From SRR to SR:

Measuring Sequence of Returns Risk

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Introduction

"Sequence of Returns Risk" (SRR) is the risk that a portfolio's purchasing power may be compromised by an unfortunate, ill-timed concurrence of investment returns and cash flows. Put differently, SRR represents the role of chance that even a well-constructed, reasonably-funded, and prudently-managed portfolio is subject to. Two people with identical careers, saving patterns, investment allocations, planned retirement spending, and life expectancy may have substantially different experiences if one is a few years older and retires on the eve of a bear market. They may even have identical long-term returns, illustrating how unlike other investment risks, SRR is an uncompensated one.

SUMMARY

- There is industry-wide room for improvement in analysis of Sequence of Returns Risk (SRR) due to the lack of a single, easy-to-understand representation of it.
- This paper creates such a metric to help decision-makers assess the impact (or lack thereof) of SRR across savings and investment strategies.

SRR is not a new concept and is generally understood amongst investment professionals. Much of the well-placed effort to mitigate SRR has been directed towards educating clients, identifying resilient spending strategies, and designing investment products to minimize it (albeit without always directly measuring it). That said, SRR is often presented as a general concept, not as a quantified risk that represents a client's specific circumstances. The area for development that this paper undertakes is to create a simple, portable, and meaningful measure of SRR that can be applied to investment strategies and their applicable cash flows. This can provide investment decision-makers with a standardized representation of SRR, allowing for robust and expedient comparisons.

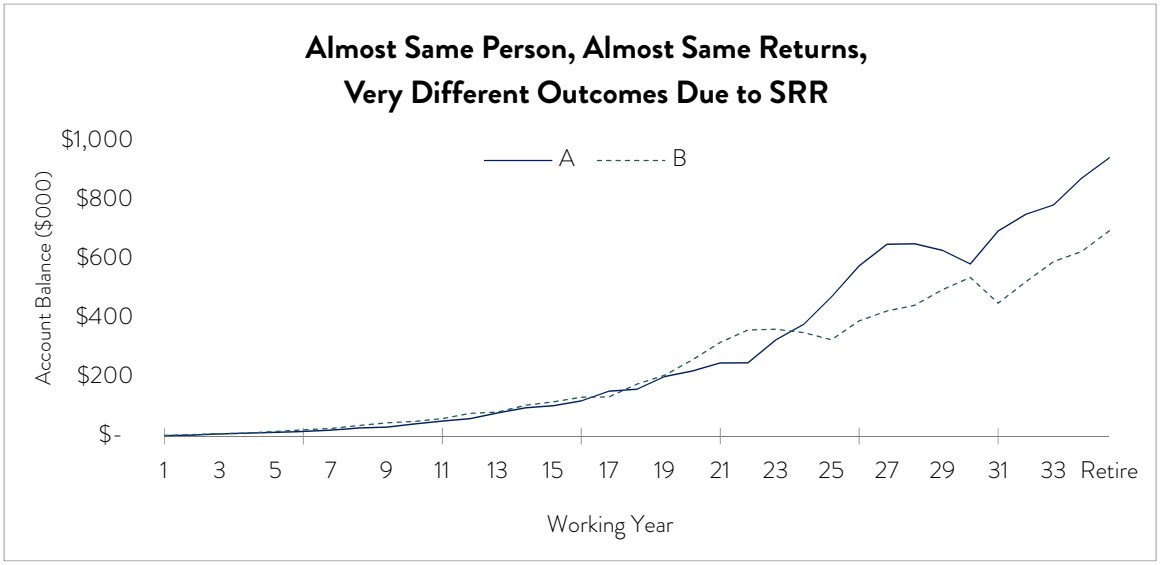
Components of SRR and Three Examples

This paper examines SRR in terms of three fundamental components: investment returns, cash flows, and their timing. While variables such as liquidity costs, portfolio size, management fees, administrative fees, mortality, risk-aversion, investor behavior and alpha could also be extracted from the fundamental components in subsequent work, for simplicity sake this analysis treats them as endogenous. The following examples illustrate SRR and its effects under different circumstances.

Example One: A Basic Illustration

Consider two workers (A and B); whose thirty-five year careers start in 1973 and 1978 respectively. Both earn the same initial salary of $20,000 that annually increases by 3%, and both dutifully put 10% of that salary into a 60/40 portfolio. Workers A and B retire at age 65 in 2007 and 2012 respectively and withdraw 70% of their final salary annually, increasing it at an annual rate of 3%.

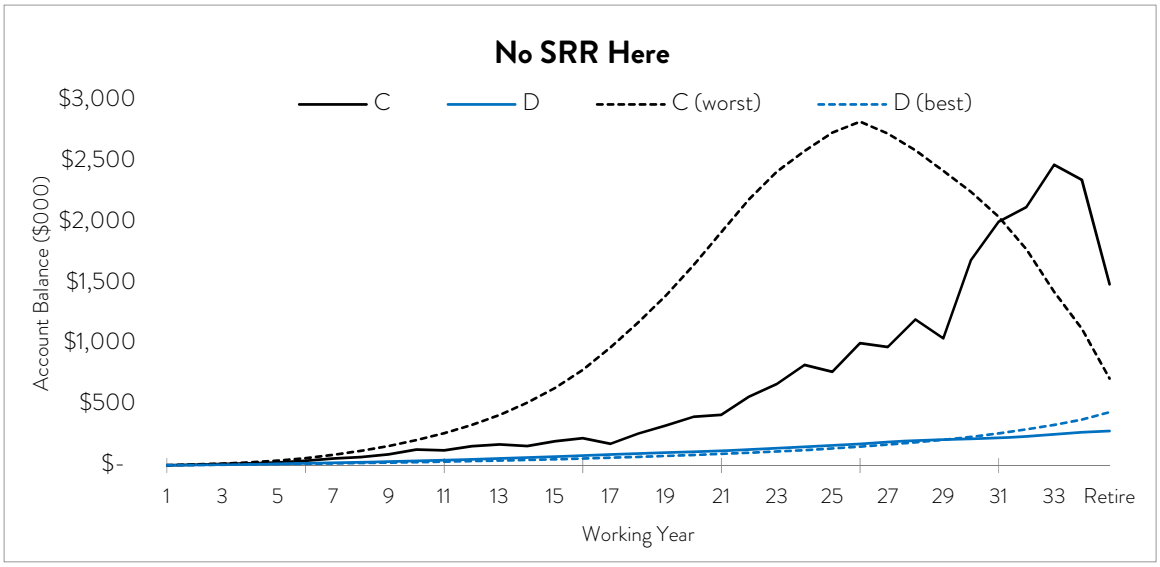
Remarkably, although worker A had a slightly lower investment return while working, fortuitous timing allows her to retire with a balance that is 36% higher. B would have to save 36% more than A per year, every year, to have the same balance at retirement! Even though A's balance drops in 2008, prior asset accumulation provided a substantial capital cushion relative to needed income. B's balance grows over the first five years of retirement while A's shrinks, but A is still in the lead. Fortunately for both, their return requirements for the remainder of their life expectancy (the "Twenty-Five Year IRR at 70") remain achievable. A has been luckier, but both appear ok. The table below provides comparisons.



	A	B
Investment Return While Working	10.22%	10.34%
Retirement Year	2007	2012
Balance at Retirement	$943,595	$695,894
Blanace at Age 70	$894,784	$837,517
Twenty-Year IRR at Age 70	5.03%	5.62%

Example Two: SRR Means Failure and Success are Possible

This first example shows how the same strategy can have different results thanks to SRR. A second and more extreme example shows its boundaries. In this example, workers C and D have the same salary, career, and retirement spending as A and B. C's savings is invested 100% in US Small Cap Stocks while D's goes into Cash. Both retire in 2008. Although C's account declines dramatically in 2008 while D's earns 1.6%, C is still over $1 million ahead at retirement and is over $3 million ahead five years later! In fact, even the least and most favorable rearrangement of returns for C and D respectively leads to the same result of C being well positioned for retirement while D remains unprepared. SRR is absent because, using this data set, C could not fail and D could not succeed. To be material, SRR must be able to tip the scales.



	C	D
Investment Return While Working	16.35%	6.02%
Retirement Year	2008	2008
Balance at Retirement	$1,491,019	$283,578
Balance at Age 70	$3,741,912	$68,785
Twenty-Five Year IRR at 70	-4.84%	71.38%

Example Three: For the Detailed Enthusiasts to Read and Everyone Else to Skip

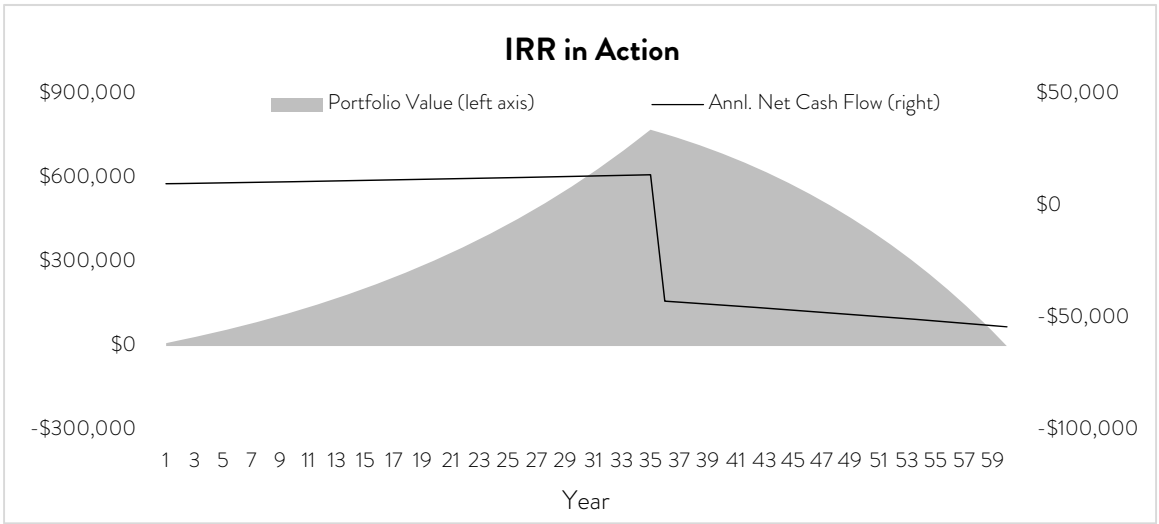
Words like "underhanded", "sinister", "pernicious", "sneaky", and "insidious" are often used in describing SRR because of its ability to "cheat" investors out of deserved victory, or at least contribute to unfair results. The final example seeks to illustrate the remarkable degree to which this can be the case by comparing two technically identical workers (E and F). They begin work in 1978 with the same salary, same 60/40 investment strategy, and *overall* savings and retirement spending pattern as A and B. The wrinkle here is that E saves annually while F saves once every three years. To make up for lost time, F saves much more every third year such that by retirement, E and F's contributions have the exact same net present value[1]. Even though F's investments were the same as E's on paper, the fact that they were more concentrated exposed F to more SRR. At retirement E's balance is $37,811 (6%) higher; equivalent to nearly a full year of retirement income! By age 70 the difference has grown to $60,849. While it is unrealistic of course to think that someone will only save every third year, it is more likely that cash flows will be irregular, opening the door for SRR. The confounding factor in this case is that their account balances are different at all.

[1] Net present value (NPV) being the value of future cash flows discounted by an assumed investment return (in this case the arithmetic mean investment return). NPV represents the hypothetical value of future cash flows as of today.

	E	F
Investment Return While Working	10.34%	10.34%
Retirement Year	2012	2012
Balance at Retirement	$695,894	$658,083
Balance at Age 70	$837,517	$776,667
Twenty-Five Year IRR at 70	5.62%	6.31%

Now the Challenge

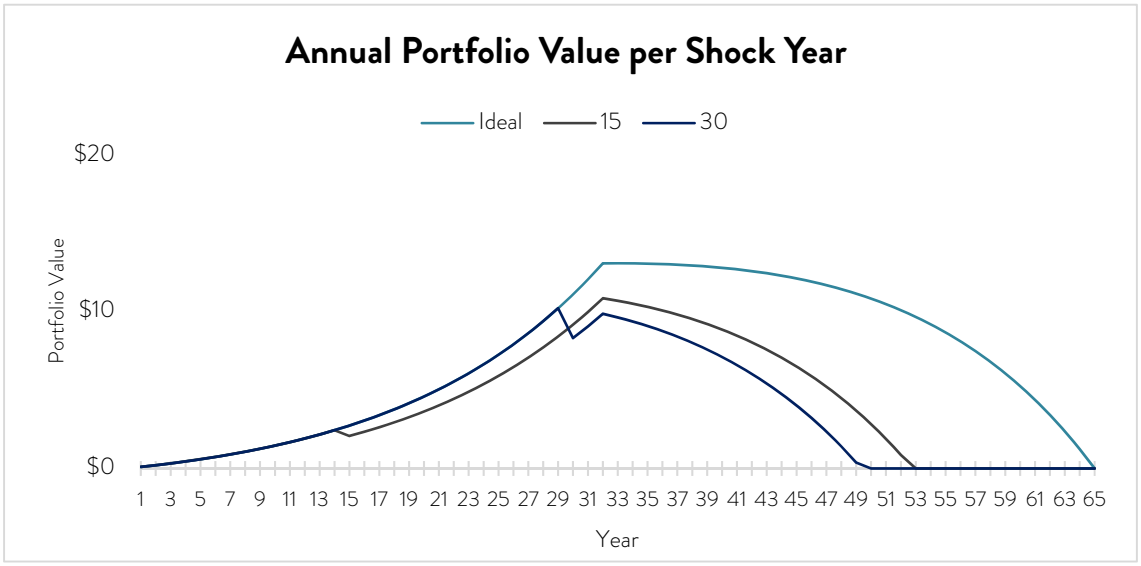
Thus far this paper repeats what practitioners have done; illustrate the concept of SRR. Moving forward, the challenge is to combine SRR's components of returns, cash flows, and timing into a single measure. To start, we derive an "Internal Rate of Return" (IRR) as a target return that equates a portfolio's expected contributions and distributions, and their applicable timing, over its lifetime. If a portfolio achieves its IRR, with absolutely no volatility of returns, its last expected cash flow will reduce its balance to $0. The "IRR in Action" chart illustrates a hypothetical investor whose account balance grows by its IRR, net of inflows and eventual distributions. At the end of the investment horizon, the portfolio is spent down to the penny. In reality, a portfolio's returns may fluctuate around its IRR, inviting SRR into the picture.



A metric that is representative of SRR should incorporate savings relative to spending (and the resulting IRR) as well as high likelihood of the investment portfolio achieving the IRR, proportionally discounted to the extent that required and expected returns differ. To this effect, we create a hypothetical investor with an assumed:

- Starting salary ($1)
- Annual salary raise
- Annual savings rate
- Retirement year
- Retirement spending as percent of salary
- Annual increase in retirement spending
- Life expectancy
- Expected investment return
- Expected investment risk

By deriving an IRR from the salary, savings and spending assumptions, we estimate the "Ideal" experience where everything goes according to plan; the investor makes their exact required return every year, reaches their exact life expectancy, and never experiences an income shortfall. We then compare these annual portfolio values to alternative investment experience in which a portfolio achieves the IRR in all years except one. In that one exception year, the portfolio receives a *shock-return* based on assumed risk and return levels[2]. To illustrate, the "Annual Portfolio Value per Shock Year" chart compares the annual values of a portfolio that monotonically hits its IRR (the Ideal portfolio) versus those that underperform in years 15 and 30 respectively. Year 30 is exhausted first due to the fact that its shock year occurs when the portfolio is near its maximum dollar value, illustrating the timing aspect of SRR (note that asset allocations of 15 and 30 have identical long-term investment returns).



[2] In this paper we pick a return from the lower-end (bottom 5%) of a normally distributed expected range of returns. However, other distributions and points therein may be utilized.

We repeat this exercise for each year, taking the value of the Ideal portfolio relative to the shocked portfolio (high ratios indicate higher SRR) and multiply each ratio by the likelihood that its return will be close to the IRR in that year. Investments whose expected returns are far above or below the IRR will have their ratio greatly reduced to reflect the fact that SRR is not as large of a risk to them. We then take the average annual figure and call it the Sequence Ratio (SR ©)[3].

Adjusting the inputs creates different SRs, making the metric portable across investment and cash flow scenarios. The table below shows each input's relationship with SRR. For those interested in stress-testing, each input in the table above may be treated as its own variable, illustrating the expected influence a given input bears on results and extreme cases.

Input	Relationship to Sequence of Returns Risk	Comments
Starting Salary	None	-
Salary Raise	Positive	Assuming retirement spending is based on final salary.
Savings Rate	Negative	-
Retirement Year	Negative	-
Retirement Spending as a % of Salary	Positive	-
Annual Retirement Spending Increase	Positive	-
Life Expectancy	Positive	-
Expected Return	Negative	-
Expected Risk	Positive	May be negative if expected return is far below IRR.

Initial Testing

The next step is to calculate SRs for a few scenarios and see if the results generally match the intuition that a higher SR implies higher SRR. The results in "SR (bolded) by Investments and Saver Type" generally show a positive relationship between SR and the proximity of IRR (which in turn is derived from expected cash flows) to expected return. The Low Saver scenario, for example, has the highest return requirement (IRR = 14.7%) and Small Cap Stock, whose expected return is 14.1%, has the highest SR. In the High Saver scenario Cash has the highest SR as its expected return is comparable to the IRR. Volatility also influences the results. For example, Small Cap Stock has the highest SR by a small margin in the Mid Saver scenario despite having an expected return that is close to twice the IRR, reflecting the fact that its expected risk is over twice that of the 60/40 portfolio. Generally, when either comparable volatility reduction or return enhancement are viable (all else held equal), the results suggest the former is more effective in lowering the SR.

[3] The specific formula is: Average [(Value of Ideal Portfolio in Year $_{1, 2, \ldots x}$ / Value of Shocked Portfolio in Year$_{1, 2, \ldots x}$) x (0.5-absolute value (percentage probability of achieving the IRR in year$_{1,2,\ldots x}$ – 0.5)] .

SR (bolded) by Investments and Saver Type

Investments/ Saver Type	Cash	60/40	Small Cap Stock
Low Saver	**0.00**	**0.70**	**1.38**
Mid Saver	**0.06**	**0.51**	**0.55**
High Saver	**0.49**	**0.27**	**0.35**
Expected Return	3.1%	9.7%	14.1%
Expected Risk	2.6%	10.2%	20.7%

Assumptions by Saver Type

Raise	Savings Rate	Ret. Yr.	Ret. Spend / Salary	Ret. Spend Raise	Years in Ret.	IRR
2.0%	5.0%	25	80.0%	2.0%	40	14.7%
1.0%	10.0%	33	70.0%	1.0%	32	7.4%
0.0%	15.0%	40	60.0%	0.0%	25	3.0%

Expected return is the arithmetic average of annual returns of Ibbotson indexes for Cash, a 60/40 allocation to Large Cap and Intermediate-Term Government Bonds, and Small Cap Stock from 1988-2017. Expected risk is the standard deviation of these annual returns.

Validating SR

While SR might seem like a plausible risk metric thus far, the question of whether it provides useful additional information not already captured in standard risk analyses needs answering. To address this question, we perform a monte carlo analysis for each saver and investment allocation wherein the portfolio receives its investment returns shock at retirement versus a base case where no such shock occurs[4]. In theory, *obtainable* investment success should be reduced as SR rises. The table below compares investment success for the Low, Mid, and High Savers in "No Shock" and "Shock at Retirement" scenarios. Small Cap Stock's high SR corresponds to a significant change in investment success for the Low Saver.

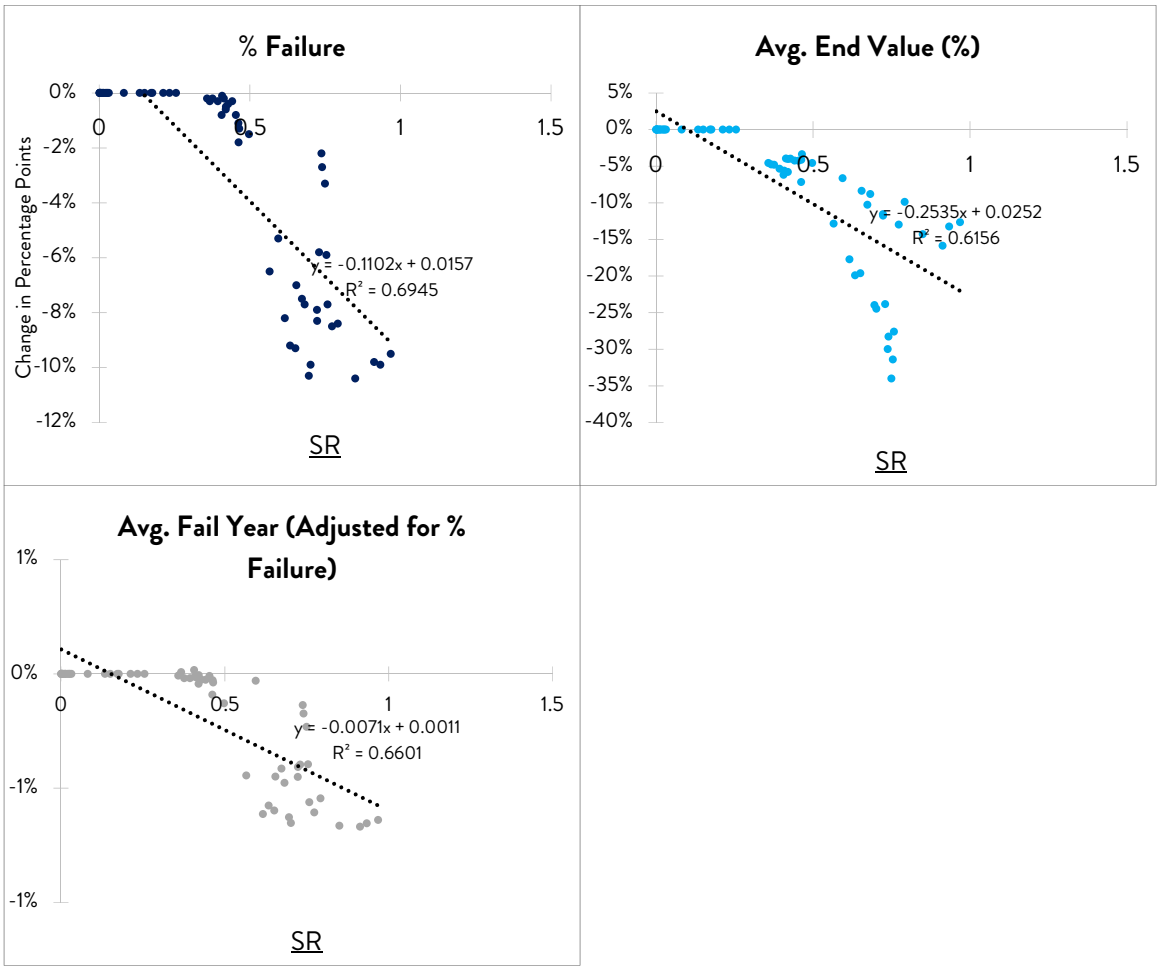
		Low Saver			Mid Saver			High Saver		
		Cash	60/40	Small Cap Stock	Cash	60/40	Small Cap Stock	Cash	60/40	Small Cap Stock
No Shock	% Failure	100.0%	99.7%	81.9%	100.0%	13.1%	7.8%	46.5%	0.0%	0.2%
	Avg. Fail Year	26.0	30.3	33.1	39.4	52.8	46.7	62.5	NA	50.0
	Avg. End Value ($)	$0.0	$0.2	$482.7	$0.0	$188.2	$2,848.9	$1.4	$495.1	$4,657.4
Shock at Retirement	% Failure	100.0%	99.8%	88.7%	100.0%	17.6%	11.2%	52.1%	0.0%	0.4%
	Avg. Fail Year	25.0	28.4	30.6	38.2	51.6	46.0	61.2	NA	50.5
	Avg. End Value ($)	$0.0	$0.1	$362.6	$0.0	$168.5	$2,697.6	$1.2	$478.6	$4,502.5
Change in Investment Success	% Failure	0.0%	-0.1%	-6.8%	0.0%	-4.5%	-3.4%	-5.6%	0.0%	-0.2%
	Avg. Fail Year	-1.0	-1.8	-2.5	-1.2	-1.3	-0.7	-1.3	0.0	0.5
	Avg. End Value (%)	0%	-59%	-25%	0%	-10%	-5%	-18%	-3%	-3%
	SR	**0.00**	**0.70**	**1.38**	**0.06**	**0.51**	**0.55**	**0.49**	**0.27**	**0.35**

Uncoincidentally, Small Cap Stock has the most uncertain probability of success in this scenario (the others being nearly sure failures). Likewise, Cash has the highest SR and most uncertain outcome in the High Saver scenario. In statistical terms, the correlation between the SR and the change in % Failure is -0.72, indicating that SR does generally provide additional information that has not been provided in an already robust risk analysis. While it is not always indicative (for example the Low Saver, 60/40 scenario's relatively high SR of 0.70 did not correspond to a material change in outcomes), an SR above 0.50 tends to correspond to a

[4] Investment returns in the "No Shock" scenario are evenly adjusted downwards to have equal long-term investment returns as the "Shock" scenario. Not doing so would positively bias the returns of the "No Shock" scenario.

material change in success. Correlations between SR and "Avg. Fail Year" and "Avg. End Value (%)" are -0.57 and -0.85 respectively.

For good measure we generate an additional twenty hypothetical "Savers" with savings and spending patterns at random points between those of the original Low and High Savers. We then calculate their SR under a Cash, 60/40, and Small Cap Stock portfolio (creating sixty SRs) and perform the same exercise as above to compare the relationship between SR and percentage changes in investment success. The accompanying charts show the negative relationships between SR and the various measurements representing changes in investment success[5]. Generally, SRR tends to exert marginal influence on outcomes for SRs over 0.50. Likewise, the many SRs below 0.50 represent cases where outcomes did not change between a standard monte carlo and shock at retirement scenario (i.e. no false negatives). The reader may also note that the range of SR values is fairly low and stable, which also can facilitate comparisons.



[5] Removing Cash (which has the lowest average SR), 60/40, or Small Cap Stock (highest SR) from the sample set does not alter the general results.

Conclusion

This paper's main objective is to perform the fundamental legwork of creating a risk metric. That being presumably done, potential applications or modification of SR are countless. In terms of applications, many present-day investment products (such as target date funds, pensions, health and welfare trusts, etc.) may be analyzed in conjunction with their expected cash flows to determine where SRR is most severe. This in turn can help steer investors towards solutions that are efficient in terms of SRR as well as standard analyses. In terms of modifications, SR's inputs can be altered extensively. Practitioners may wish to use different and multiple risk and return assumptions overlapping with a variety of savings scenarios. Overall, SR offers a new and useful vantage point to address what can be a very confounding investment risk.