk depends on the degree of cash flow relative to the direction of the portfolio value's trend. Sequence risk is only really a concern when the value of a portfolio drops *combined* with an ongoing cash flow requirement (for example, lifetime income for a retiree). An increase in the value of a portfolio does not increase sequence risk and, while it is possible for a portfolio with no cash-flows to experience sequence risk (for example, just before retirement), outgoing cash flows are typically required.

The fundamental withdrawal rate formula is portfolio value ($X) times a withdrawal rate (WR%) to equal the annual distribution amount ($Y). Therefore WR% = $Y / $X. Because sequence risk relates to the order of returns, especially negative returns, as the denominator value $X (or portfolio account balance) decreases, the inverse relationship forces WR% higher, which translates to a higher probability of failure, a direct relationship with WR%.

Literature Review

Recent market events have increased the available literature on sequence risk, a topic that had not received much scrutiny in the past. Furthermore, Mitchell (2009) states, "Existing research does not address the question of acceptable probabilities of failure (running out of money before the end of the planning horizon) …" where *acceptable* is an explicitly defined limit or zone, rather than a value determined and then unmonitored once distributions have begun. Milevsky (2006) writes, "The first decade of retirement is the most crucial one in determining whether your retirement plan will be successful." Continuing, "It seems that the first seven years of retirement are the most crucial in affecting the probability of ruin." The implication is that, as time passes, the risk of ruin subsides. This observation emanates from *referring* to the date the withdrawals began and then counting forward from that date. This creates a time paradox. For example, how can it be that the sequence risk for a couple that is 10 years into their projected 40-year retirement period be different than that for a couple about to retire with a projected 30-year distribution period? The real question that a retiree should be asking is, "What is the *current* probability of ruin for the *current* exposure to a detrimental market?" Because time is dynamic, and withdrawals are taken currently, the starting point for measuring sequence risk should always be from the present going forward.

Time Measurement

With traditional retirement distribution thinking, both measurement points, retirement age and average mortality age, actually "float with time" as the retiree ages. The authors' convention in this paper is to fix the mortality age point, called "target end date," so that measurement of distribution periods dynamically reflect *time remaining* from the *current* retirement age as the retiree ages. Previous research has demonstrated that age 95 is a reasonable target end date for a retiring couple (Blanchett 2008) as well as individuals (Frank 2009). Trying to "fudge" a shorter target end date through rationalization of disease or sickness may be fraught with risk through unforeseen medical advances and cures. However, selecting a distribution period that is too long subjects the retirees to under consumption, meaning they could have consumed more during their lifetimes. Therefore, when determining the length of the distribution period, the estimate should be neither too conservative nor too aggressive.

> "Even when you equalize the total period returns for a simulation, some runs may fail while others pass, the reason being the order, or sequence, in which they are experienced."

What Is Sequence Risk?

When considering sequence risk, it is first important to separate the order of returns from the returns themselves. Monte Carlo simulations involve generating a random series of returns dispersed around a mean return, with the variability defined by the standard deviation. To demonstrate why and how return order (or more generally, sequence risk) is important, an iterative simulation of 10,000 runs was conducted based on various equity allocations (which correspond to historical real rates of return and historical standard deviations) for a 30-year distribution period based on a 5 percent initial real withdrawal rate.

For this simulation, though, the returns for each of the runs are "equalized" so that the simulation has the same real rate of return for the entire 30-year distribution period. Therefore, the only difference in the individual simulations would be order (sequence) or returns experienced by the portfolio. This method was used so as to "isolate" and control other return factors to demonstrate the effect of sequence risk on a portfolio, and the results are included in Figure 1.

Figure 1 demonstrates that even when the return for the entire period in each test run is the same, there can still be a considerable dispersion in the potential probability of failure. The key is when the low returns are realized. Those runs that fail tend to have lower than average *initial* returns (and above average ending returns), while the runs that pass have

Figure 1: Probability of Failure for Various Equity Allocations with 30-Year Distribution Period and a 5% Initial Real Withdrawal Rate

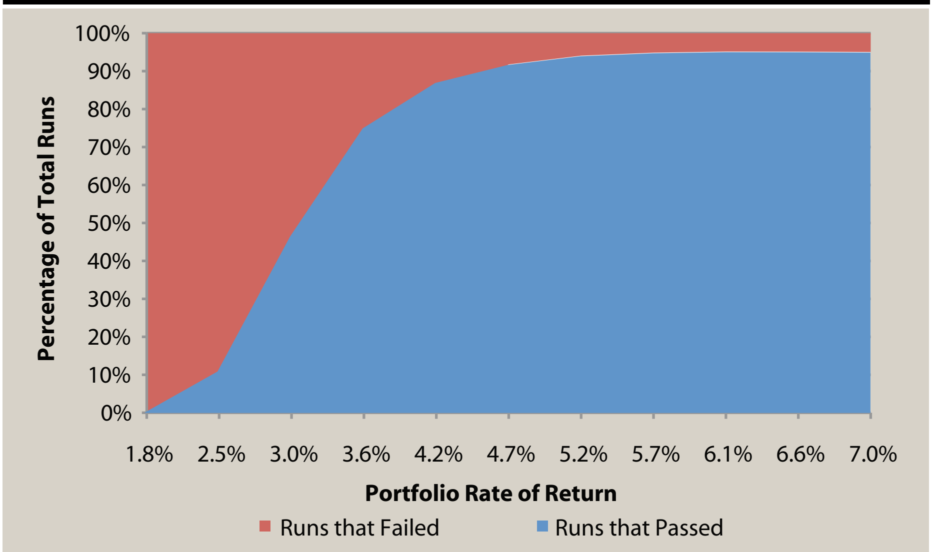
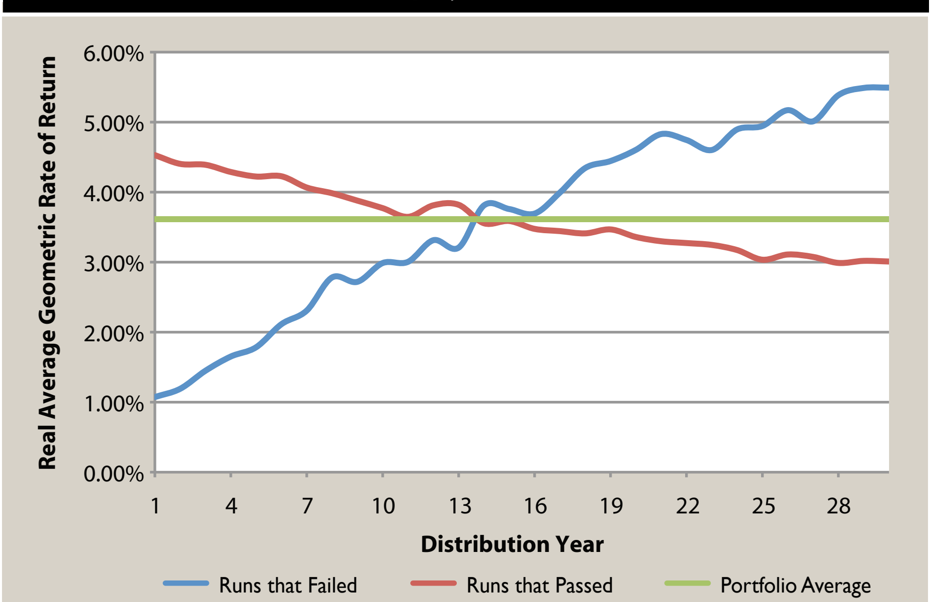


Figure 2: Return Differences Between Those Portfolios that Passed and Failed for the 30% Equity Portfolio



higher than average *initial* returns (and below average ending returns). To summarize, even when you equalize the total period returns for a simulation, some runs may fail while others pass, the reason being the order, or sequence, in which they are experienced. Brayman (2009) found similar results; lucky or unlucky sequence of events explained more of the phenomenon than over- or under-achieving expected returns. This concept is demonstrated visually in Figure 2, where the average returns of passing runs and failing runs are separated for a single simulation.

What Happens to Sequence Risk over Time?

While it is commonly assumed that sequence risk "goes away," sequence risk is actually something that is always present. With time, the portfolio tends to move into a range of either certain failure or certain success. This is why withdrawal rates should be lower for longer distribution periods and may be higher for shorter distribution periods, *with an equal exposure to probability of failure* (Figure 3).

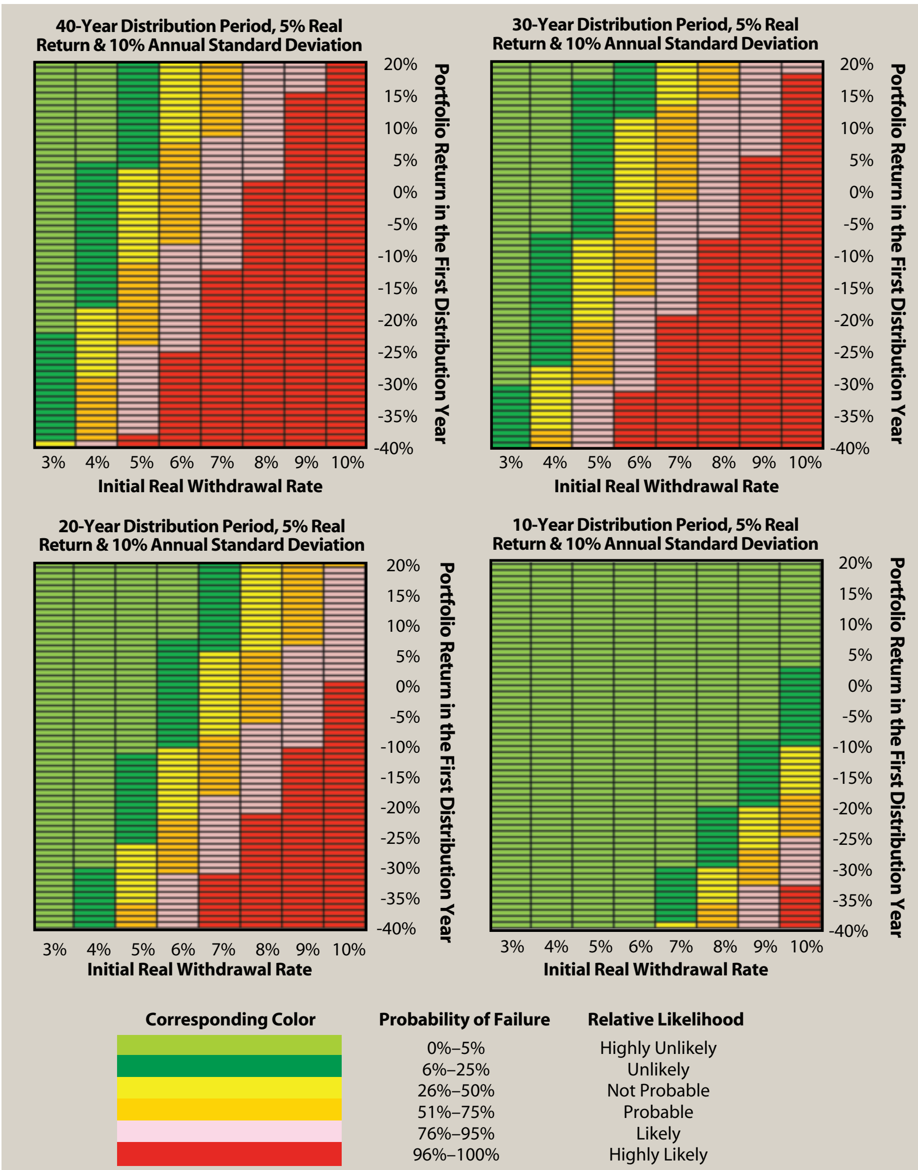
First generation withdrawal thinking has been to establish an initial withdrawal rate (WR%) and then adjust the resulting dollar distribution ($Y) for inflation. Thus, the withdrawal rate is not directly adjusted, because an initial dollar amount is increased (decreased) for inflation (deflation). However, when the stock market falls, the *current* withdrawal rate (the withdrawal as a percentage of the portfolio assets) increases, potentially dramatically, due to the inverse relationship of the dollar distribution to the portfolio value.

For example, if a portfolio were to drop in value by 25 percent, a retiree with a $1 million portfolio and a $40,000 withdrawal would see the withdrawal rate as a percentage of total assets increase from 4 percent ($40,000/$1 million) to 5.33 percent ($40,000/$750,000) (not including the annual withdrawal). Clearly, a 5.33 percent distribution rate has a higher probability of failure than a 4 percent distribution rate for the same distribution period. Such a relative change in portfolio value can occur at anytime during the retiree's lifetime. This concept is illustrated graphically in Figure 3, which reflects the probability of failure for various periods based on the initial real withdrawal rate and the real return of the portfolio in the first year for a 60/40 portfolio (that is, the return for the first year is listed on the y-axis, and the following returns are randomized). The graphs for the time periods in Figure 3 have been arranged to demonstrate the fact that the probability of failure "ticks down" to a termination date/age.

Moving from Uncertainty to Certainty

As a distribution portfolio moves through time, the "uncertainty" of its outcome declines. At the beginning of most Monte

Figure 3: Comparison of Various Withdrawal Rates with Varying First Year Portfolio Returns for Different Distribution Periods (60/40 Portfolio)



Carlo simulations, the probability of achieving a goal is defined by a certain probability. What happens, though, if you "revisit" the probability of the portfolio successfully achieving its goal through time? Doing so allows the individual to see that the uncertainty associated with the outcome moves to one of two outcomes: certain success or certain failure. This concept is demonstrated in Figure 4, which shows the range of "uncertain" outcomes where the probability of failure is between 5 percent and 95 percent (a probability of failure below 5 percent is deemed to be certain success while a probability of failure above 95 percent is deemed to be certain failure). Figure 4 demonstrates the concept of how in the absence of any type of intervention (for example, changing the portfolio allocation or the withdrawal rate) the uncertainty surrounding the outcome of a given decumulation decreases through time.

Referring to the time measurement discussion above, imagine all the end points in Figure 4 set at the client's calendar age 95. This helps emphasize the current year range of outcomes illustrated and the changing nature of withdrawal rates with time.

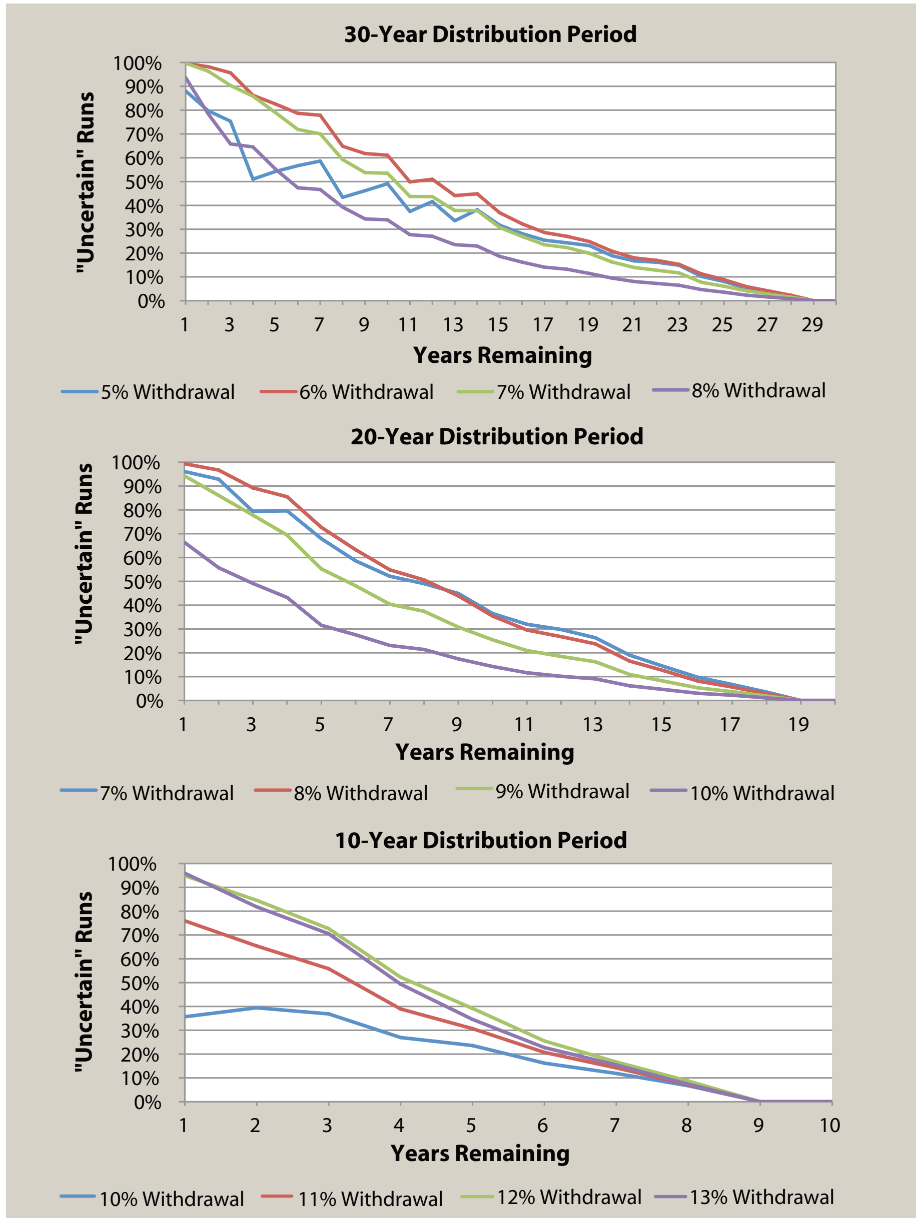
Taking an Adaptive Approach to Distribution Planning to Manage Exposure to Sequence Risk

Previous research by Blanchett and Frank (2009) introduced a relatively simple framework for adjusting the annual real withdrawal from a distribution portfolio based on the ongoing probability of success of the portfolio. By recalculating the probability of portfolio failure each year (that is, replicate the methodology that financial planners typically employ when working with clients) it becomes possible to make adjustments if sequence risk becomes an issue. The authors suggested that exposure to sequence risk is recognizable when the probability of failure (of the same portfolio allocation and same withdrawal dollar amount) begins to rise. The probability of failure begins to go up when the *current* withdrawal rate goes up.

For the revisiting strategy, the probability of failure was calculated for each year of each run of each scenario to replicate the dynamic approach an adviser may take when working with a retired client as markets change. The withdrawal stayed the same, increased, or decreased based on the probability of success for the current withdrawal rate. Figure 5 demonstrates the various success rates for a distribution strategy without revisiting (that is, when the withdrawal does not change) and with revisiting (that is, when the withdrawal changes are based on the projected probability of success for the portfolio). Similar to Figure 4, the reader can see in Figure 5 that the uncertainty associated with a given simulation decreases through time.

Figure 5 suggests it is possible to recognize exposure to sequence risk and make adjustments to a portfolio to improve the likelihood of retirement success. Two actions directly under the client's control are: (1) reduce the portfolio's exposure to decline through a change in the asset allocation or (2) reduce the portfolio's distributions (that is, a retiree pay cut).

Figure 4: Range of "Uncertain" Outcomes (Probability of Failure Between 5% and 95%) for a 60/40 Portfolio for 30-Year Distribution Period



Probability of Failure Trajectories

The basic formula WR% = \$Y / \$X is a generalized form where key defining subscripts are not displayed. Each WR% has associated with it a probability of failure (POF) for a given remaining distribution time (*t*), which is displayed in Figure 6. This information is obtained from Figure 2 in Blanchett and Frank (2009). Note that different portfolio allocations and withdrawal strategies would have different graphs published in the previous paper.

The simulations in Figure 6 are based on a constant distribution period and assume a static withdrawal rate. WR% may be written more specifically for this discussion as $WR\%_{(POF,\ t)}$ to accentuate the relationships between time, withdrawal rate, and probability of failure.[1] Introducing a dynamic remaining distribution time (*t*) variable helps explain why a withdrawal rate WR%, for example 9 percent for *t*=10, may be greater than a withdrawal rate of 4 percent for *t*=30, and yet both have similar probability of failure rates (0 percent–5 percent) as they both lie on the same probability of failure trajectory (upper edge of the green zone). As the portfolio value increases or decreases as a function of market value, $WR\%_{(POF,\ t)}$ varies inversely along the probability of failure trajectory. In other words, when *t* is held constant, for a decreasing portfolio value \$X (denominator), the probability of failure goes up because the withdrawal rate has increased relative to a set annual withdrawal \$Y, or vice versa. However, *t* is not constant.

A different way to visualize Figure 6 would be to determine withdrawal rates for various time periods and withdrawal rates with the same approximate probability of failure. This has been done in Figure 7, where the probability of failure for each of the simulations is 0 percent–5 percent (that is, deemed highly unlikely). Higher threshold landscapes (for example, Figure 6's yellow zone) would map out higher on the x-axis compared to the 0 percent–5 percent threshold illustrated, because corresponding withdrawal rates are higher. In other words, the 0 percent–5 percent landscape is the lowest probability of failure landscape. Note that as distribution time shortens, withdrawal rates may increase, all with a similar approximate exposure to probability of failure.

Advisers and their clients should determine, based on client circumstances, what an appropriate probability of failure decision threshold should be. For example, a retiree with little discretionary flexibility should have a lower threshold than a retiree who has discretionary expenses that can be reduced, thus giving this second retiree more tolerance for a higher threshold before making withdrawal adjustments in order to affect their probability of failure. This is another area where further probability of failure research is currently being explored (Frank, Klement, Mitchell 2010).

Since sequence risk is ever present, to what degree is a retiree exposed to the

Figure 5: The Aggregate Probabilities of Failure (per Year and Run) When the Probability of Failure Is Revisited Annually

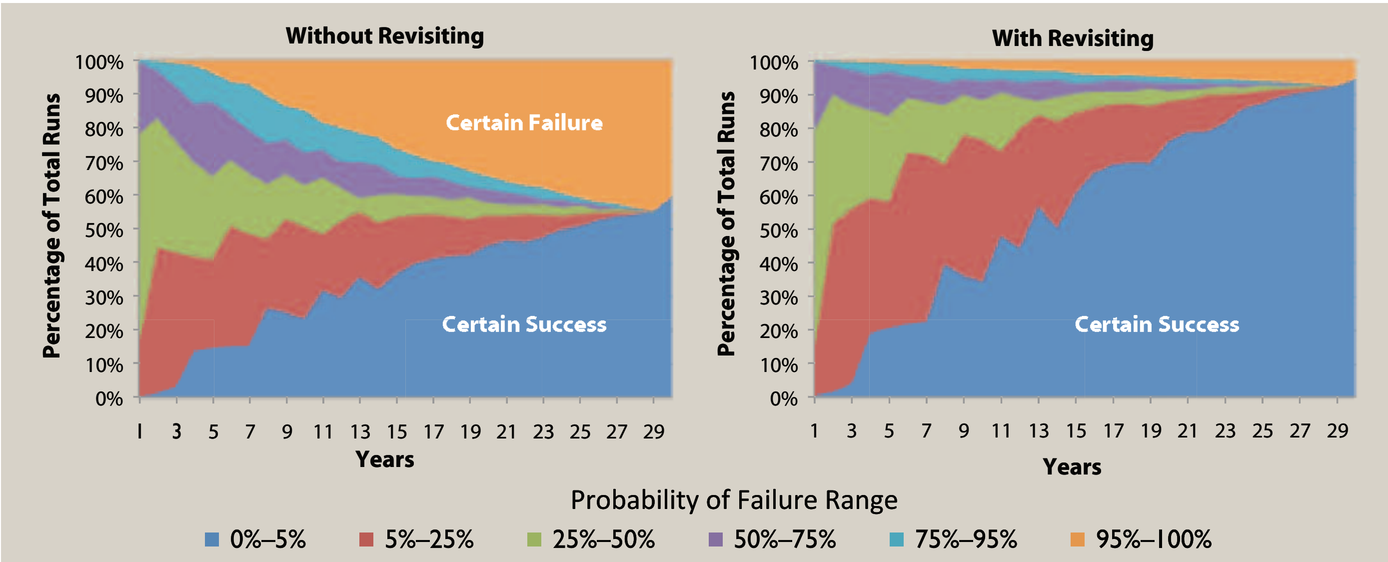
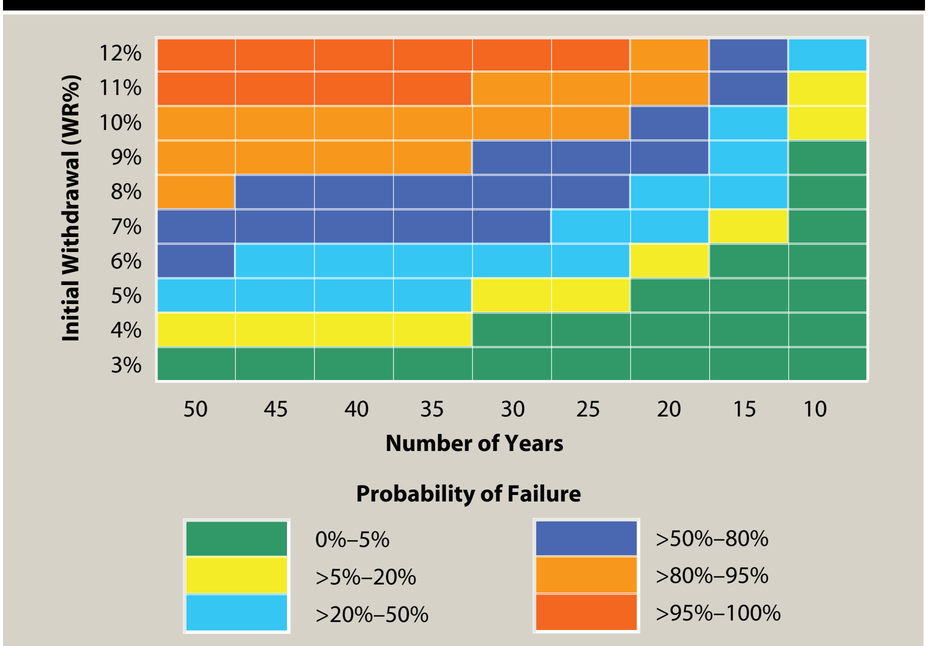


Figure 6: Illustration of the Concept of Probability of Failure (POF) Trajectories, Illustrated with a Hypothetical Path of a Withdrawal Rate Drawn over Time ($WR\%_{POF,t}$) (Blanchett and Frank 2009, Figure 2)



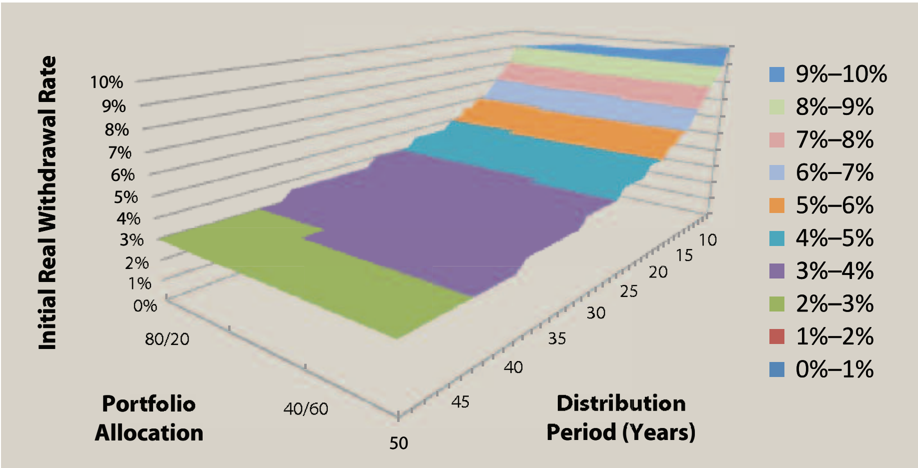
effects of sequence risk? For example, referring to Figure 6, starting at 30 years and taking an initial 4 percent inflation adjusted withdrawal, that 4 percent would be below the 5 percent current withdrawal rate possible when time remaining (t) is 20 years, *unless* the portfolio growth rate had exceeded the inflation rate; in which case the exposure to sequence risk is moot because the portfolio has grown in value rather than declined. Stated differently, if portfolio values were to now decline at t=20 (that is, WR% increases and sequence risk is experienced), then for the probability of failure to exceed 5 percent, for example, this would correlate to a withdrawal rate of over 6 percent. Figure 7 illustrates this three dimensionally by graphing what withdrawal rates would be necessary to exceed the 5 percent probability of failure zone with different portfolio allocations and time remaining.

Therefore, the concept of time *remaining* (t) is necessary to evaluate properly the exposure to sequence risk. Knowing the withdrawal rate alone does not suffice, because that value may have differing probability of failure rates depending on the distribution time (t) remaining (Blanchett and Frank, 2009) and portfolio allocation. Thus, the important value that the adviser should monitor for the *current* exposure to sequence risk is the probability of failure rate at that moment in time t.

Conclusions

Reliance on a *single* simulation, albeit many thousands of runs, to be accurate for any *future* period is not prudent. Monitoring current exposure to probability of failure when portfolio values decline is not "fire and forget," but an ongoing exercise.

Figure 7: Probability of Failure of 0% to 5% with Changing Withdrawal Rate and Portfolio Allocation over Time



The long-term future, as well as any past period, is not as relevant as the short-term future. This paper demonstrated that sequence risk is always present in the short term, and can be measured indirectly through evaluation of the current probability of failure of the current withdrawal rate over the remaining distribution period.

It may appear that sequence risk "goes away" with time. However, a closer inspec,tion of Figure 6 indicates that the *exposure* to sequence risk may decrease with time if the withdrawal rate is below an "optimal" trajectory (for example, boundary between green and yellow zones). For example, a withdrawal rate at 30 years *remaining* with a probability of failure of 0 percent–5 percent has a similar probability of failure rate for a 5 percent withdrawal rate at 20 years, and similar again to a 9 percent withdrawal rate at 10 years remaining. Figure 7 provides the same observations for four portfolio allocation slices. Sequence risk would appear to diminish with time by constraining the withdrawal rate below a rate otherwise possible for the period remaining.

The possibility of a higher withdrawal rate is arguably the retiree's goal, especially if that rate has a similar probability of failure. Hence, a probability of failure rate trajectory emerges in which the withdrawal rate may increase over time but the probability of failure rate remains relatively constant simply because of the *remaining distribution period shortening.*

The temptation is to withdraw more early with thoughts of withdrawing less later, that is, consumption "smoothing." However, sequence risk exposure suggests this is a risky strategy because it essentially entails an increased probability of failure, when portfolio values decline, with an already increased probability of failure through a higher withdrawal rate resulting from an attempt to smooth withdrawals over time. A smoothing strategy may work for those affluent retirees who have the discretionary ability to reduce their expenditures, possibly dramatically, during declining markets in order to adjust their exposure to sequence risk's effects on probability of failure.

> "The authors suggest slowly increasing the withdrawal rate over time along a probability of failure trajectory, when the exposure to sequence risk is within a feasiblility 'zone.'"

The *current year* is the first year in the time sequence, regardless of how many years remain in the sequence or how many years may have passed before. Hence, there appear to be two methods to manage the portfolio's *exposure* to sequence risk. First, by managing the *current* withdrawal rate so as not to exceed an excessive *current* probability of failure (Figure 6). Second, by managing the *current* asset allocation so as not to exceed an excessive exposure to *current* volatility of the asset class exhibiting marked decline—another method to manage probability of failure (Figure 7). Some combination of these two may also be used to manage probability of failure. For risk averse clients, or those who cannot adjust their expenditures down when portfolio values fall, the adviser may suggest they start with a reduced WR% to reduce exposure to declining markets on the probability of failure—observe in Figure 7 that this is the result when a conservative portfolio is chosen. Additional research is required to investigate the efficacy of the above strategies.

Arguably, the goal of withdrawal planning is to maximize the distributions over the client's lifetime. The authors suggest slowly increasing the withdrawal rate over time along a probability of failure trajectory, when the exposure to sequence risk is within a feasiblility "zone," to accomplish this. However, decline in portfolio value as a result of market declines or sudden unplanned additional withdrawals would result in a higher withdrawal rate with a commensurate increase in probability of failure going forward. The reverse would be true with market gains or suddenaditonal deposits (for example, inheritance).

A fire-and-forget approach to retirement distributions is unlikely to be possible because market returns are always volatile.

Some degree of portfolio decline is probably acceptable, as the market tends to recover most of the time. With cyclical market declines that take longer to correct, damage may be done to a portfolio trying to sustain long-term distributions. Recognizing a withdrawal rate that continues to grow is the key to evaluating the probability of failure associated with that withdrawal rate.

First generation thought was to apply an *initial* withdrawal rate to the portfolio value to derive a dollar amount to be withdrawn; a dollar amount that subsequently is increased for inflation to arrive at another dollar amount. Hence, there is no referral to what the withdrawal rate may be currently, nor to the current probability of failure. Second generation thought is that one needs to periodically refer to the current withdrawal rate and *current* probability of failure. This paper demonstrated that, by referring to the probability of failure, one may evaluate the exposure to sequence risk.

Second generation thought should change perspective from initial to current withdrawal rate; from distribution period to distribution time remaining; and finally, should elevate probability of failure to higher consideration, especially as a method to evaluate exposure to sequence risk; all of these under dynamic considerations where all the variables change continuously and simultaneously.

Understanding the "physics" of possible statistical states of the dynamic interaction of all the variables including the fourth dimension of *changing* time (Δt) as the retiree ages during retirement will usher in the third generation of thought about managing distributions, as portfolio values change based on market forces, which results in variable exposures to sequence risk that can be measured by the probability of failure.

Although the discussion about sequence risk has been in terms of withdrawal rate research, the purpose of this paper is to shift more attention to the use of probability of failure as a dynamic tool to continually evaluate ongoing exposure to adverse market sequences (risk) as a retiree ages through his or her distribution years.
It appears probability of failure may be more prominent a value to understand than simply the withdrawal rate alone as a valuable tool for sequence risk evaluation. Further research is required on strategies to respond to sequence risk each time it develops over a retiree's remaining lifetime.

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Endnote

1. To represent all the variables incorporated into a withdrawal percentage value, a more complete withdrawal rate expression would be $WR\%_{N, I, i, \sigma, \mu, t, \Delta t}$ where, for the portfolio, N = number of distribution years of the portfolio simulation, I = inflation, i = rate of return, σ = standard deviation, μ = probability of failure, t = time set at a fixed target end date, for example age 95, and Δt = change in time (years) to represent aging of the person. There are two "time" functions to represent the number of years for the portfolio, and the number of years of the person. Convention used in this paper was to set both time functions to the same number of years and both with low probability of failure (POF), arguably the retiree's goal of not outliving his or her money. POF of the person would represent a low probability of outliving the target end age using current life tables.

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