Safe Withdrawal Rates:
A Guide for Early Retirees

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Abstract: When talking about withdrawal rates in retirement it's hard to ignore the 4% rule. The origin of this rule goes back to the work of Bengen (1994, 1996, 1997, 2001) and Cooley, Hubbard and Walz (1998, 2011), more commonly known as the Trinity Study. The Trinity Study showed that withdrawing 4% of the portfolio value at the beginning of retirement and subsequently adjusting the withdrawals for inflation, will likely sustain a 30-year retirement in a portfolio comprised of 50-100% stocks and 0-50% bonds. This result is relevant to the average retiree with a horizon of only 30 years and not the typical early retiree with a much longer horizon, though. We perform extensive simulations and case studies targeted at early retirees and show that the longer horizon and today's expensive equity valuations will likely necessitate a lower initial withdrawal rate.

About the author: Mr. ERN and his wife plan an early exit from the job market, probably in early 2018. Researching blogs on early retirement, they became excited enough about the topic to open their own personal finance blog, www.earlyretirementnow.com, where they write about all aspects of investing for and during retirement. Mr. ERN is actually a "Dr. ERN" having earned a Ph.D. in economics. He currently works for a large Wall Street firm, researching economics and its implications for investment strategies and asset allocation.

1 Introduction

Initially published as The Ultimate Guide to Safe Withdrawal Rates – Part 1: Introduction on December 7, 2016.

We just calculated over 6.5 million safe withdrawal rates. Well, not by hand, of course, but by writing a computer program that loops over all possible combinations of retirement dates, and other model parameters. Not a big surprise here, but it took a lot of work to put this together. We can't possibly fit all results into one single post, so we publish our results in multiple parts. Today, we briefly introduce our research and some baseline results. Stay tuned for more to come in the next few weeks/months!

The plan to work on this research came after one of those moments when we realized that if you want something done right and exactly applicable to our own situation, we just have to do it ourselves. We wanted to do a lot more robustness analysis than we had seen anywhere in the blogging world.

1.1 Nonconformist among the nonconformists

When talking about withdrawal rates in retirement it's hard to ignore the 4% rule. The origin of the 4% rule goes back to the work of Bengen (1994, 1996, 1997, 2001) and Cooley, Hubbard and Walz (1998 and

2011), more commonly known as the Trinity Study. The Trinity Study showed that withdrawing 4% of the portfolio value at the beginning of retirement and subsequently adjusting the withdrawals for inflation, will likely sustain a 30-year retirement in a portfolio with 50-100% stocks and 0-50% bonds. This result is tailored to the average retiree with a horizon of only 30 years, though and not the average early retiree with a much longer horizon.

Intriguingly, very few early retirement planners or bloggers question the validity of the 4% safe withdrawal rate rule. When you retire in your 30s or even 40s you are by nature nonconformist. You question the consensus, the people with the McMansions and the full-size SUVs in the driveway. People who are otherwise extremely suspicious about everything consensus suddenly eat up the 4% rule without much questioning or checking under the hood:

- People take the Trinity Study at face value, extrapolate the 30-year windows from Trinity to 50+ years (bad, bad, bad idea!!!),
- wave their hands about how the 4% rule did just fine in 2001 and 2008 (believe me, it didn't),
- wave their hands about how one can just slow consumption growth (who knew it was that easy?),
- and by the way, Social Security will also save your behind come age 67 (good luck with that!).

Has anybody actually done any *serious* simulations that are truly applicable to the FIRE community? Something comparable to the original Trinity Study, but with more bells-and-whistles and robustness checks applicable to the FIRE community? I don't like the "hand-me-down" research targeted at my parents' retirement. So, when you want something done, and done right, you gotta do it yourself! Which is what we did with the 6.5 million safe withdrawal rates.

1.2 What we do to be more relevant for early retirees

1. The study is done at a monthly frequency (not just annual like cFIREsim), starting with equity and bond returns in January 1871 and going through September 2016. It would be unrealistic for us to withdraw funds only once per year at the beginning of the year and have – on average – 6 months of cash sitting around in our checking account.
2. We look at the sustainable withdrawal rates over 30, 40, 50, and 60-year windows. It's still a good idea to keep the 30-year window for comparison, though this window length is simply too short for us in the early retirement community.
3. We look at different target final values, i.e., calibrate maximum withdrawal rates to deplete the capital (final value=0), preserve the inflation-adjusted initial capital (final value=100% of initial value) and some steps in between (final value=25%, 50%, 75% of inflation-adjusted initial value). This is useful for retirees who are uncomfortable with the idea of running out of money at some future date and/or plan to leave a bequest to their children, grandchildren, and charitable organizations.
4. We extrapolate past the current history and append equity and bond returns after September 2016. To this end, we assume long-term average returns for equities going forward (about 6.6% real p.a.). For bonds, we assume a low real return over the first 10 years: only 0% real p.a., which is actually slightly above the 9/30/2016 10Y yield (1.61%) minus the inflation expectation at the time (~2%). After the initial 10 years, bonds too will return their long-term average of 2.6% real per year. We

should note that these return assumptions are likely going to generate higher sustainable withdrawal rates due to the absence of return volatility.

5. We study how different the safe withdrawal rates and success probabilities were in various equity valuation regimes. Specifically, how do safe withdrawal rates and success probabilities look like for different Shiller CAPE ratio regimes? We did a similar study before using cFIREsim.com, but now we can rely on our own monthly simulations and easily loop over all sorts of other model parameter values.

6. We can study the impact of reducing the monthly withdrawals over time. This mimics the assumption that some people consume less as they age. Or we can take into account the impact of lower withdrawals once retirees start collecting Social Security.

7. We study how alternative withdrawal strategies, e.g., dynamic withdrawal rules rates based on equity valuation (Shiller CAPE) would have performed during this time.

1.3 Methodology in detail

We use monthly total return data (including dividends/interest) for the S&P500 and 10-year Treasury Bonds from January 1871 to September 2016. We realize that some other researchers use slightly higher yielding corporate bonds. Notice, though, that this higher yield comes at the price of higher correlation with equities and thus less diversification. Our analysis yielded that the exposure in the LQD ETF (iShares investment-grade corporate bonds) has roughly the exposure of 75% government bonds (IEF = 7-10-year US Treasuries) and 25% US equities (VTI = Vanguard US Total Equity Market ETF). So, a 60% equities 40% corporate bond portfolio has about the same return characteristics as a 70% equities, 30% government bond portfolio if you like to translate our portfolio weights into a Stock vs. Corporate Bond portfolio. The Barclays Agg (iShares ticker AGG) is somewhere in between.
Monthly returns and monthly CPI inflation are translated into monthly real returns. We assume that the retiree has withdrawn an initial amount equal to one-twelfth of the targeted withdrawal rate at the market closing price of the previous month. The remainder of the portfolio grows at the real market return during the current month. At the end of the month the retiree withdrawals the next monthly installment and rebalances the portfolio weights to the target equity and bond shares. We assume that the portfolio is subject to a 0.05% drag from fees for low-cost mutual funds.

1.4 Why 6.5 Million Safe Withdrawal rates?

We calculate safe withdrawal rates for **all possible combinations** of 1) starting dates, 2) retirement horizons, 3) equity weights, 4) final asset values and 5) withdrawal patterns:

- 1739 possible retirement start dates between February 1, 1871, and December 1, 2016.
- 4 different retirement horizons: 30, 40, 50, and 60 years
- 21 different equity weights from 0% to 100% in 5% steps (bond weight = 100%-equity weight)
- 5 different final asset value targets: 0%, 25%, 50%, 75% and 100% of real inflation adjusted initial asset value
- 9 different withdrawal patterns. The baseline assumes that withdrawals are adjusted in line with CPI inflation, but we also allow for slower than CPI-growth. We also check how lower withdrawal rates

20 or 30 years after the retirement start date (to account for Social Security income) will impact the maximum sustainable withdrawal rates.

Hence, we calculate 1,739 x 4 x 21 x 5 x 9 = 6,573,420 different safe withdrawal rates.

1.5 Base Case Results

Here's a table, roughly the same structure as they use in the Trinity Study. Major changes:

1. we use retirement lengths of 30-60 years and

2. withdrawal rates only between 3% and 5% in 25 basis point step. No serious long-term retirement planner with a horizon of 50-60 years would ever even consider a withdrawal rate above 5%, anyway, given that equities return "only" about 6.6% and you have to account for volatility and sequence of return risk.

The success criterion is a final asset value of zero as in the Trinity Study.

All Observations		Annualized Withdrawal Rate of as % of Initial Portfolio Value, then adjusted for CPI								
Final Asset Value Target = 0		3.00%	3.25%	3.50%	3.75%	4.00%	4.25%	4.50%	4.75%	5.00%
100% Stocks	30 Years	100%	100%	100%	99%	97%	94%	91%	86%	82%
	40 Years	100%	100%	99%	97%	93%	88%	84%	80%	76%
	50 Years	100%	100%	99%	95%	90%	85%	81%	77%	73%
	60 Years	100%	99%	98%	94%	89%	84%	80%	75%	70%
75% Stocks	30 Years	100%	100%	100%	100%	99%	95%	90%	84%	80%
	40 Years	100%	100%	100%	98%	93%	86%	82%	76%	69%
	50 Years	100%	100%	99%	94%	88%	82%	76%	69%	62%
	60 Years	100%	100%	97%	92%	85%	80%	71%	65%	58%
50% Stocks	30 Years	100%	100%	100%	100%	95%	91%	85%	77%	70%
	40 Years	100%	100%	98%	93%	86%	76%	65%	59%	51%
	50 Years	100%	98%	93%	85%	74%	63%	55%	46%	41%
	60 Years	100%	96%	89%	79%	65%	57%	48%	42%	36%
25% Stocks	30 Years	100%	100%	98%	90%	80%	70%	63%	57%	51%
	40 Years	97%	89%	77%	64%	55%	47%	37%	34%	32%
	50 Years	85%	75%	62%	51%	40%	34%	31%	29%	23%
	60 Years	78%	65%	51%	39%	33%	31%	27%	21%	17%
0% Stocks	30 Years	89%	80%	68%	61%	54%	50%	45%	40%	34%
	40 Years	64%	56%	47%	39%	33%	29%	24%	21%	18%
	50 Years	50%	39%	31%	27%	23%	19%	14%	12%	9%
	60 Years	35%	30%	25%	22%	16%	12%	9%	7%	7%

Success Rates for different SWRs, by equity share and retirement horizon (1871-2015)

A few conclusions from this table:

- The success rates for a 30-year horizon are roughly consistent with the Trinity study.

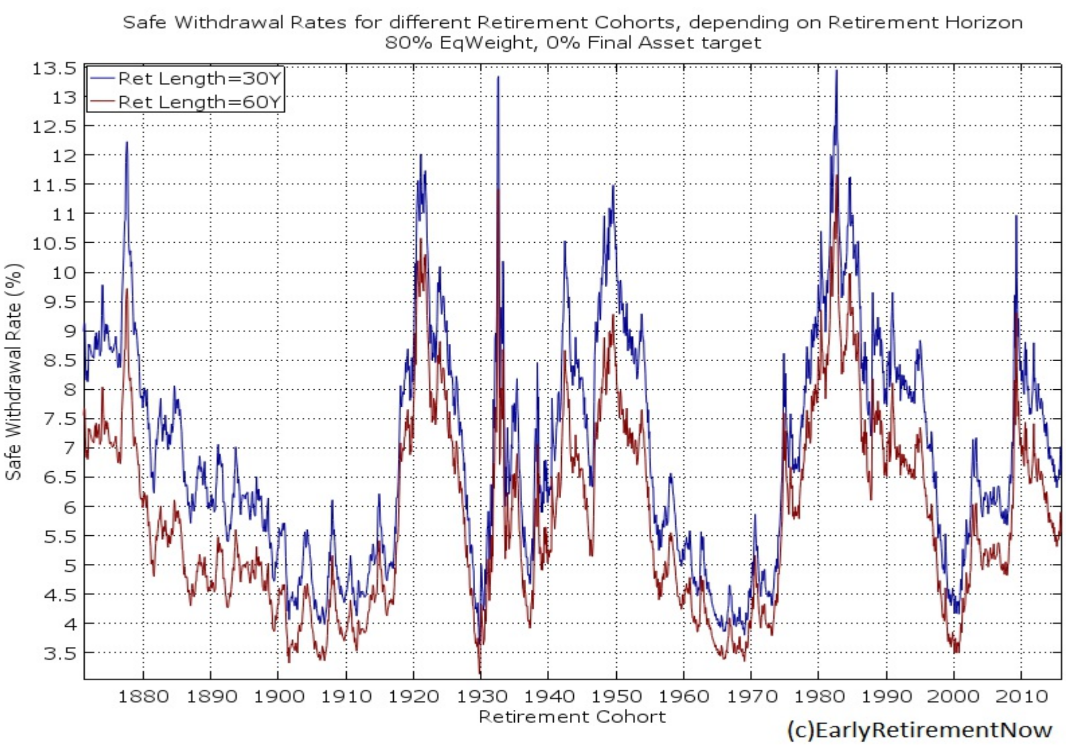
- Success probabilities stay very high at all horizons when using 75-100% equity shares and withdrawal rates of 3.5% and under.

- Success probabilities deteriorate quite a bit when the retirement horizon goes from 30 to 60 years.

- It may be true that for a 30-year horizon, an equity share of 50-100% gives consistently high success rates if the withdrawal rate is 4% or lower. Essentially the main result of the Trinity Study! But for longer horizons, 100% stocks gives the highest success rate. This goes back to our earlier research that showed that over long horizons bonds can have extended drought periods and only equity-like returns are a guarantee for not running out of money over long horizons. For example, a 4% withdrawal rate has a 95% success probability in a 50%/50% over 30 years, but only 65% over 60 years. The failure probability is 7 times higher over the 60-year horizon!

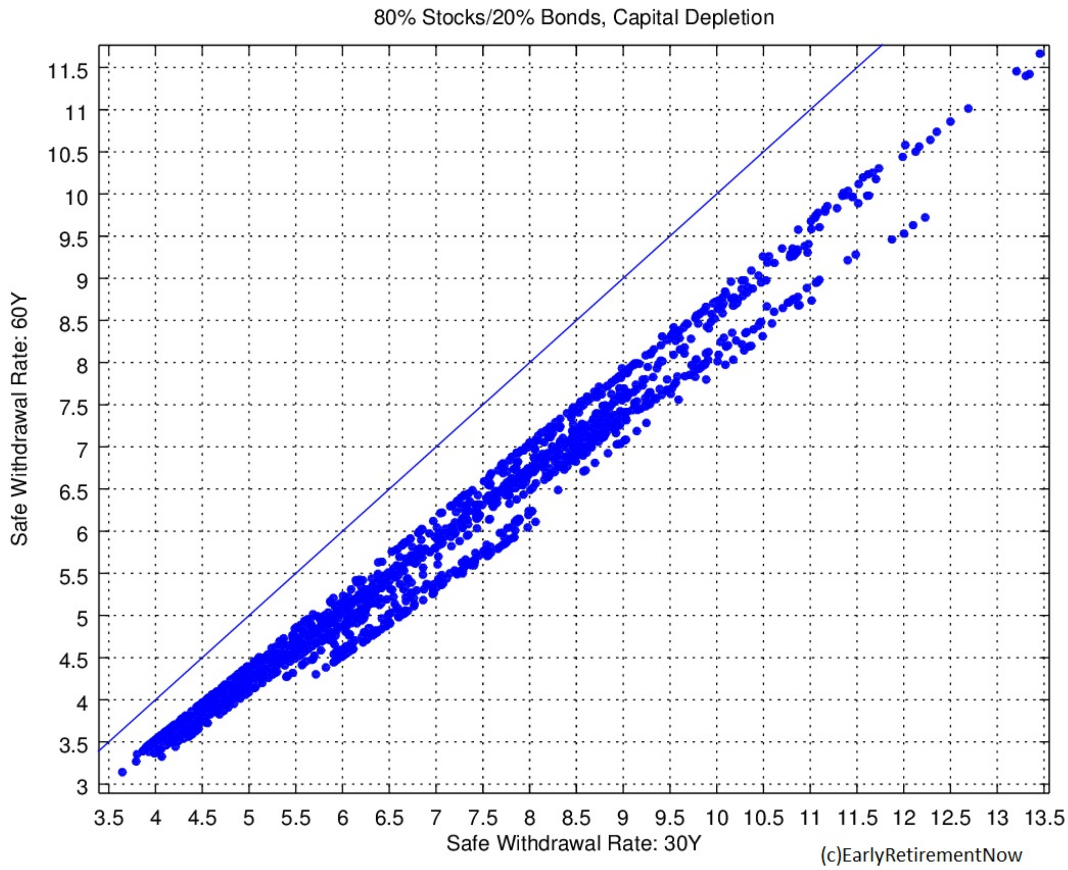
- A 5% withdrawal rate would have an unacceptably low success rate even after 30 years, and certainly after 60 years. As stated above, no early retiree should get anywhere close to a 5% withdrawal rate.

Another way to look at the data: Plot a time series chart of different safe withdrawal rates over time both for 30-year and 60-year horizons. In the chart below I use an 80% equity weight and 20% bond weight, pretty common among blogger. Unsurprisingly, the 60-year withdrawal rates are significantly below the 30-year rates. There are only a few occasions where the 30-year SWR drops below 4%, but a 60-year retirement horizon has a few stubbornly long episodes with 3.5-4% withdrawal rates. As our blogging friend FinanciaLibre pointed out, 3.5% is the new 4%, and here's our confirmation! [spoiler alert: in future posts, we will show that you'd likely have to reduce the 3.5% even further to account for a) today's high CAPE ratio and b) a higher final asset target!!!]



Safe Withdrawal Rates: 30 vs. 60-year horizons: 80% Stocks, 20% Bonds

Another way to slice the data; same chart but as a scatter plot instead of time series chart, see below. The 30-year safe withdrawal rate is on the x-axis and 60-year withdrawal rate is on the y-axis. The dots are all under the 45-degree line, no surprise here! On average, the 60-year SWR are more than a full percentage point below the 30-year SWR (below the 45-degree line), but in the region where it really matters, when the SWRs are low, the difference is "only" about 0.5%.



Safe Withdrawal Rates: 30-year horizon (x-axis) vs. 60-year horizon (y-axis). Blue line = 45-degree line

2 Capital Preservation vs. Capital-Depletion

Initially published as The Ultimate Guide to Safe Withdrawal Rates – Part 2: Capital Preservation vs. Capital Depletion on December 14, 2016.

Today's post deals with an important issue that all retirees (whether retiring early or in their mid-60s) should ask themselves: **Do we want to deplete our savings or maintain a certain minimum real value of the principal to bequeath to our heirs?** We are amazed by how little discussion there is in the personal finance community about this. Hence, today's topic:

2.1 Capital Preservation vs. Capital Depletion

1. **capital preservation**: target a certain minimum asset level (as % of the initial value) at the end of the retirement horizon. Under full capital preservation we'd aim to keep the real, inflation-adjusted value constant, by consuming "only" the capital gains, dividends, and interest over time, while keeping the principal (plus inflation-adjustment!) in place.

2. **capital depletion**: target a zero (or at least positive) final portfolio value, by consuming gains as well as principal over time

Needless to say, the Trinity Study does its calculations according to strategy 2. In other words, a "success" per Trinity is to not run out of money before the end of year 30. Whether at a 30-year or 60-year horizon, the idea of depleting capital has at least two unsettling features for us:

- We like to leave a bequest to our daughter (and future grandchildren) and several charitable causes.
- We are uncomfortable with the idea of running out of money in our late 80s and being forced to live a less than dignified final years of our retirement or becoming a burden to our daughter.

2.2 The fallacy of extrapolating from 30-year to 60-year windows

It doesn't take a rocket scientist to realize that capital preservation allows you to withdraw less than capital depletion. How much? That depends on the portfolio returns and the investment/retirement horizon. We found surprisingly little work in the FIRE community dealing with this issue, hence we got the computer running to do some research on our own.

One advantage of targeting capital preservation is that if your withdrawal strategy *preserves* capital for one 30-year window it will likely do so for a second 30-year window. But, if you *deplete* your capital after 30 years, then you cannot keep the same withdrawal rate for another 30 years. This is almost too trivial to point out, but you'll be amazed how often you hear folks on the web mixing up the two. The extrapolation fallacy usually works like this:

"There is a small probability of running out of money after 30 years. But the median final value after 30 years is likely much higher than even the starting value, even adjusted for inflation. So, let's just extrapolate 30-year window to a 60-year window."

Huh? Do you see the fallacy here? The Trinity Study is not about the *median* retiree. It's about the probability of *tail events*. We already know that a median retiree has nothing to worry about if the real withdrawal rate is roughly the same as the real capital market return. But after 30 years, there will be a significant percentage of retirees who will not be counted as a failure in the Trinity Study (portfolio value >0) but their portfolio might have been compromised enough to run dry after another 5 or 10 years. They are the people who will not be able to do a net worth "reset" back to the median after 30 years. That makes this extrapolation fallacy so dangerous.

2.3 Warmup: Some simple calculations

Before we even jump into the simulations, let's do a little warm-up exercise. To gain some insights into why the 60-year withdrawal rates are likely significantly lower than the 30-year rates, let's do some simple calculations in Excel.

Let's assume a constant 4% p.a. real (inflation-adjusted) portfolio return. A retiree with a $1,000,000 portfolio withdraws a fixed amount at the beginning of the first month and then inflation-adjusts the withdrawals every month. Let's calculate how much the retiree can withdraw under the following withdrawal strategies:

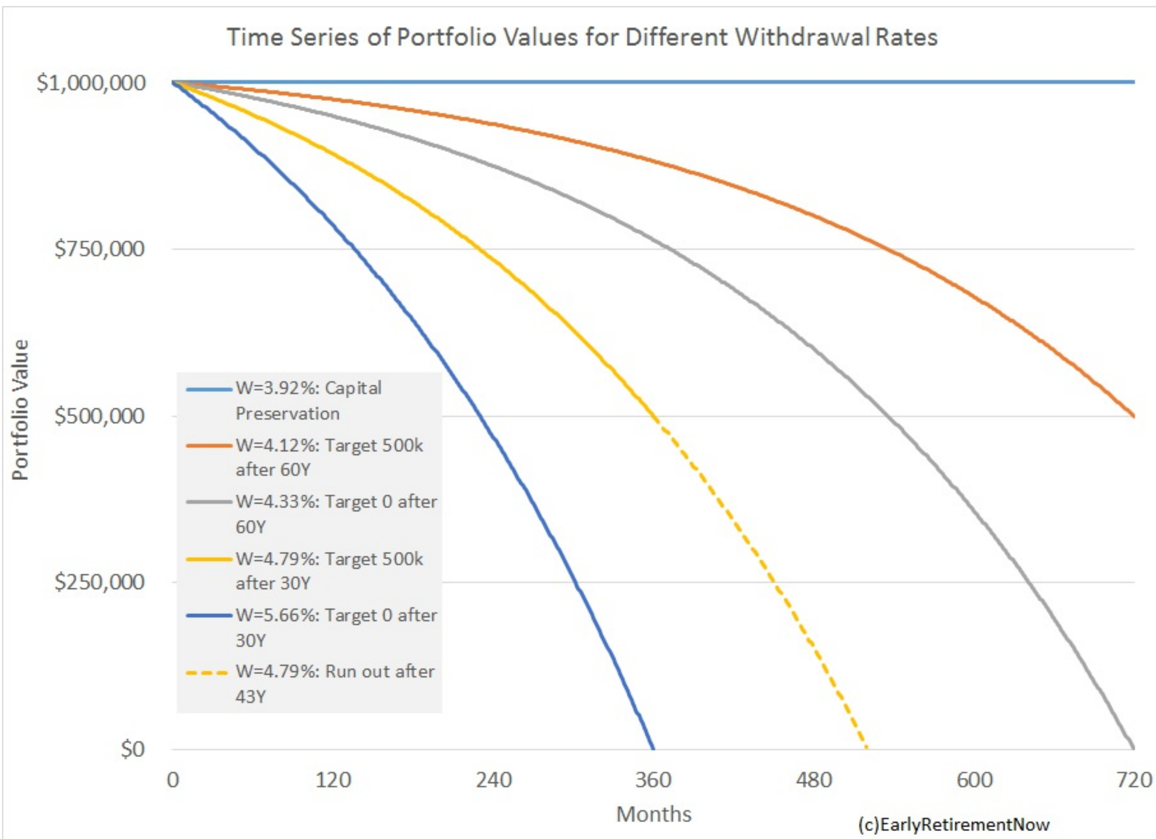
1. Capital Preservation: 3.92%. Why not 4.00%? That's because the initial withdrawal takes place at the beginning, not the end of the month. Who knew that such a trivial difference can make a 0.08% difference in the SWR?
2. Target 50% remaining net worth after 60 years: 4.12%. Amazing, how a 0.20% difference in the withdrawal rate ($167 in the first month) makes a huge difference after 60 years. But then again,

that's 60 years of compound interest for you!

3. Target capital depletion after 60 years: 4.33%. Only another 0.21% increase in the withdrawal rate and we wipe out the capital after 60 years.

4. Target 50% remaining net worth after 30 years: 4.79%. If you wonder how long would the remaining half million last at that withdrawal rate: 13 years (to be precise, 160 months, for a total of 520 months).

5. Deplete the entire portfolio after 30 years (Trinity Study assumption): 5.66%. That's a whopping 1.74 percentage points above the capital preservation rate!



Different withdrawal strategies imply very different maximum withdrawal rates!

What we find intriguing about these numbers is that over a 30-year horizon, the benefit of capital depletion adds 1.74% to your safe withdrawal rate, while over a 60-year horizon depleting your capital adds only 0.41%. That's one of the reasons we believe the Trinity Study is so flawed when applied to the early retirement community; a 60- year retirement horizon is a completely different animal from the Trinity Study 30-year horizon.

2.4 Simulations

The calculations above are all nice, but they are really only relevant for the median retiree. We don't want to commit that same flaw we pointed out above. To determine the *tail event* probabilities, we again have to employ our simulation framework, using monthly asset returns since 1871 to see how different retirement cohorts would have fared under different assumptions. The table below is an extension of the results from last week. We report success probabilities over 30 and 60-year horizons (we leave out the 40 and 50-year figures to keep the table size manageable). The new feature in this table is that we calculate success probabilities not just for a capital depletion target but also for maintaining 25%, 50%, 75%, and 100% of the capital after 30 and 60 years. Note that the success criterion applies only to the *final* period. You could temporarily fall below that target, but as long as you finish above the target, we call it a success.

As we already saw last week, for a 60-year horizon, a withdrawal rate of 3.5% or below and an equity weight of 75% yielded excellent success probabilities. The good news is that targeting a higher final asset value does not mess up our success probabilities much. For example, at 100% stocks and 3.5% withdrawal rate, the success rate drops from 98% to 96% when going from capital depletion to a 100% final target value. Still acceptable! For a 30-year horizon, it's a very different story. At 4% withdrawal rate and 100% equity weight you have a 97% success rate when targeting capital depletion but only 80% success rate when targeting 100% capital preservation. The intuition goes back to the simple Excel calculations: Over 30 years, capital depletion gives you such a big boost to the allowable withdrawal rate because the horizon is so much shorter. Hence, to achieve capital preservation we'd have to either seriously cut our withdrawal rate or accept much lower success rates.

All Observations		Annualized Withdrawal Rate of as % of Initial Portfolio Value, then adjusted for CPI								
Final Asset Value Target = 0		3.00%	3.25%	3.50%	3.75%	4.00%	4.25%	4.50%	4.75%	5.00%
100% Stocks	30 Years	100%	100%	100%	99%	97%	94%	91%	86%	82%
	60 Years	100%	99%	98%	94%	89%	84%	80%	75%	70%
75% Stocks	30 Years	100%	100%	100%	100%	99%	95%	90%	84%	80%
	60 Years	100%	100%	97%	92%	85%	80%	71%	65%	58%
50% Stocks	30 Years	100%	100%	100%	100%	95%	91%	85%	77%	70%
	60 Years	100%	96%	89%	79%	65%	57%	48%	42%	36%
25% Stocks	30 Years	100%	100%	98%	90%	80%	70%	63%	57%	51%
	60 Years	78%	65%	51%	39%	33%	31%	27%	21%	17%
0% Stocks	30 Years	89%	80%	68%	61%	54%	50%	45%	40%	34%
	60 Years	35%	30%	25%	22%	16%	12%	9%	7%	7%

All Observations		Annualized Withdrawal Rate of as % of Initial Portfolio Value, then adjusted for CPI								
Final Asset Value Target = 0.25*Initial		3.00%	3.25%	3.50%	3.75%	4.00%	4.25%	4.50%	4.75%	5.00%
100% Stocks	30 Years	100%	100%	99%	97%	94%	90%	85%	82%	78%
	60 Years	100%	99%	97%	93%	88%	83%	79%	75%	70%
75% Stocks	30 Years	100%	100%	100%	98%	94%	88%	84%	79%	74%
	60 Years	100%	100%	96%	91%	84%	78%	70%	63%	57%
50% Stocks	30 Years	100%	100%	98%	94%	88%	82%	71%	65%	60%
	60 Years	98%	95%	86%	75%	62%	54%	46%	40%	34%
25% Stocks	30 Years	98%	92%	81%	69%	59%	54%	48%	39%	35%
	60 Years	71%	58%	44%	35%	32%	28%	23%	19%	15%
0% Stocks	30 Years	67%	59%	51%	45%	39%	35%	32%	27%	23%
	60 Years	30%	25%	22%	17%	13%	10%	8%	7%	6%

All Observations		Annualized Withdrawal Rate of as % of Initial Portfolio Value, then adjusted for CPI								
Final Asset Value Target = 0.50*Initial		3.00%	3.25%	3.50%	3.75%	4.00%	4.25%	4.50%	4.75%	5.00%
100% Stocks	30 Years	100%	99%	97%	93%	89%	85%	82%	78%	74%
	60 Years	100%	99%	96%	93%	88%	83%	79%	74%	69%
75% Stocks	30 Years	100%	100%	98%	93%	88%	83%	77%	70%	65%
	60 Years	100%	100%	95%	89%	83%	77%	68%	61%	55%
50% Stocks	30 Years	99%	97%	93%	85%	74%	66%	59%	53%	46%
	60 Years	98%	93%	83%	70%	59%	50%	44%	38%	32%
25% Stocks	30 Years	79%	66%	59%	53%	46%	38%	35%	33%	31%
	60 Years	65%	51%	39%	33%	29%	25%	20%	17%	13%
0% Stocks	30 Years	48%	42%	37%	33%	29%	25%	23%	21%	19%
	60 Years	26%	23%	19%	14%	11%	8%	7%	6%	5%

All Observations		Annualized Withdrawal Rate of as % of Initial Portfolio Value, then adjusted for CPI								
Final Asset Value Target = 0.75*Initial		3.00%	3.25%	3.50%	3.75%	4.00%	4.25%	4.50%	4.75%	5.00%
100% Stocks	30 Years	99%	96%	93%	89%	85%	81%	77%	73%	68%
	60 Years	100%	99%	96%	92%	87%	83%	78%	73%	67%
75% Stocks	30 Years	99%	96%	92%	86%	80%	74%	67%	61%	58%
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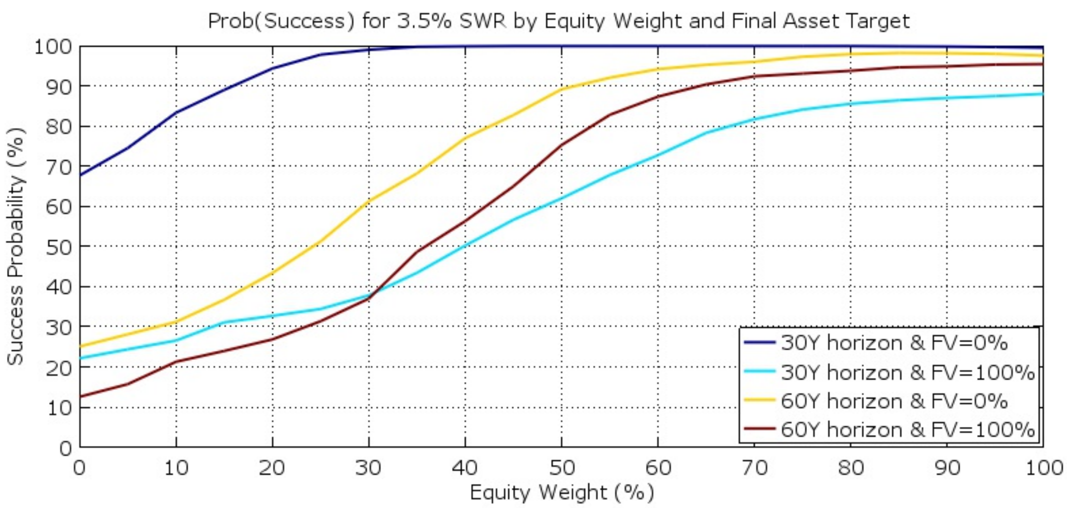
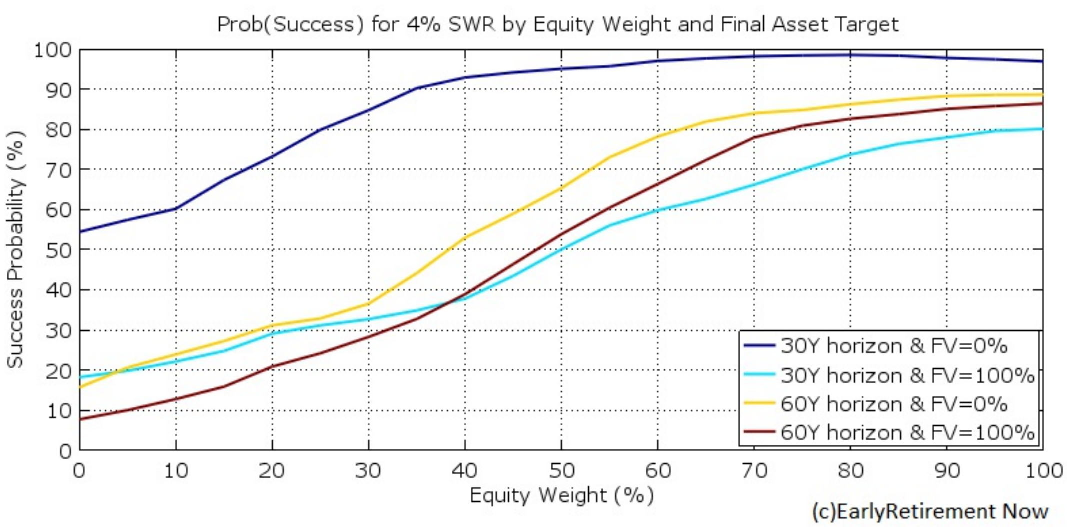
0% Stocks	30 Years	35%	29%	27%	25%	22%	20%	18%	16%	13%
	60 Years	23%	21%	15%	12%	9%	7%	6%	5%	4%

All Observations		Annualized Withdrawal Rate of as % of Initial Portfolio Value, then adjusted for CPI								
Final Asset Value Target = 1.00*Initial		3.00%	3.25%	3.50%	3.75%	4.00%	4.25%	4.50%	4.75%	5.00%
100% Stocks	30 Years	96%	93%	88%	84%	80%	75%	71%	67%	62%
	60 Years	100%	99%	96%	92%	86%	82%	77%	72%	67%
75% Stocks	30 Years	94%	90%	84%	78%	70%	64%	60%	56%	52%
	60 Years	100%	99%	93%	87%	81%	73%	65%	58%	52%
50% Stocks	30 Years	80%	70%	62%	56%	50%	44%	39%	36%	32%
	60 Years	96%	88%	75%	62%	54%	46%	40%	34%	29%
25% Stocks	30 Years	47%	38%	34%	33%	31%	29%	27%	22%	19%
	60 Years	52%	38%	31%	27%	24%	20%	16%	13%	11%
0% Stocks	30 Years	26%	24%	22%	20%	18%	15%	12%	10%	9%
	60 Years	22%	17%	13%	10%	8%	7%	6%	5%	3%

Success Probabilities for different Withdrawal Rates, Equity Shares, Retirement Horizons and Final Asset Target Values

We also found some interesting insights when plotting the success probabilities of different withdrawal strategies as a function of the equity weight, see chart below. It's basically some of the same information as in the table above, but easier to visualize. The top chart is for a 3.5% withdrawal rate and the bottom chart for the 4% rate. Each chart has 4 lines for the different combinations of 30-year and 60-year retirement horizons, each with capital depletion (FV=0%) and capital preservation (FV=100%).





How to trash the Trinity Study with one single chart: Success probabilities as a function of the equity share (x-axis), two different withdrawal rates (top/bottom chart) for four different withdrawal strategies.

The dark blue line (30Y horizon, capital depletion) is what the Trinity Study is all about. And, according to this chart, it's a completely different animal (probably a different animal from a different continent) from the other three lines:

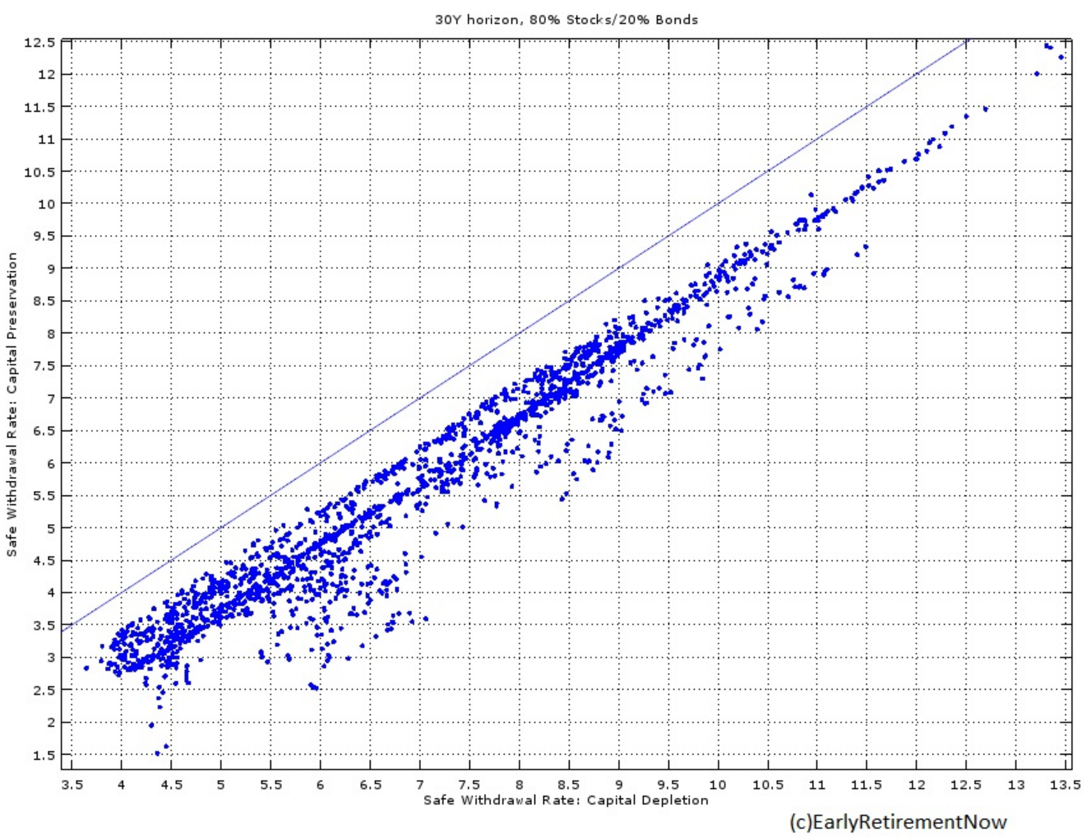
- Success rates are significantly higher under the Trinity Study assumptions than under the other, FIRE-relevant parameterizations. At 3.5% withdrawal rates, the 30-year, FV=0 rule is pretty much fool-proof even at equity shares significantly below 50%. Not so over the 60-year horizon or for a 30-year horizon with capital preservation. For equity weights between 50% and 100% we face success rates that can be quite a bit lower. For example, look at the 65% success rate vs. 95% success rate for capital depletion, 50% equity weight, and 4% withdrawal rate.

- The retirement horizon has implications for the **portfolio allocation**. While the Trinity Study suggested that pretty much any equity share between 50% and 100% is close to foolproof (and we confirmed that result) the simulations over 60-year horizons suggest that the success probability is monotonically increasing in the equity weight. Even more importantly, the success probabilities seem to drop off quite significantly when going below 70% equity weight. Over longer horizons, bonds are bad!

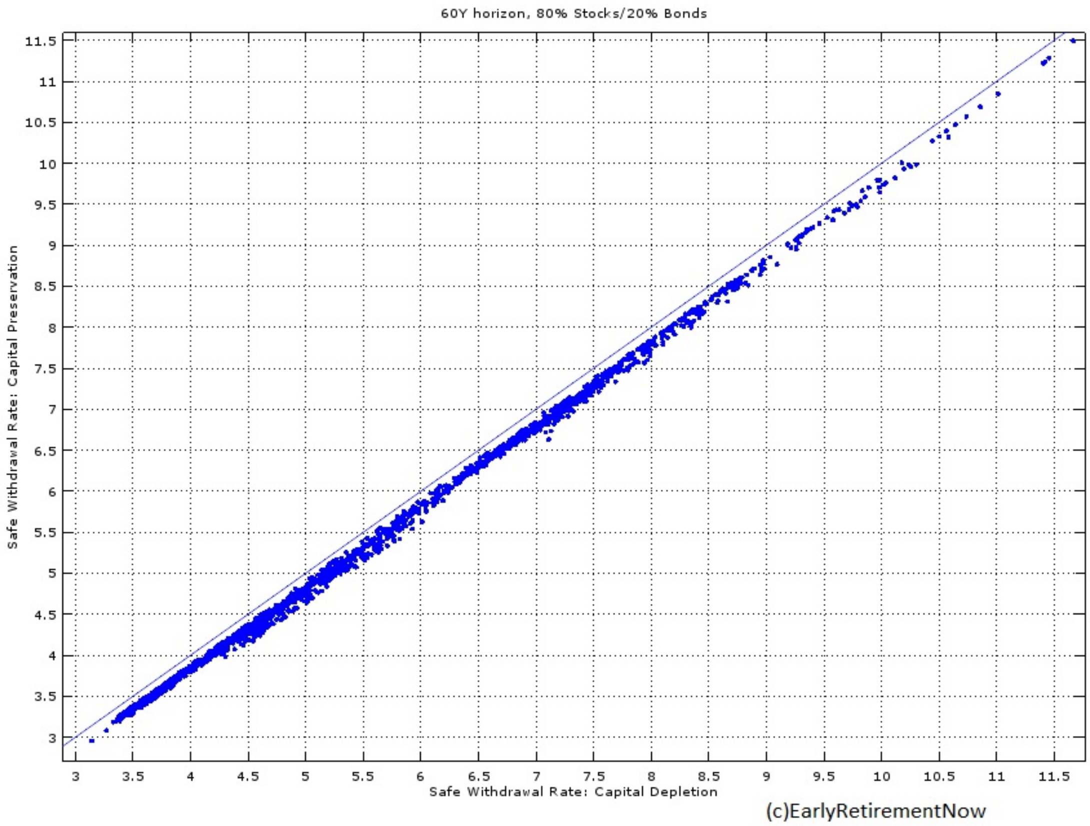
Another intriguing result from this chart: The 60-year capital preservation rule had a slightly *higher* (!) success rate than the 30-year capital preservation rule, at least for high enough equity shares. How is that possible? It's quite intuitive: If your portfolio value was, say, 90% after 30 years, then you would have failed the 30-year capital preservation condition. But with the average portfolio return above 4% for a high enough equity share, you can likely get above the 100% target again over the next 30 years

2.5 Capital Depletion vs. Preservation Scatter Plots

Just like last week, let's create a scatter plot of the maximum allowable withdrawal rates under two different withdrawal strategies. Here are two charts, each with the SWR under capital depletion (FV=0) on the x-axis and under capital preservation (FV=100%) on the y-axis. The first chart for a 30-year horizon and the second chart for a 60-year horizon.



Safe Withdrawal Rates over a 30-year horizon for an 80/20 portfolio: Capital Depletion (x-axis) vs. Capital Preservation (y-axis). Blue line = 45-degree line



Safe Withdrawal Rates over a 60-year horizon for an 80/20 portfolio: Capital Depletion (x-axis) vs. Capital Preservation (y-axis). Blue line = 45-degree line

For a 30-year horizon, the dots tend to fall significantly below the 45-degree line. The median distance is about 1.25%. So, to preserve capital over a 30-year horizon you'd have to cut your SWR by about 1.25 percentage points. Ouch! In contrast, over a 60-year horizon, there is only a relatively tiny distance between the dots and the 45-degree line, only about 0.19%. Lowering the withdrawal rate by less than one-fifth of a percentage point can make the difference between running dry after 60 years and capital preservation. That's good news and bad news at the same time. If you care about leaving a bequest you don't have to curb your consumption by much to ensure maintaining your portfolio value for 60 years. But the bad news is that over a 60-year horizon, small changes in the withdrawal rate can have huge consequences on final outcomes.

Summary

- Safe withdrawal rules *can* be extrapolated when the success criterion is capital preservation, at least if the equity share is high enough.

- If the success criterion is capital depletion, as in the Trinity Study, we should not extrapolate safe withdrawal rules to longer horizons. Our simulations show that your failure rates grow significantly when going from 30 to 60-year horizons. You'd have to apply a 0.50% haircut to the withdrawal rate to achieve the same success rate again.

- Bonds may look attractive in the Trinity Study setting but due to their low expected return (only 2.6% real over the entire time period since 1871) they pose a significant risk of running out of money in the long-run. This is consistent with our earlier post on the long-term risks of low bond returns.

3 Equity Valuation

Initially published as The Ultimate Guide to Safe Withdrawal Rates – Part 3: Equity Valuation on December 21, 2016.

Welcome back to our safe withdrawal rate series! Over the last two weeks, we already posted part 1 (intro and pitfalls of going beyond a 30-year horizon) and part 2 (capital preservation vs. capital depletion). Today's post deals with yet another early retirement pet peeve: safe withdrawal rates are likely overestimated given today's expensive equity valuations. We wrote a similar piece about this issue before, but that was based on cFIREsim external simulation data. We prefer to run our own simulations to be able to dig much deeper into this issue.

So, the point we like to make today is that looking at long-term average equity returns to compute safe withdrawal rates might overstate the success probabilities considering that today's equity valuations are much less attractive than the average during the 1926-current period (Trinity Study) and/or the period going back to 1871 that we use in our SWR study.

Thus, following the Trinity Study too religiously and ignoring equity valuations is a little bit like traveling to Minneapolis, MN and dressing for the **average** annual temperature (55°F high and 37°F low, see source, which is 13 and 3 degrees Celius, respectively). That may work out just fine in April and October when the average temperature is indeed pretty close to that annual average. But if we already know that we'll visit in January and wear only long sleeves and a light jacket we should be prepared to freeze our butt off because the average low is 8°F=13°C! Likewise, be prepared to work with lower withdrawal rates considering that we're now 7+ years into the post GFC-recovery with pretty lofty equity valuations.

How do we account for today's equity valuations? Very simple, we run our simulations and then compute success probabilities, not just averaging over **all** observations but we also bucket the over 1,700 possible retirement start dates in our study by how cheap or expensive equities were at the time. We'll do so by looking at the well-known **CAPE Ratio**.

3.1 A quick CAPE ratio primer

The measure for equity valuation we use is the **CAPE ratio**. We are all familiar with the PE ratio. Price divided by earnings measures how much you're paying per dollar of the current annual earnings (normally a four-quarter trailing E, though PE ratios based on estimates of future earnings are common, too). This is done both on the individual equity level, but also for an index, e.g., the S&P500.

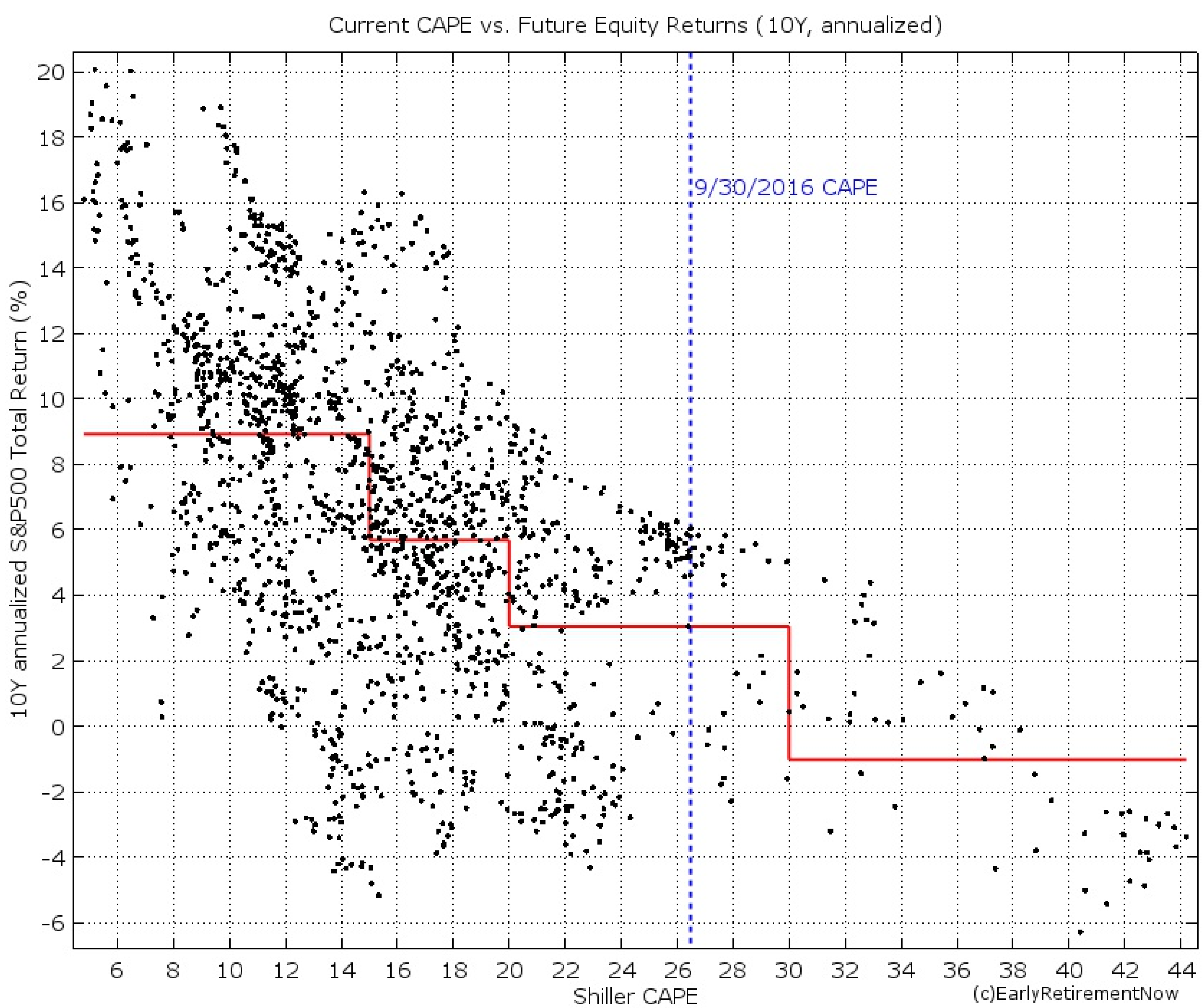
Robert Shiller, who is one of the 2013 economics Nobel Prize winners, introduced another interesting concept: The cyclically-adjusted price earnings (CAPE) ratio (see free data on Shiller's site). It divides today's index level by a 10-year rolling **average** of real (CPI-adjusted) earnings. Think of it as the average real earnings over an entire business cycle. Shiller found that the usual PE ratio is a bit too noisy; remember, you divide two highly volatile series P and E. However, making the E portion of the PE less volatile apparently gives you a sharper predictor of future returns.

The median CAPE ratio is just about 15. Which is quite intriguing because if we were to invert that number 1/15=0.0667=6.67% (= CAE**Y** = cyclically-adjusted earnings **yield**) we'd land almost exactly at the long-term average real equity return of around 6.6% (see more details here). That's more than a coincidence because the real return on the index *should* roughly equal the average real earnings yield in the index. Since 1871, the CAPE was anywhere between 5 when stocks are really cheap at or near the bottom of recessions/bear markets to over 40 at the height of the dot-com bubble. And most importantly:

The Shiller CAPE is correlated with future equity returns

That's right, today's CAPE ratio is pretty good at predicting future equity returns. Well, not perfectly but there seems to be a strong and statistically significant inverse relationship between the CAPE and forward-looking equity returns, see chart below where we plot the CAPE ratio versus the subsequent 10-year annualized S&P500 return. For something as ostensibly unpredictable as stock returns, this is truly amazing. Equity returns are not exactly a random-walk! If we split the CAPE into four regions we get pretty different average equity returns by bin:

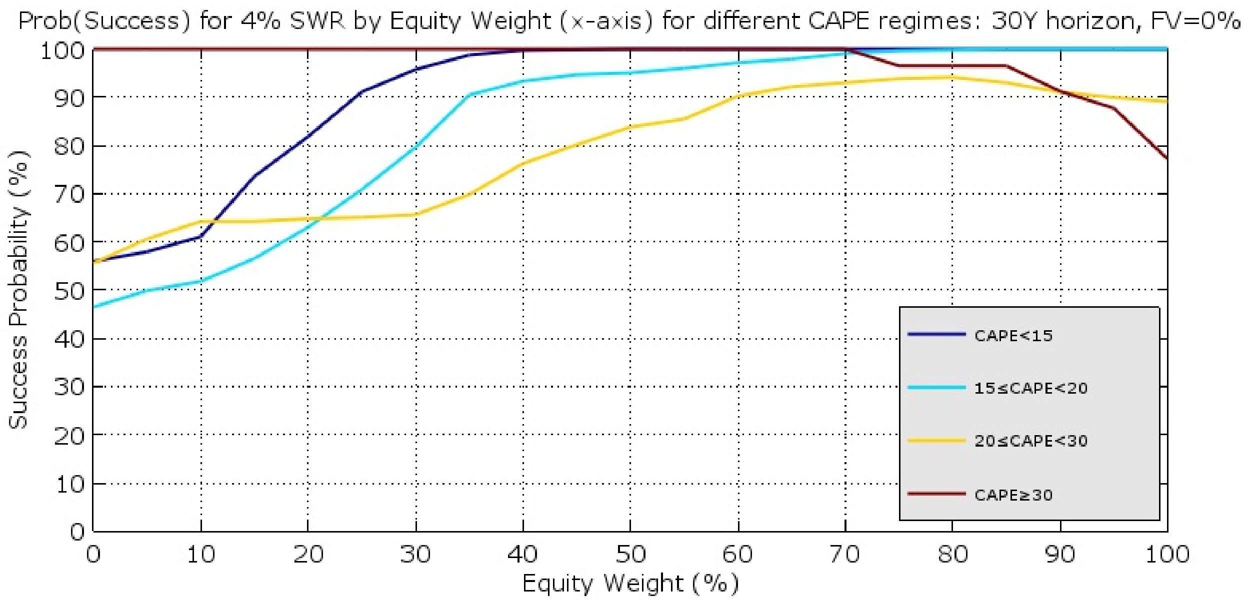
- CAPE below 15 (below the median): Average equity return of 9% real (!)
- CAPE slightly elevated (15-20): Average equity return just under 6%, still very solid returns that will likely support a 4% safe withdrawal rate.
- CAPE moderately elevated (20-30): Only about 3% real return (!) going forward. Today's CAPE falls into this range. The 9/30/2016 level was at just under 27, and after the recent rally, it's even a bit above 27.
- CAPE severely elevated (30+): A below -1% real return over the next ten years. Bummer! Good luck starting your retirement in that environment!

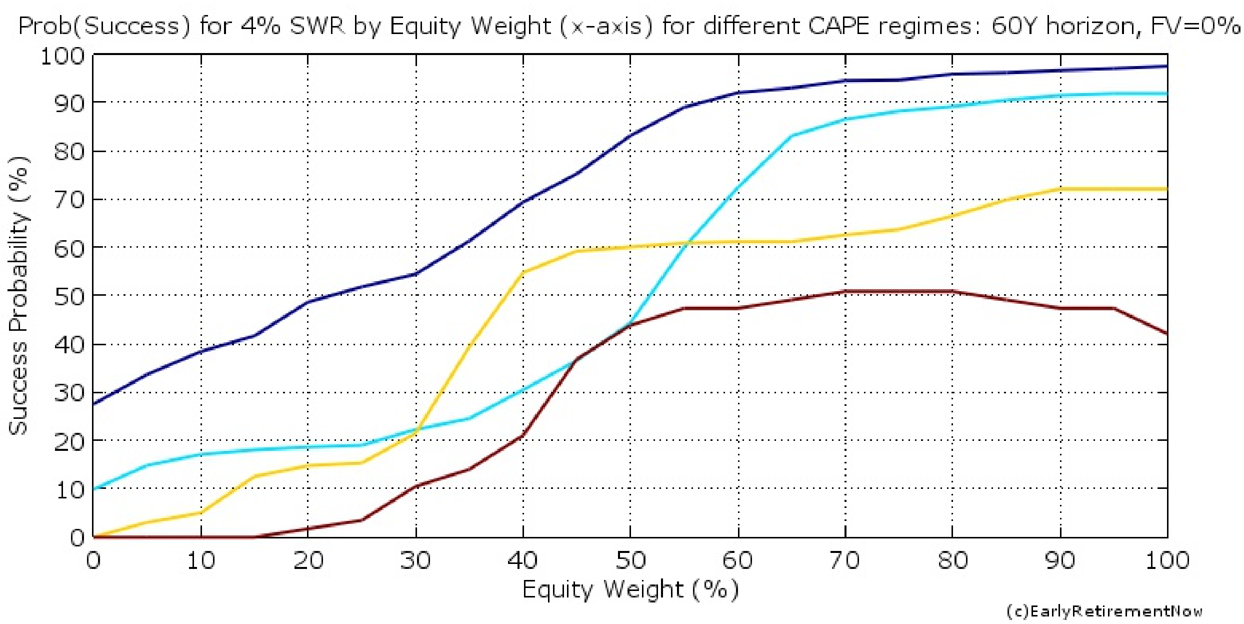


Scatter Plot of Shiller CAPE (x-axis) vs. subsequent 10-year annualized real total return. Red lines = average in the bins CAPE<15, CAPE between 15 and 20, CAPE between 20 and 30, and CAPE above 30.

3.2 Simulation results

Let's look at the Success rates over 30-year (top panel) and 60-year horizons (bottom panel). The charts have the familiar format you might remember from before, plotting the success rates as a function of the portfolio equity share (rest invested in 10Y Treasury Bonds). In this chart, each line corresponds to the success rate of a different CAPE regime at the beginning of the retirement.





Success Rates of the 4% Rule with capital depletion, as a function of the portfolio equity share for different CAPE regimes and different horizons (top=30Y, bottom=60Y)

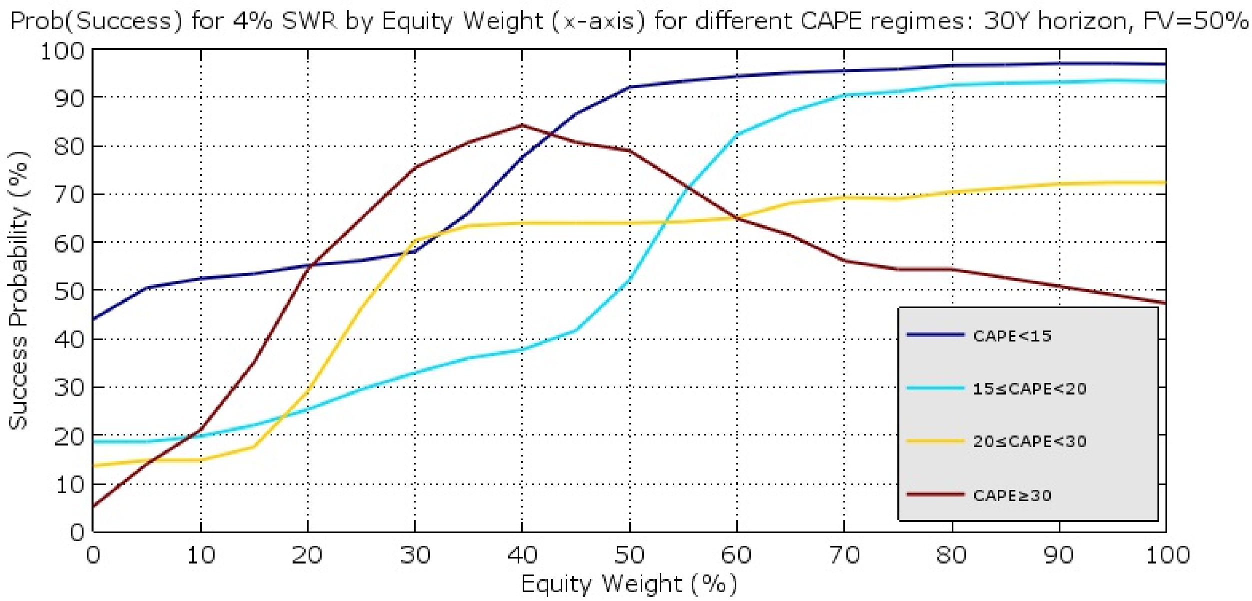
Quite intriguingly, over the 30-year horizon (top panel) and for equity weights greater than 40%, every single failure of the 4% rule occurred when the CAPE was above 20 at the start of the retirement. In contrast, for all CAPE<20 you have a 100% success rate. I wish the original authors of the Trinity Study had dug deeper into when those failures occur.

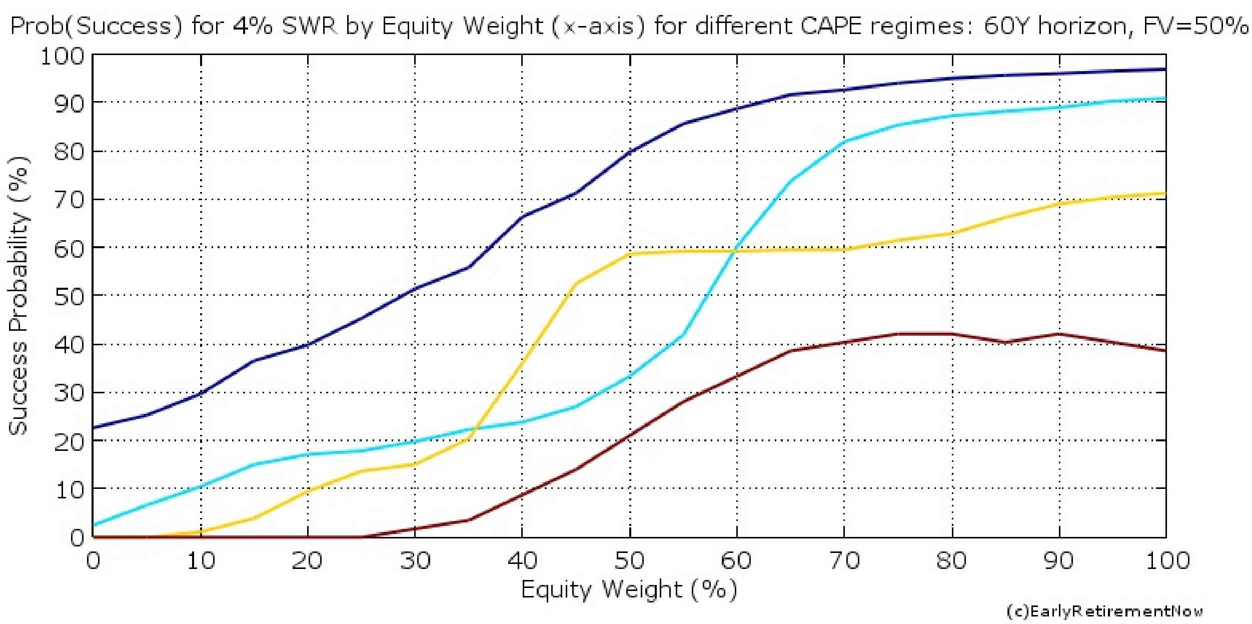
Also, did we mention that a 30-year horizon is a completely different animal from a 60-year horizon? Oh, yeah, we pointed that out before, but just to state the obvious, success probabilities are much, much lower over the longer horizon.

Anyway, the current CAPE of 27 falls smack into the 20-30 region represented by the yellow line. At a 60-year horizon with capital depletion, we are now looking at a 72% success rate with 100% equities (much lower than the 89% success rate over 30 years). Quite amazingly, lowering your equity share in response to expensive equity valuations will actually *lower* (!) your success probability. How crazy is that? True, for a seriously overvalued equity market (CAPE above 30) you do get a bit of a hump-shaped curve (see maroon line in the bottom panel) with a sweet spot between 70 and 80% equity weight (same is true for the 30-year horizon with both the 20-30 CAPE and 30+ CAPE). But for the other three lines in the bottom chart, including the yellow line representing today's regime, we see that the success probability is solidly increasing monotonically in the equity weight. **Equities rule when you're looking at a 60-year horizon!** Again: due to the long horizon, investing in equities is the way to go even if they are overvalued in the short-term. Bonds with a 2.6% long-term real return just threaten your long-term sustainability as we mentioned here. (Of course one solution would be to have a higher bond share only until equities return to a CAPE<20 and then increase the equity share again. But we haven't calculated that yet.)

3.3 Higher final value target

As we stated previously, a zero final asset value is not acceptable to us due to our strong desire to leave a bequest. As expected, once we target a higher than zero final asset value, the success probabilities diminish even more, as we pointed out previously. Below are the charts for targeting a 50% final asset value target.



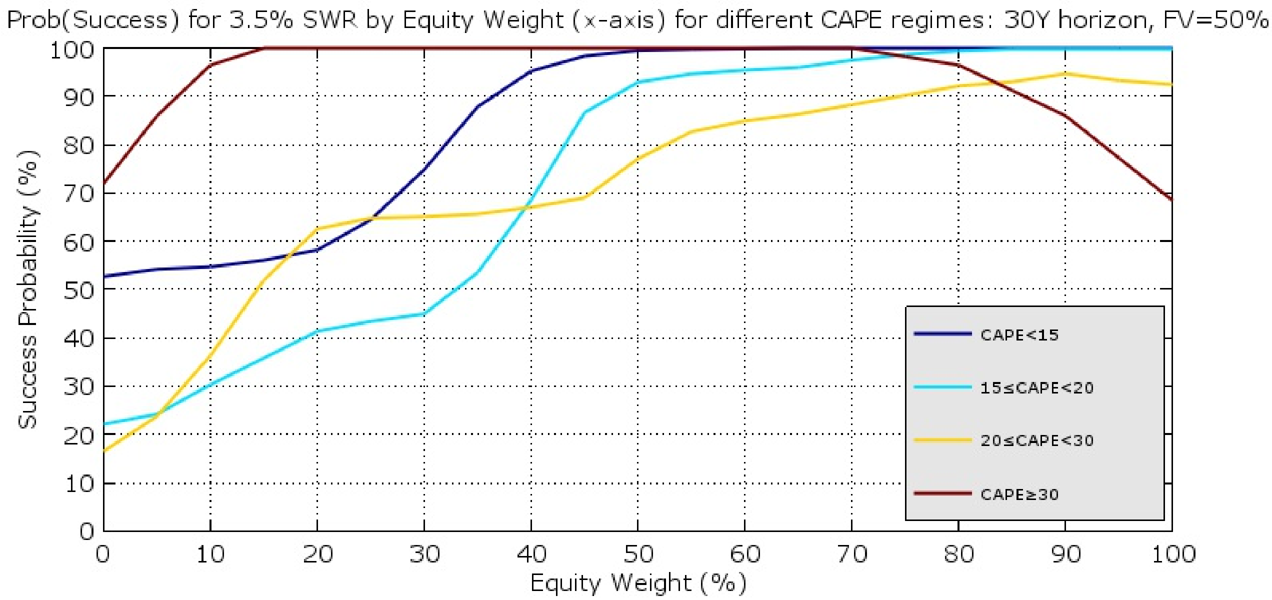


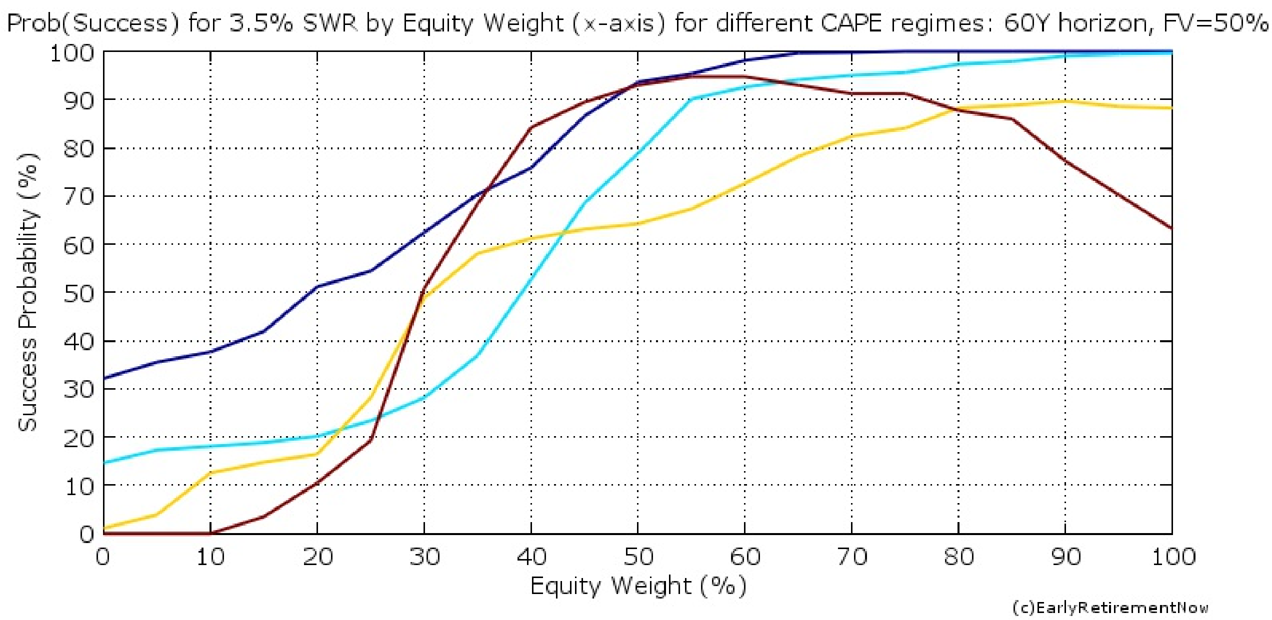
Success Rates of the 4% Rule with a 50% final value target, as a function of the portfolio equity share for different CAPE regimes and different horizons (top=30Y, bottom=60Y)

Now even the CAPE regimes of below 15 or 15-20 no longer guarantee success over a 60-yerar horizon (or even a 30-year horizon for that matter). Bummer! The only good news is that the higher final asset target only lowers the success probability to 71%, from 72% (bottom chart, yellow line, 100% equities).

3.4 Let's lower the SWR to 3.5%

Lowering the withdrawal rate to 3.5% should improve the success rates, as we pointed out last week: at 100% equity share we had a 96% success probability preserving 50% of the final value after 60 years. That rate goes down to 88% when the CAPE ratio is between 20 and 30. Of course, for CAPE values below 20, the 100% equity portfolio had a 100% success rate, both over 30 and 60-year horizons. Nice to know, but again, today's CAPE is at 27. For me personally, a 12% failure probability is still a bit too high.

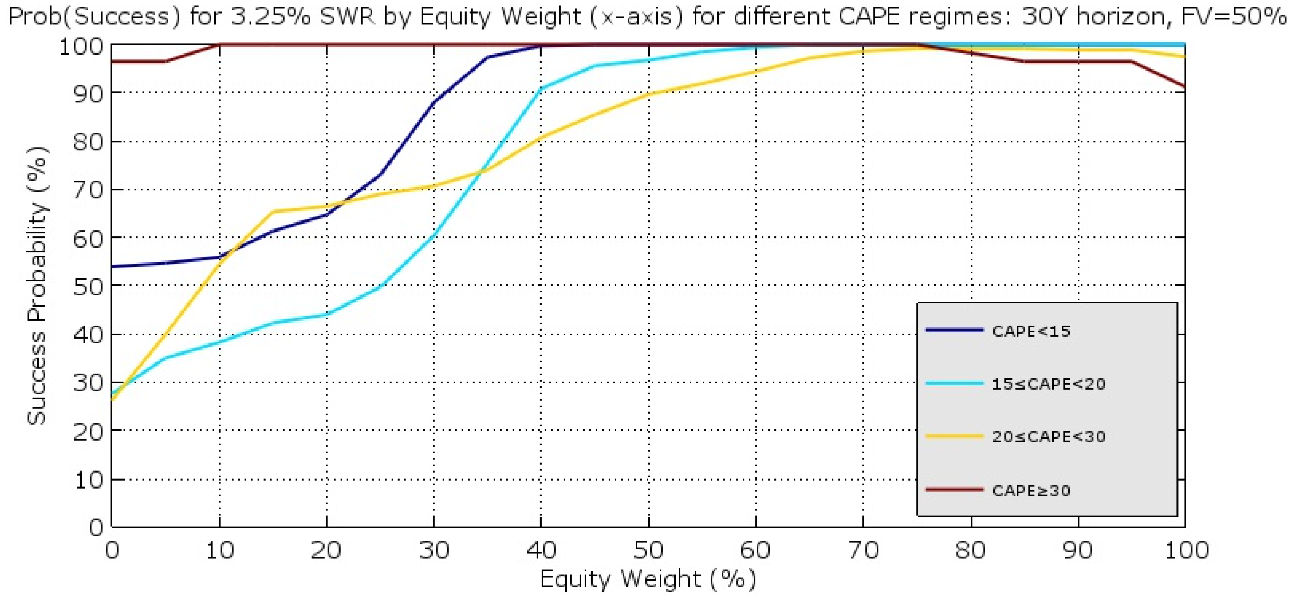


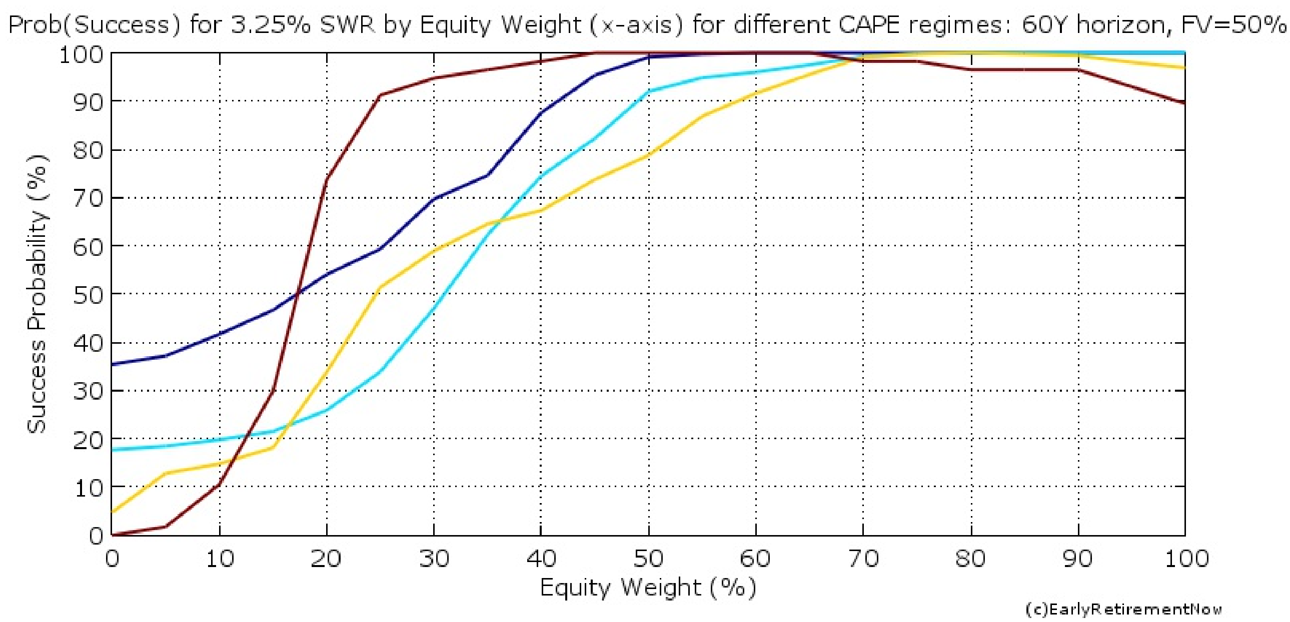


Success Rates of the 3.5% Rule with a 50% final value target, as a function of the portfolio equity share for different CAPE regimes and different horizons (top=30Y, bottom=60Y)

3.5 How about 3.25%?

To insulate ourselves from running out of money we likely have to lower the SWR all the way to 3.25%. Now we can get all the way to 97% success probability with 100% equities and even close to 100% with an equity share of 80-90%, see chart below.





Success Rates of the 3.25% Rule with a 50% final value target, as a function of the portfolio equity share for different CAPE regimes and different horizons (top=30Y, bottom=60Y)

I wouldn't want to get my hopes too high about the benefits of bonds, though. Despite the recent rally in bond yields (and the resulting pummeling of bond prices) since November 8, yields are still extremely low by historical standards. For example at 2% annual inflation and around 2.5-2.6% yield for the 10Y Treasury Bond, we are looking at 0.5-0.6% real yield. Much less than the average 2.6% real return!

3.6 Conclusion

We face a triple-whammy of bad news when it comes to safe withdrawal rates and using the Trinity Study data for our purposes:

1. We have a longer retirement horizon. My wife will be in her mid-30s when we retire and her family seems to have a longevity gene. We like the money to last until my wife is at least in her mid-90s. We face a 60-year retirement horizon, twice the longest horizon the Trinity Study considers.

2. We like to leave a bequest

3. Today's equity expected returns could be low due to the current sky-high equity valuations

All of that does not bode well for the 4% rule. To push failure rates of the withdrawal strategy to a low enough level, we'd likely have to lower the SWR to 3.25%.

Quite intriguingly, bonds don't offer much benefit for the success rates, unless stocks are wildly overvalued, with much higher CAPE ratios than today's value (>30!). For CAPE ratios below 30, mixing in bonds has either only a marginal benefit or even *lowers* the success probability.

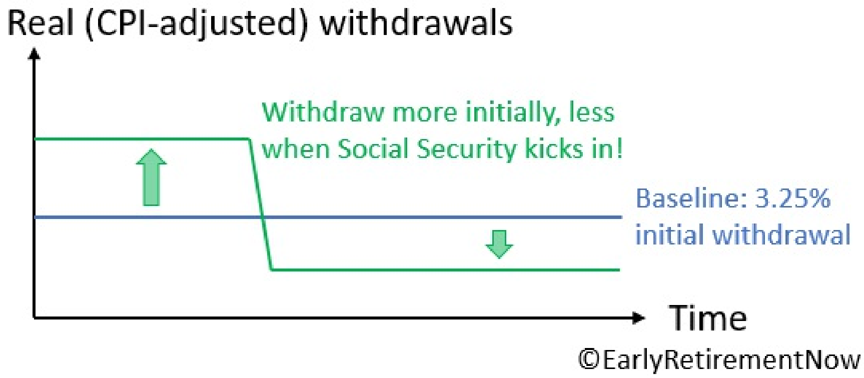
What we learned so far: The Trinity Study and many in the FIRE crowd seem to recommend a generous withdrawal rate and conservative stock vs. bond allocation. But with a 4% SWR and 70-80% equity weight you have a roughly 1 in 3 chance of wiping out your money after 60 years. We want to do the **opposite**: A conservative withdrawal rate (e.g. 3.25%) and a generous equity weight (e.g. 100%). Who would have thought!?

4 Social Security and Pensions

Initially published as The Ultimate Guide to Safe Withdrawal Rates – Part 4: Social Security and Pensions on January 4, 2017.

The bad news inherent in our research so far is that the sensible safe withdrawal rate with an acceptable success rate melted down all the way to 3.25%. So much for the 4% safe withdrawal rate! That 25x annual spending target for retirement savings just went up to 1/0.0325=30.77 times.

But not all is lost! Social Security to the rescue! We could afford lower withdrawals later in retirement and, in turn, scale up the initial withdrawals a bit, see chart below. How much? We have to get the simulation engine out again!



With Social Security (and/or a pension) later during retirement, we can afford higher initial withdrawal rates!

4.1 Our personal situation

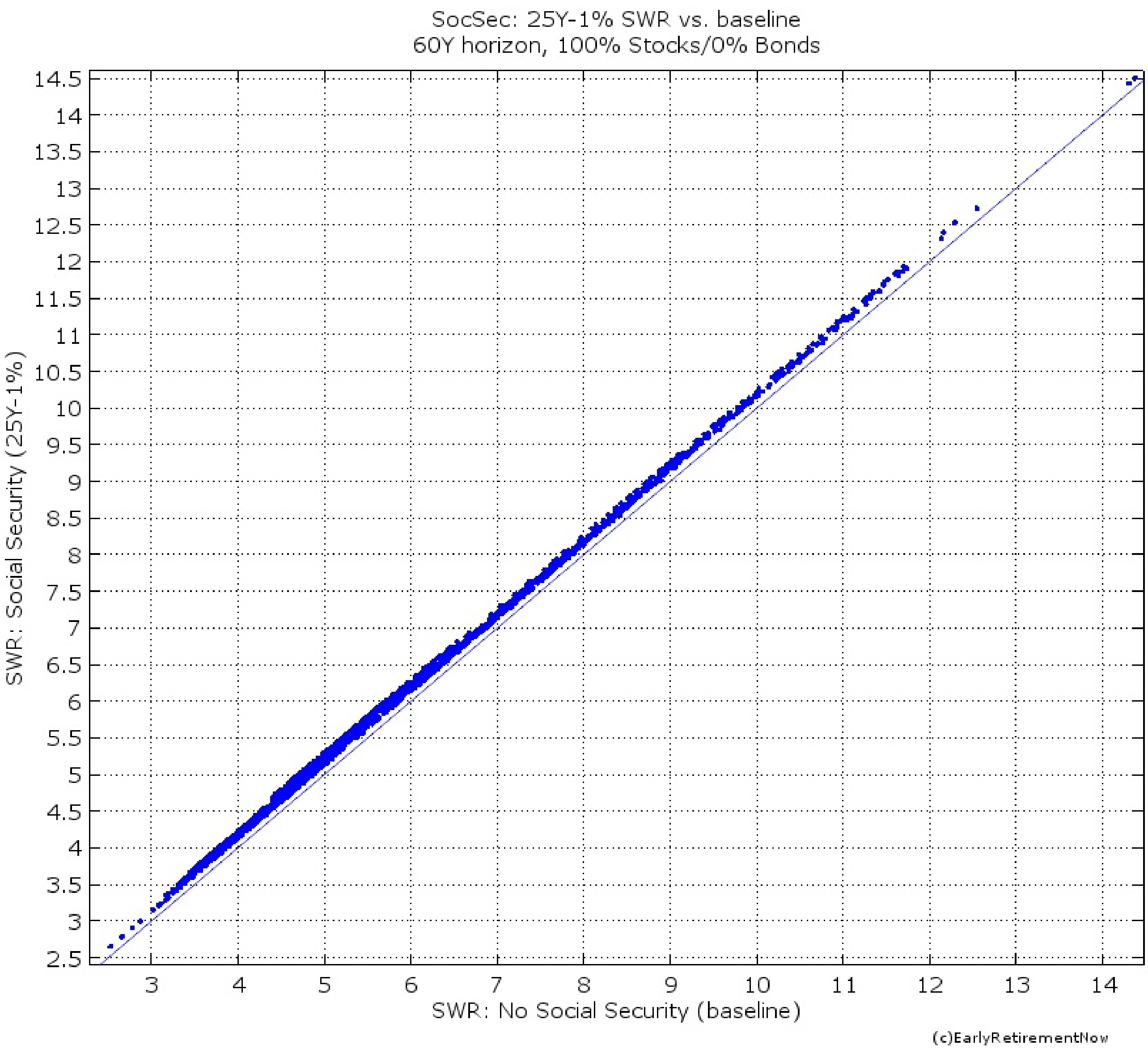
Under the current Social Security setup, Mr. ERN is eligible for Social Security at age 62, which is 18 years after the planned retirement. But we will likely wait until Mr. ERN is in his late 60s to maximize the Social Security benefit. That's roughly 25 years into our 60-year retirement. Together with the benefit from Mrs. ERN and a small legacy pension for Mr. ERN, we expect a total combined annual benefit of about 0.01 times our financial net worth at the start of our retirement. That's all under the (rosy?) assumption that there are no benefit cuts in Social Security, whether through adjustments in the benefits formula, changes in the retirement age or some form of means-testing. The likelihood of benefit cuts is a whole separate topic for a future post, though.

So, 35 years worth of 1% extra income during a 60-year retirement horizon affords us a 1% / 60 x 35 = 0.583% extra withdrawal, right? Withdraw 3.25%+0.583%=3.833% for the first 25 years and 2.833% for the next 35 years, which combined with the social security benefit generates a fixed real consumption path of 3.833% of initial net-worth. Almost back to 4%, how cool is that? Almost too good to be true! Well, unfortunately, this back-of-the-envelope calculation **is** too good to be true. The time value of money messes up the entire calculation! In other words, Social Security benefits many years in the future are going to be worth a lot less in today's dollars. And even worse, the dreaded Sequence of Return Risk (SoRR) comes into play here again because we front-load the withdrawals. How much of a haircut do we have to apply to our calculation? We need to look at our simulations to find out.

4.2 SWR simulations: 1871-2015

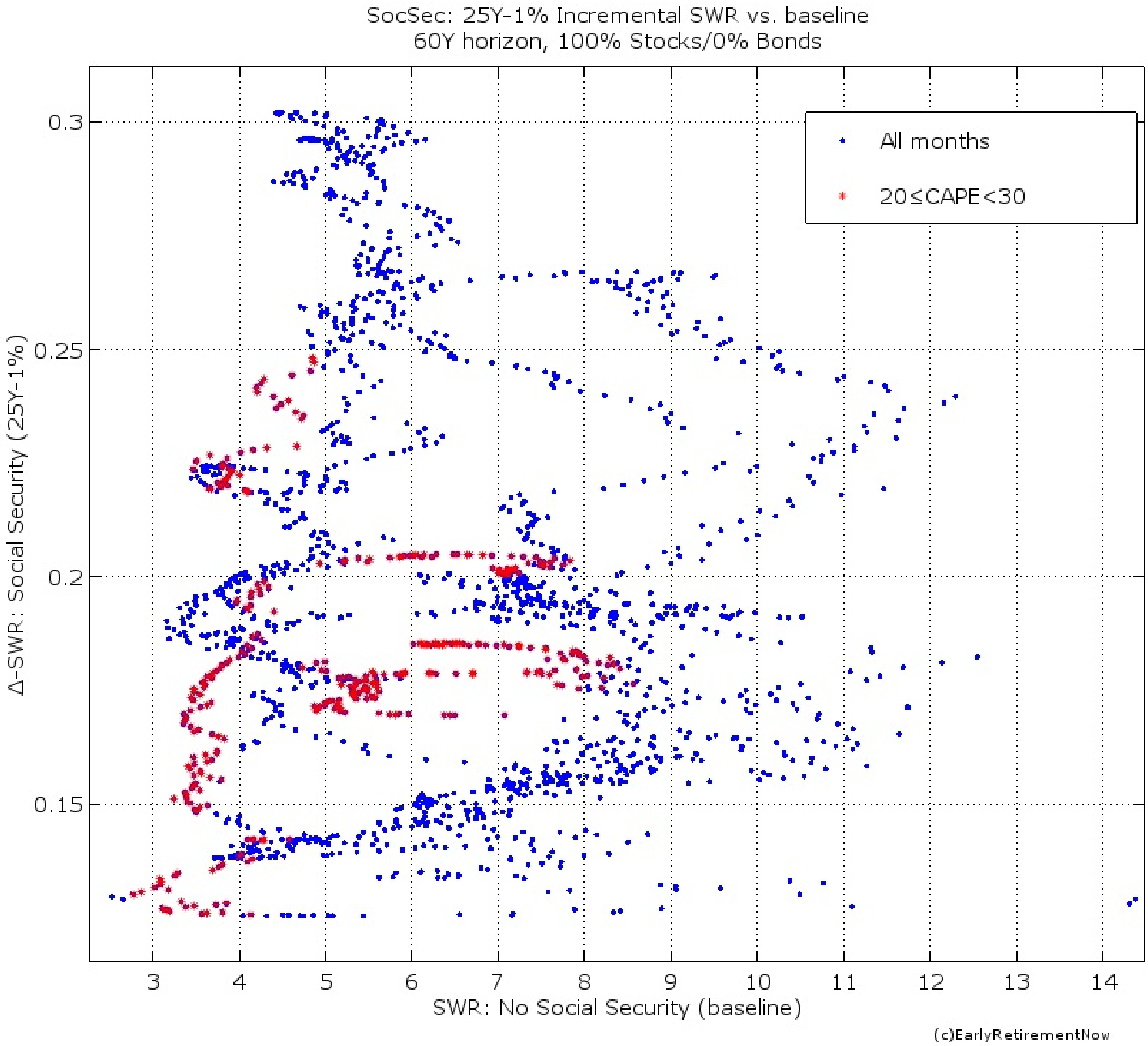
The baseline simulation (more scenarios below), is what we call "25Y-1%" where we start with a withdrawal rate x% in the first year, inflation-adjust over time and take the withdrawals from the portfolio down by 1 percentage point (also adjusted for inflation) once we draw Social Security benefits. For each possible starting date, we solve for the withdrawal rate that *exactly matches* our final value target (50% of beginning value, in real terms) after 60 years.

In the scatterplot below we do the usual analysis as before: Compare SWRs in two different scenarios: No Social Security (x-axis) vs. our likely Social Security benefits (y-axis). Of course, all dots are above the 45-degree line indicating a higher SWR, but not by much.



Safe Withdrawal Rates over a 60-year horizon for a 100% Equity portfolio: Baseline (no Social Security) (x-axis) vs. Social Security Benefits after 25 years, amounting to 1% of T=0 Net Worth (y-axis). Blue line = 45-degree line.

Because the scatterplot above was so hard to decipher, let's plot the **increase** in the SWR due to the Social Security benefits on the y-axis, see chart below. I do this for all months, but I also mark the dots when the CAPE ratio was between 20 and 30 (12/31/2016 CAPE is around 28, according to Professor Shiller, page accessed on January 2, 2017). The increase in the SWR from our Social Security assumption is a lot leaner than the back-of-the-envelope calculation. Bummer! The SWR increase ranges from about 0.12% to just under 0.25%, with a median of around 0.18%. This will not bring our SWR back to 4%!



Safe Withdrawal Rates over a 60-year horizon for a 100% Equity portfolio: Baseline (no Social Security) (x-axis) vs. increase in SWR due to Social Security Benefits after 25 years.

4.3 How about other Social Security and Pension assumptions?

We look at a total six scenarios, three starting dates: 20, 25, and 30 years into retirement and two different benefit levels: 1% and 2% of the initial retirement nest egg. So, for example, if you have a $1,000,000 portfolio and expect $20,000 in benefits after 30 years you'd look at the 30Y-2% model. As we mentioned above, our own personal situation comes closest to the 25Y-1% model.

Instead of plotting the scatterplots above, let's just display one summary statistics table about how much the different Social Security / Pension models increase the SWR, see table below, specifically the median increase. Note that the order is from the smallest to the largest discounted sum of benefits (30Y-25Y-20Y). We calculate the median increase for all months, for months with a CAPE between 20 and 30, and also for months when the CAPE was between 20 and 30 and the baseline SWR was below 4%. We calculated the latter because we wanted to see how much of a difference our Social Security would have made when we really have to rely on it due to bad financial market performance.

Social Security Regime	Benefit Level	All Months	20≤CAPE<30	20≤CAPE<30 and Baseline SWR<4%
Social Security after 30Y	1%	0.131%	0.124%	0.110%
	2%	0.262%	0.248%	0.220%
Social Security after 25Y	1%	0.191%	0.179%	0.164%
	2%	0.382%	0.359%	0.329%
Social Security after 20Y	1%	0.268%	0.259%	0.248%
	2%	0.535%	0.518%	0.496%

Median Increase in the SWR from getting Social Security benefits. 100% equity allocation, 60-year horizon.

In our personal situation, we'd expect a 0.191% increase not conditioning on the CAPE regime, 0.179% for today's CAPE regime, and 0.164% conditional on actually having to rely on Social Security. Hmmm, slightly disappointing. What's particularly unfortunate in our calculations is that the increase in the SWR is lower when we need it the most, namely when the CAPE is high and the baseline SWR is already below 4%. Unless you expect very generous benefits, Social Security will not serve as a panacea for the 4% rule!

A little side note: The incremental effect on the SWR exactly doubles when going from 1% to 2% worth of Social Security benefits. That's no coincidence. It's a mathematical result. So if someone happens to expect Social Security and/or Pension benefits amounting to, say, 1.3% of your initial net worth, simply take the 1% figure above and multiply by 1.3. See the mathematical appendix for more details.

4.4 Failure rates of different SWRs

We can also look at the failure rates of different withdrawal rates between 3 and 4% in 25bps steps, see table below.

CAPE Regime	Social Security Regime	Benefit Level	Withdrawal Rate				
			3.00%	3.25%	3.50%	3.75%	4.00%
CAPE between 20 and 30	Baseline: No Social Security	0%	0.6%	3.1%	11.7%	21.2%	28.8%
	Social Security after 30Y	1%	0.6%	2.0%	5.6%	17.0%	25.4%
		2%	0.3%	0.8%	3.6%	11.7%	21.8%
	Social Security after 25Y	1%	0.6%	2.0%	3.9%	14.8%	24.0%
		2%	0.0%	0.6%	2.8%	7.5%	18.2%
	Social Security after 20Y	1%	0.3%	0.8%	3.4%	11.5%	20.7%
		2%	0.0%	0.3%	0.8%	3.6%	11.7%
All CAPE regimes	Baseline: No Social Security	0%	0.2%	1.0%	3.7%	7.4%	12.1%
	Social Security after 30Y	1%	0.2%	0.5%	1.8%	5.4%	9.2%
		2%	0.2%	0.3%	1.0%	3.6%	7.3%
	Social Security after 25Y	1%	0.2%	0.5%	1.2%	4.5%	8.4%
		2%	0.1%	0.2%	0.7%	2.2%	5.5%
	Social Security after 20Y	1%	0.2%	0.3%	1.0%	3.5%	7.0%
		2%	0.1%	0.2%	0.3%	1.0%	3.5%

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Failure Rates of different initial SWRs (columns) under two CAPE regimes (top=current, bottom=all months), Social Security parameters (rows), 60-year horizon, 50% final asset value target, 100% equity weight.

Bottom line: If you're unlucky and face adverse capital marker returns early on in retirement and you keep withdrawing your initial rate then your portfolio will be so compromised by the time you reach your Social Security age that it won't make much of a difference anymore.

So, in today's environment, the highest withdrawal rate we'd personally be comfortable with is 3.5%. That has a 3.9% failure rate. The 4% SWR would have had a 28.8% failure rate in the absence of Social Security and only a pretty generous benefit worth 2% p.a. and 20 years after the retirement would significantly reduce the failure rate to 11.7%. Under all other parameterizations, the failure rates were still around 20%. Unacceptably high!

Even before accounting for potential future benefit cuts, Social Security benefits will not make a huge difference in the Safe Withdrawal Rate and will most definitely not save the 4% rule!

4.5 Data, data, data. And more data

Let's look at some more data tables that cover more assumptions. Hopefully, this can serve as a reference for readers who want to look beyond the ERN family assumptions and see how the failure rates would have looked like in their personal situation.

- Retirement horizon: 60 years (first table) and 50 years (second table). We don't even display anything below 50 years considering that most folks in the FIRE crowd will retire in their 30s, maybe early 40s.
- Today's CAPE regime (20-30) in the top half of each table vs. unconditional on CAPE regime in the bottom half of each table, just for reference.
- Three different social security parameters: None at all, 1% benefits after 25 years (ERN family

assumption), 2% benefits after 30 years (for example \$1,000,000 portfolio and \$20k in benefits after 30 years).

- Four different equity shares: 70/80/90/100%. I don't even go below 70% because the failure rates get so much worse. Also, recall that the bond index I use here is a 10y Treasury index with no credit risk. A 30% allocation to a safe government bond index plus 70% equities roughly corresponds to a 40% allocation to investment grade bonds plus 60% equities. We definitely do not recommend going below that equity allocation to preserve long-term sustainability of the portfolio.

- Capital Depletion vs. 50% final asset target (left vs. right half of table)

- Five different withdrawal rates between 3 and 4% in 0.25% steps.

		Horizon	60-Year Horizon									
		Final Value Target	Capital Depletion					50% Final Value Target				
CAPE Regime	Social Security Assumption	Withdraw Rate → / Equity Share ↓	3.00%	3.25%	3.50%	3.75%	4.00%	3.00%	3.25%	3.50%	3.75%	4.00%
CAPE 20 to 30	No Social Security	70%	0.0%	0.3%	12.6%	26.3%	37.4%	0.0%	0.8%	17.6%	32.7%	40.5%
		80%	0.0%	0.0%	5.9%	23.5%	33.5%	0.0%	0.0%	11.7%	25.4%	37.2%
		90%	0.0%	0.6%	6.1%	21.2%	27.9%	0.0%	0.6%	10.3%	24.3%	31.0%
		100%	0.6%	2.5%	7.0%	19.0%	27.9%	0.6%	3.1%	11.7%	21.2%	28.8%
	25Y-1%	70%	0.0%	0.0%	0.3%	15.4%	27.7%	0.0%	0.0%	3.1%	20.9%	33.5%
		80%	0.0%	0.0%	0.0%	10.9%	24.9%	0.0%	0.0%	1.4%	16.5%	27.1%
		90%	0.0%	0.0%	0.8%	10.6%	23.5%	0.0%	0.3%	1.1%	15.1%	26.3%
		100%	0.3%	0.8%	3.6%	12.0%	22.1%	0.6%	2.0%	3.9%	14.8%	24.0%
	30Y-2%	70%	0.0%	0.0%	0.0%	8.4%	22.9%	0.0%	0.0%	0.3%	15.4%	27.4%
		80%	0.0%	0.0%	0.0%	6.1%	22.3%	0.0%	0.0%	0.0%	11.2%	24.6%
		90%	0.0%	0.0%	0.6%	7.0%	19.8%	0.0%	0.0%	0.8%	11.7%	21.5%
		100%	0.0%	0.6%	2.8%	8.9%	19.6%	0.3%	0.8%	3.6%	11.7%	21.8%
All CAPE regimes	No Social Security	70%	0.0%	0.1%	3.9%	8.9%	15.9%	0.0%	0.5%	5.5%	12.5%	19.1%
		80%	0.0%	0.1%	2.0%	7.7%	13.7%	0.0%	0.1%	3.6%	9.0%	15.7%
		90%	0.1%	0.2%	1.8%	7.1%	11.6%	0.1%	0.2%	3.2%	8.3%	13.5%
		100%	0.2%	0.7%	2.4%	6.4%	11.3%	0.2%	1.0%	3.7%	7.4%	12.1%
	25Y-1%	70%	0.0%	0.0%	0.1%	4.7%	10.1%	0.0%	0.0%	1.0%	6.2%	13.6%
		80%	0.0%	0.0%	0.1%	3.3%	8.6%	0.0%	0.1%	0.4%	5.0%	10.4%
		90%	0.0%	0.1%	0.3%	2.8%	8.2%	0.1%	0.2%	0.3%	4.5%	9.1%
		100%	0.2%	0.3%	1.0%	3.6%	7.6%	0.2%	0.5%	1.2%	4.5%	8.4%
	30Y-2%	70%	0.0%	0.0%	0.0%	2.5%	7.1%	0.0%	0.0%	0.1%	4.6%	9.9%
		80%	0.0%	0.0%	0.1%	1.6%	6.7%	0.0%	0.0%	0.1%	3.2%	8.4%
		90%	0.0%	0.1%	0.2%	1.8%	6.4%	0.0%	0.1%	0.3%	3.0%	7.6%
		100%	0.1%	0.2%	0.7%	2.6%	6.4%	0.2%	0.3%	1.0%	3.6%	7.3%

60-Year horizon failure rates of different Withdrawal Rates (columns), with different final asset targets (left=capital depletion, right=50% FV target), for different CAPE regimes (top=current CAPE regime, bottom=all months), and Social Security assumptions and equity shares (rows).

		Horizon	50-Year Horizon									
		Final Value Target	Capital Depletion					50% Final Value Target				
CAPE Regime	Social Security Assumption	Withdraw Rate → / Equity Share ↓	3.00%	3.25%	3.50%	3.75%	4.00%	3.00%	3.25%	3.50%	3.75%	4.00%
CAPE 20 to 30	No Social Security	70%	0.0%	0.0%	4.7%	20.9%	32.7%	0.0%	1.7%	17.6%	33.0%	40.5%
		80%	0.0%	0.0%	2.0%	18.4%	28.2%	0.0%	0.6%	12.8%	27.7%	37.7%
		90%	0.0%	0.3%	1.7%	15.9%	26.5%	0.0%	0.6%	10.6%	24.6%	32.4%
		100%	0.3%	1.7%	4.5%	15.9%	26.5%	0.8%	3.4%	11.7%	21.2%	29.1%
	25Y-1%	70%	0.0%	0.0%	0.0%	10.3%	22.6%	0.0%	0.0%	4.2%	22.1%	34.9%
		80%	0.0%	0.0%	0.0%	6.1%	22.6%	0.0%	0.0%	1.7%	19.8%	29.3%
		90%	0.0%	0.0%	0.6%	7.8%	20.1%	0.0%	0.6%	2.5%	16.2%	26.5%
		100%	0.0%	0.6%	2.8%	9.5%	20.1%	0.6%	2.8%	4.2%	15.1%	25.7%
	30Y-2%	70%	0.0%	0.0%	0.0%	4.5%	21.2%	0.0%	0.0%	1.4%	18.4%	31.3%
		80%	0.0%	0.0%	0.0%	3.6%	18.7%	0.0%	0.0%	0.6%	13.4%	26.5%
		90%	0.0%	0.0%	0.6%	4.7%	18.7%	0.0%	0.3%	1.7%	13.1%	25.4%
		100%	0.0%	0.6%	2.8%	7.3%	17.6%	0.6%	2.2%	4.2%	14.2%	23.2%
All CAPE regimes	No Social Security	70%	0.0%	0.0%	1.7%	6.6%	13.5%	0.0%	0.6%	5.4%	12.1%	18.2%
		80%	0.0%	0.0%	0.7%	5.8%	11.4%	0.0%	0.2%	3.9%	9.2%	15.3%
		90%	0.1%	0.2%	0.7%	5.5%	10.3%	0.1%	0.2%	3.2%	8.2%	13.4%
		100%	0.2%	0.5%	1.5%	5.3%	9.8%	0.3%	1.0%	3.7%	7.2%	12.1%
	25Y-1%	70%	0.0%	0.0%	0.0%	3.1%	7.2%	0.0%	0.0%	1.3%	6.4%	13.7%
		80%	0.0%	0.0%	0.1%	1.8%	7.2%	0.0%	0.1%	0.5%	5.8%	10.6%
		90%	0.0%	0.1%	0.2%	2.1%	7.0%	0.1%	0.2%	0.8%	4.9%	9.1%
		100%	0.1%	0.2%	0.9%	2.9%	6.8%	0.2%	0.7%	1.3%	4.5%	8.8%
	30Y-2%	70%	0.0%	0.0%	0.0%	1.5%	6.3%	0.0%	0.0%	0.4%	5.3%	11.3%
		80%	0.0%	0.0%	0.1%	1.0%	5.7%	0.0%	0.1%	0.2%	3.8%	8.9%
		90%	0.0%	0.1%	0.2%	1.3%	5.9%	0.1%	0.2%	0.5%	3.6%	8.5%
		100%	0.1%	0.2%	0.7%	2.2%	5.8%	0.2%	0.6%	1.2%	4.3%	7.7%

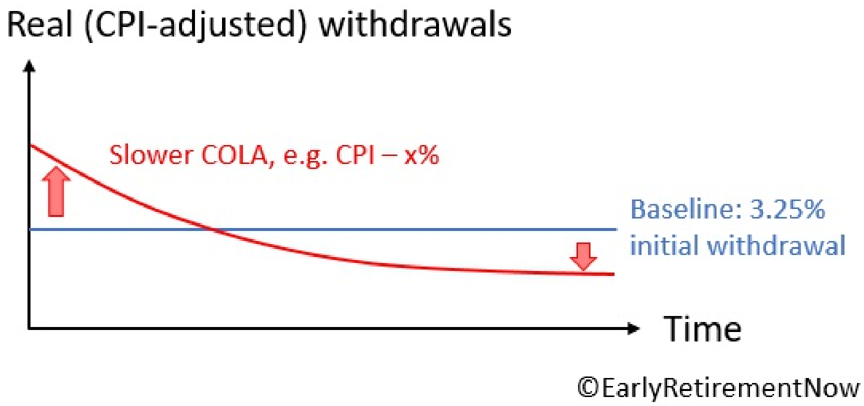
50-Year horizon failure rates of different Withdrawal Rates (columns), with different final asset targets (left=capital depletion, right=50% FV target), for different CAPE regimes (top=current CAPE regime, bottom=all months), and Social Security assumptions and equity shares (rows).

5 Cost-of-Living Adjustments

Initially published as The Ultimate Guide to Safe Withdrawal Rates – Part 5: Cost-of-Living Adjustments on January 11, 2017.

Welcome back to the Safe Withdrawal Rate Series. Last week we wrote about how Social Security can impact the SWR estimates. Even under the most optimistic assumption (no changes to the Social Security benefits formula), we didn't think that the 4% withdrawal rate is safe.

But how about tinkering with the inflation adjustments, also called Cost-of-Living adjustments (COLA)? I often hear that one way to save the 4% rule in periods when the stock market doesn't cooperate is to not do inflation adjustments for a few years. Or simply utilize the fact that we all potentially spend less (in real terms) as we age! How much can we push the initial withdrawal rate in that case?

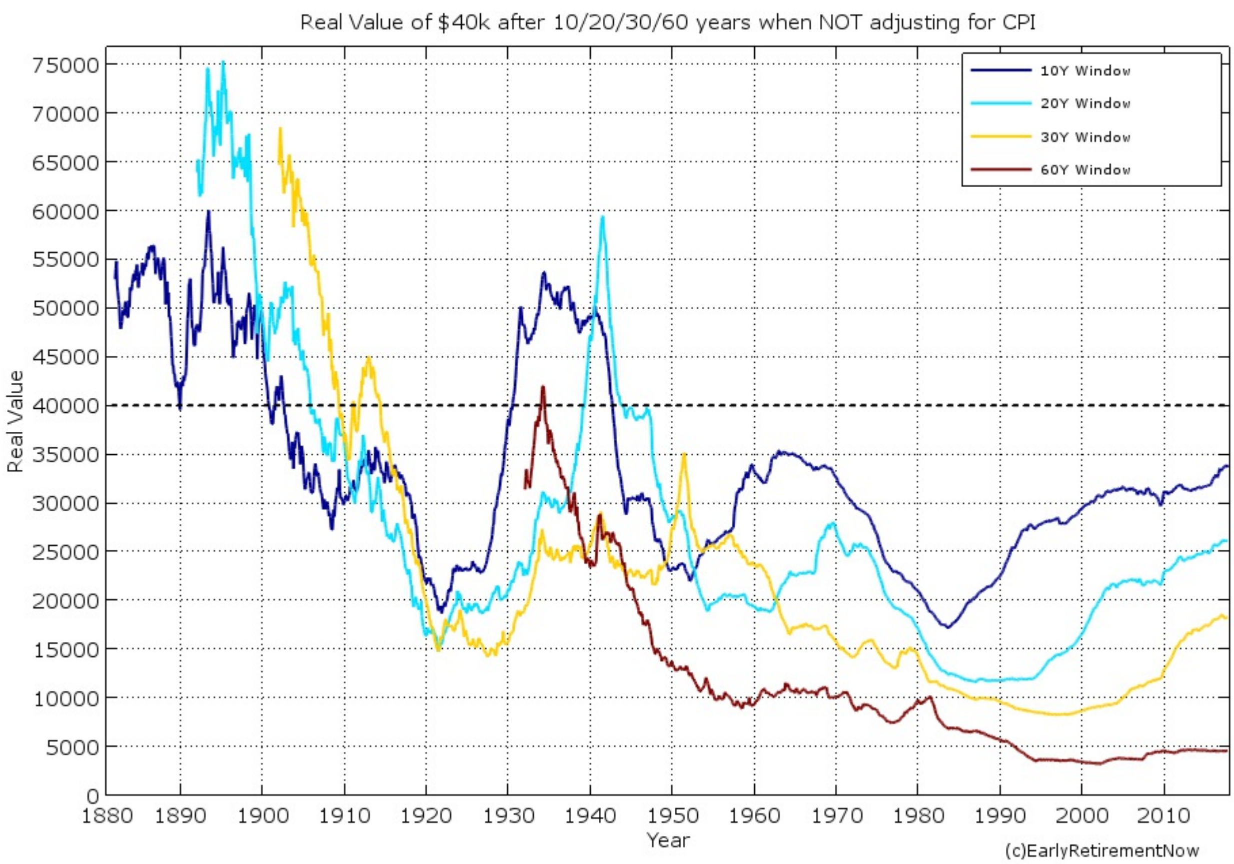


With a declining real withdrawal rate, we can afford higher initial withdrawals!

5.1 COLA - How not to do it

The first table in the often cited Trinity Study, apparently the gold standard of retirement research, looks at the success rates of withdrawal strategies that **don't** do the cost-of-living adjustments (i.e., keep **nominal** withdrawals constant).

That seems like an interesting exercise to do before jumping into the inflation-adjusted study, right? Wrong! To me, this is a pretty cringeworthy and nonsensical exercise for the following reason. See the chart below where we plot the purchasing power of an initial withdrawal of $40,000 p.a. over 10, 20, 30, and 60 years when foregoing CPI-adjustments:



How real value much is left over after 10/20/30/60 years when not adjusting an initial $40,000 withdrawal for CPI? Results vary wildly by cohort!

Not doing inflation adjustments during the 1970s would have implied a massive erosion of purchasing power: Your initial $40,000 withdrawal in 1970 dollars would have been worth only around $8,000 in the year 2000. Not quite a Zimbabwe-style runaway inflation, but still pretty bad. Good luck living your golden years on that amount! On the other hand, in the 1930s you would have massively *increased* your CPI-adjusted consumption in a deeply deflationary decade. So, that retiree would have fared much better (in real consumption terms, not in final value). Lumping them all together and calculating success rates is not very meaningful then. It's comparing apples and oranges! Sorry to say this, but in my eyes, anybody who looks at safe withdrawal rates in purely nominal terms suffers some serious loss of credibility. It proves that even the combined brainpower of 3 PhDs can create some junk science.

5.2 COLA - How to do it right

If we want to make the case that people consume less as they age, we should still do the calculations in real space but then shrink the expenses at a certain (real) rate per year, as we propose here. Essentially, chip away a small percentage of the purchasing power every year to account for the fact that we could potentially consume less over time. How much should we shrink consumption (and thus withdrawals) over time? Let's look at what happens when we do the COLA adjustments as CPI minus x% for several different values of x, see table below.

	Cost of Living Adjustment: CPI minus x%						
Years in retirement	0.00%	0.50%	1.00%	1.50%	2.00%	2.50%	3.00%
0	$100.00	$100.00	$100.00	$100.00	$100.00	$100.00	$100.00
5	$100.00	$97.52	$95.10	$92.72	$90.39	$88.11	$85.87
10	$100.00	$95.11	$90.44	$85.97	$81.71	$77.63	$73.74
15	$100.00	$92.76	$86.01	$79.72	$73.86	$68.40	$63.33
20	$100.00	$90.46	$81.79	$73.91	$66.76	$60.27	$54.38
25	$100.00	$88.22	$77.78	$68.53	$60.35	$53.10	$46.70
30	$100.00	$86.04	$73.97	$63.55	$54.55	$46.79	$40.10
35	$100.00	$83.91	$70.34	$58.92	$49.31	$41.23	$34.44
40	$100.00	$81.83	$66.90	$54.63	$44.57	$36.32	$29.57
45	$100.00	$79.81	$63.62	$50.66	$40.29	$32.00	$25.39
50	$100.00	$77.83	$60.50	$46.97	$36.42	$28.20	$21.81
55	$100.00	$75.90	$57.54	$43.55	$32.92	$24.85	$18.73
60	$100.00	$74.03	$54.72	$40.38	$29.76	$21.89	$16.08

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Real value of $100 after N years of COLA with CPI minus x%.

After 60 years even a tiny value of x will erode our purchasing power by a lot. Personally, we might still be comfortable with 0.5% (around 26% erosion of purchasing power) but certainly not 1.0%. For retirees with a very high initial withdrawal amount, say, $100,000 p.a. it might be possible to go all the way up to x=1%, because that would cut down the real withdrawals to a still-generous $54,720. But does anybody want to start at $40,000 at age 30 and shrink the withdrawals to slightly less than $22,000 at age 90? That will be eaten up by medical bills alone. And forget about going to 1.5% or more. So we will study only the 0.5% and 1.0% versions, in addition to the baseline:

- **Baseline:** Increase withdrawals in line with CPI
- **COLA=CPI-1.0%:** Shrink the real withdrawals by 1.0% p.a.

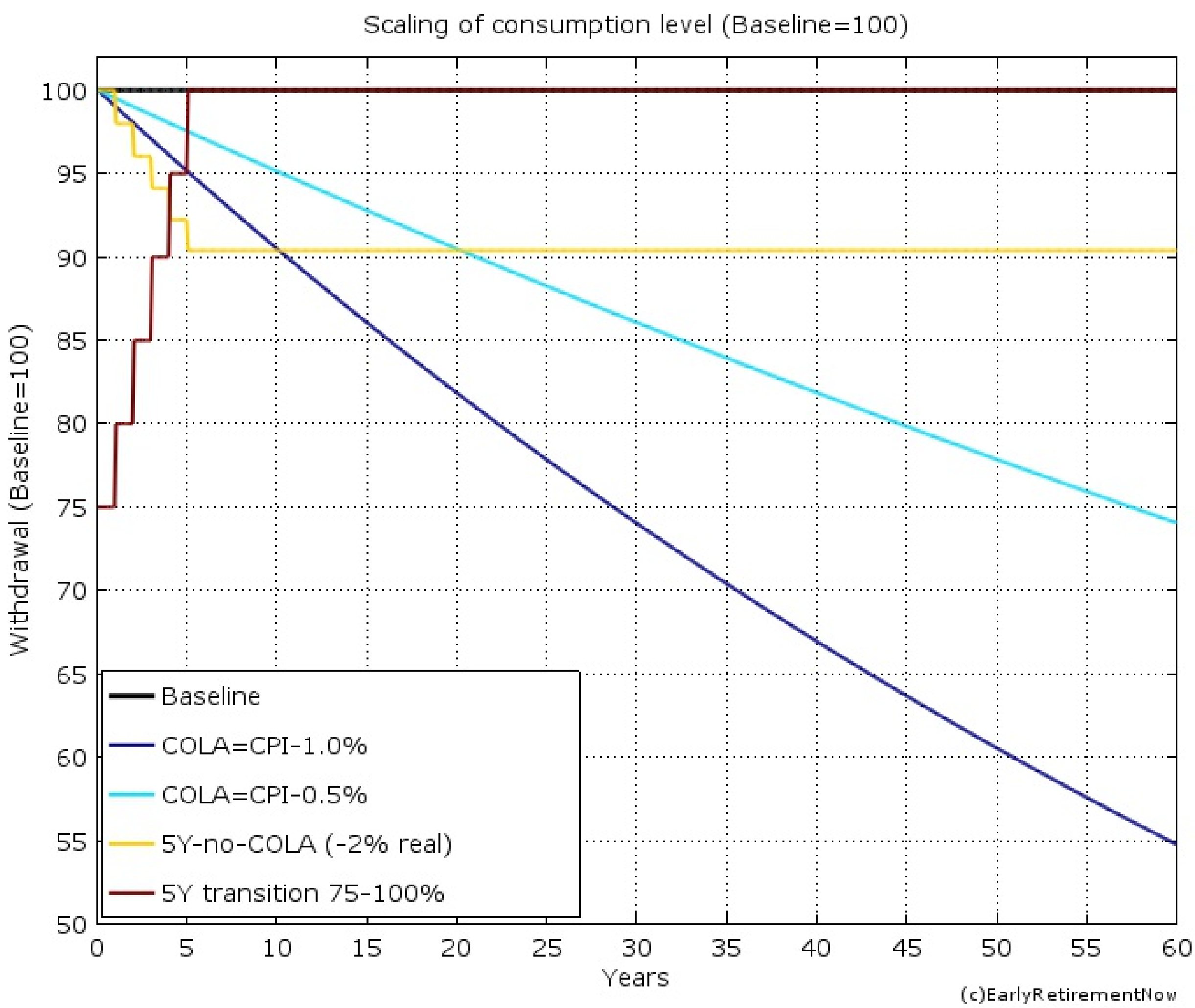
- **COLA=CPI-0.5%:** Shrink the real withdrawals by 0.5% p.a.

We also throw in another two scenarios of tinkering with the withdrawal amounts over time:

- **5Y-no-COLA:** shrink the real withdrawals by 2% for five years and hold them constant after that. Starting in year 6 this would mean that the withdrawals are about 9.6% lower than initially ($0.98^5 = 0.904$). That's the solution often quoted as the panacea to bad market returns early on: simply forego the inflation adjustments for a while. Assuming 2% inflation forecasts over the foreseeable future, this withdrawal pattern would exactly accomplish that. Also, notice we never scale the withdrawal up again. Then a 4% initial withdrawal would mean you consume only about 3.6% of the initial net worth in the long-term.

- **5Y transition 75%-100%:** Somewhat the opposite of assumption above; gradually smooth into retirement, for example, by preserving some small income source initially and phasing it out over 5 years, or by simply being extremely frugal initially. Withdraw only 0.75 times the long-term target in year 1, 80% in year 2, ..., 95% in year 5 and then the long-term target in year 6 and onward. Also notice that if this procedure yields a, say, 3.5% SWR in the simulations, the initial withdrawal rate would only be 2.625% of the initial net worth and we'd scale that ratio up to 3.5% over the next five years.

See chart below for the scaling of withdrawals in real dollars, compared to $100 in the baseline:



Withdrawal amounts using different scales over time (Baseline = 100).

5.3 Simulation results

As we did last week with the different Social Security assumptions, let's look at the median increase in the withdrawal rate that the withdrawal pattern affords us, see table below. We calculate this again for all months, for months with the CAPE between 20 and 30 and for months with the CAPE in that range and the baseline SWR<4%. Quite intriguingly, for the first two assumptions you roughly increase the initial withdrawal rate by exactly the 1.0% or 0.5% rate adjustment to the COLA (+0.932% and +0.462%, respectively) when we take the median of all months. But that advantage quickly melts down to only about three-quarters of that amount when taking the median over only the current CAPE regime (20 to 30) and about half when the CAPE is elevated and the baseline 4% rule would have failed (0.558% and 0.275%, respectively). So, the unpleasant fact is that the **COLA-x% works best when we need it the least**. That makes perfect sense: because we have such a front-loaded consumption pattern we get hit by the dreaded **Sequence of Return Risk**!

Withdrawal Assumptions	All Months	20≤CAPE<30	20≤CAPE<30 and Baseline SWR<4%
COLA=CPI-1.0%	0.932%	0.767%	0.558%
COLA=CPI-0.5%	0.462%	0.379%	0.275%
5Y-no-COLA (-2% real)	0.519%	0.459%	0.332%
5Y transition 75-100%	0.244%	0.206%	0.105%
			©EarlyRetirementNow

Median Increase in the SWR from alternative withdrawal assumptions. 100% equity weight, 60-year horizon.

We get qualitatively similar results with the other two withdrawal patterns. The 5Y-no-COLA adds about a half percentage point (0.519%) to the withdrawals (before taking it away again over the next 5 years!!!) and the 5Y smooth transition into retirement boasts a respectable quarter point increase in the median increase of the SWR (0.244%). But the bump in allowable SWRs melts away again when we take into account today's high CAPE value and even more when we look at the retirement dates with low enough initial returns that pushed the baseline SWR below 4%. Not a pretty picture.

Next comes a similar table to last week's; let's look at the failure probabilities over different initial withdrawal rates, see below. The top part of the table is for today's CAPE regime. None of the alternative withdrawal patterns offer a failure probability good enough to justify the 4% rule. OK, maybe the CPI-1.0%, where we would push the failure rate to slightly below 10%, but as we said before that would be a bit too aggressive of a cut in consumption for our taste. All other withdrawal patterns still have failure probabilities around 20%, which is completely unacceptable for us.

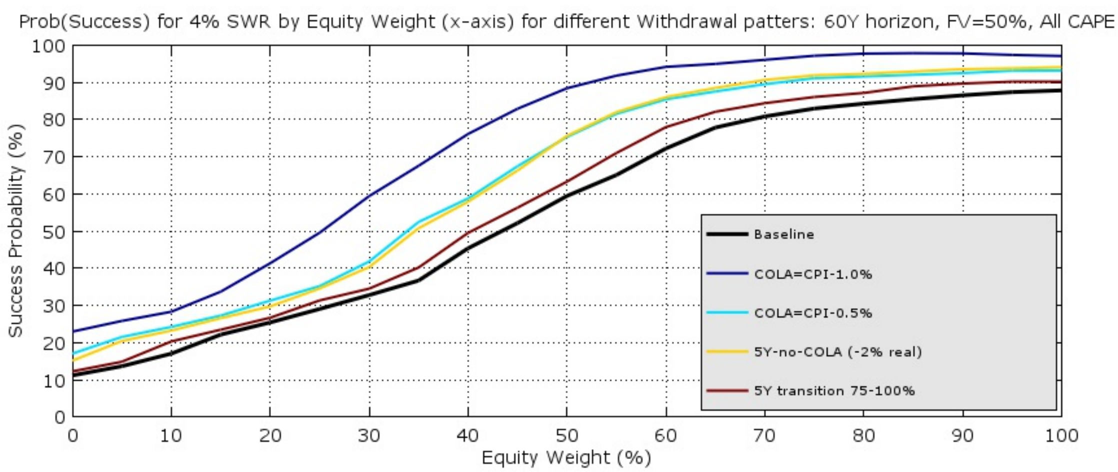
CAPE Regime	Withdrawal Assumptions	Withdrawal Rate 3.00%	3.25%	3.50%	3.75%	4.00%
CAPE between 20 and 30	Baseline	0.6%	3.1%	11.7%	21.2%	28.8%
	COLA=CPI-1.0%	0.0%	0.3%	0.8%	3.4%	8.9%
	COLA=CPI-0.5%	0.3%	0.8%	3.4%	10.3%	20.4%
	5Y-no-COLA (-2% real)	0.0%	0.6%	2.8%	6.7%	17.6%
	5Y transition 75-100%	0.6%	1.7%	6.1%	17.0%	27.1%
All CAPE regimes	Baseline	0.2%	1.0%	3.7%	7.4%	12.1%
	COLA=CPI-1.0%	0.1%	0.2%	0.3%	1.0%	2.9%
	COLA=CPI-0.5%	0.2%	0.3%	1.0%	3.3%	6.8%
	5Y-no-COLA (-2% real)	0.1%	0.2%	0.9%	2.3%	5.9%
	5Y transition 75-100%	0.2%	0.5%	2.0%	5.7%	9.8%
						©EarlyRetirementNow

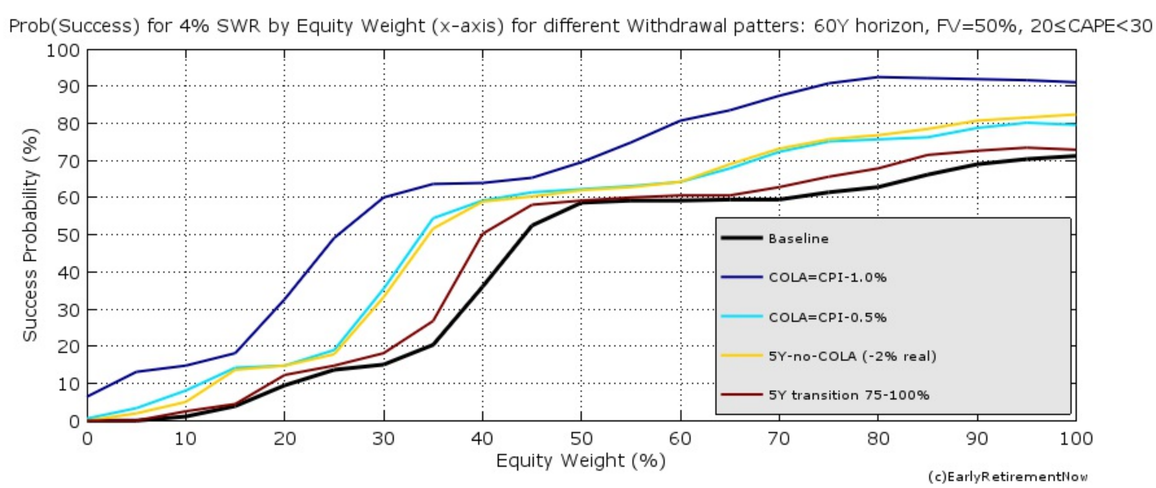
Failure Rates of different initial SWRs (columns) under two CAPE regimes (top=current, bottom=all months), Withdrawal parameters (rows), 60-year horizon, 50% final asset value target, 100% equity weight.

What the table seems to indicate is that you might gain a 0.25% increase in the SWR for the less aggressive withdrawal rules and 0.50% for the CPI-1.0% rule. In other words, the 3.25% SWR has a 3.1% failure rate in the baseline scenario and with COLA-1.0% we can push all the way to 3.75% SWR to still keep the failure probability in the low single digits. For the other withdrawal patterns, we're talking 3.50% again, so that's roughly a quarter point improvement

5.4 Why 100% equities?

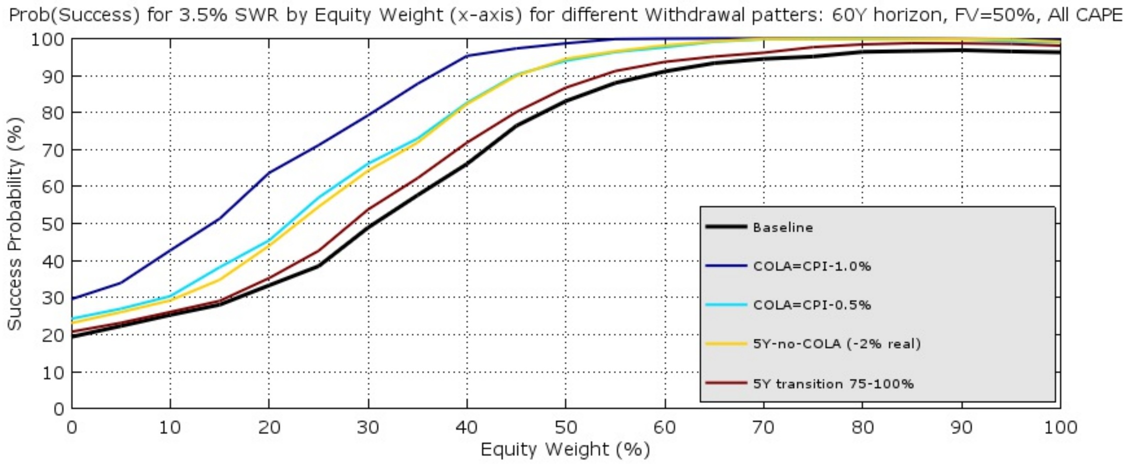
Why did we use a 100% equity share in the simulations above? It goes back to the earlier findings in the previous parts of the SWR series (especially part 2 and part 3): The success probabilities mostly go up with the equity weight, at least over a 60-year horizon. The only time that's not true is when right at the start of retirement stocks are seriously overvalued (CAPE>30). But for completeness, we again display the success probabilities over different equity weights, see chart below for a 4% withdrawal rate. The top chart is for all CAPE ratios and the bottom for the CAPE between 20 and 30 (current CAPE is around 28). We confirm again that the success probabilities are almost monotonically increasing in the equity weight:

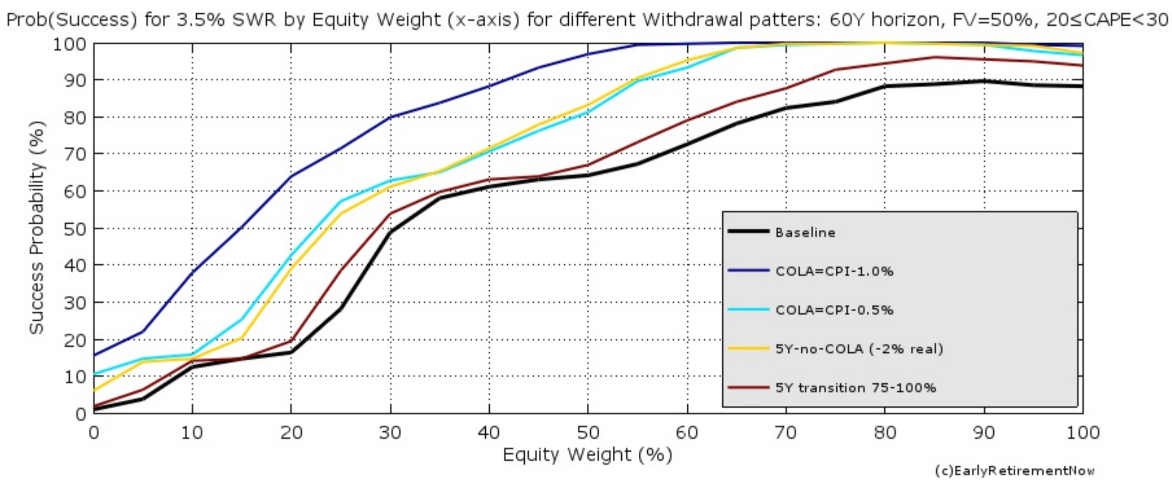




Success Rates of the 4% Rule with a 50% final value target, as a function of the portfolio equity share for different withdrawal patterns and CAPE regimes (top=all CAPE levels, bottom=CAPE between 20 and 30).

And the same chart for a 3.5% withdrawal rate. There is again a plateau of 100% (or close to 100%) success rate for high enough equity shares, and that's true even for slightly overvalued equities (CAPE between 20 and 30). It looks like the sweet spot for less than 100% that exists over 30 years doesn't carry over to 60 years. It's the same curse of low bond returns we've talked about in the past.





Success Rates of the 3.5% Rule with a 50% final value target, as a function of the portfolio equity share for different withdrawal patterns and CAPE regimes (top=all CAPE levels, bottom=CAPE between 20 and 30).

5.5 Why we won't bet on COLA

We did this study about tinkering with the COLA anticipating that probably a lot of folks will ask for it. Personally, we don't plan to mess around with our COLA and the lifecycle spending amounts very much.

The little bit of gain in the initial withdrawal rate is not worth the potential for spending cuts later in life when we are least able to earn a supplemental income.

But isn't it true that people spend less as they age? Yes, that's what economists have shown but I would ask back: Do people spend less because they **want** to or because the **have** to? Our blogging friend Fritz at Retirement Manifesto had a great post the other day about how woefully unprepared Americans are when it comes to retirement savings. There is some evidence that people spend less in retirement because they have to: Social Security benefits are pretty modest and even adding other supplemental income from retirement savings and annuities, pensions, etc. leaves most retirees still far below the earnings potential of the median household in the 50-65-year age range.

If I were to adjust the lifecycle spending pattern at all, I'd probably *raise* my old-age consumption. We might travel less, but likely prefer to travel in more comfort and at a higher cost. There will be less backpacking and more cruise vacations after I reach age 60! Moreover, we will certainly have higher health expenditures than today. And on healthcare it's a double whammy: higher expenses when we get old and likely less help from the government than even today's retirees are used to. So, in our personal spreadsheet of spending plans, I currently have a scenario where I bump up withdrawals to more than CPI rates after age 70 exactly for that reason. Another reason not to rely on the 4% rule.

6 A Case Study: 2000-2016

Initially published as The Ultimate Guide to Safe Withdrawal Rates – Part 6: A 2000-2016 case study (or: Welcome to the Potemkin Retirement Village) on January 18, 2017.

In our research so far, we have been quite skeptical about the 4% rule. That would be especially true for early retirees with a much longer horizon than the standard 30 years. Though, by reading through some of the research from the heavy hitters in the retirement research world, even the foundation of the 4% rule over **30 years** seems to be crumbling a little bit:

- Finke, Pfau and Blanchett (2013) and Pfau (2015) have been warning that in today's asset valuation regime the Trinity Study success rates are likely overrated. The argument is similar to ours in Part 3 of this series: we live in a low return world now and comparisons with past average returns could overstate the success probability of the 4% rule. Finke, Pfau and Blanchett (2013) and Pfau (2015) use a slightly different methodology (Monte Carlo simulations) but reach similar results.

- Even Michael Kitces, arguably one of the great defenders of the 4% rule, has (inadvertently?) demonstrated that the 4% rule over 30 years isn't all that sound. In the discussion after the famous "ratcheting post," some readers (including yours truly) pointed out that we can't replicate the success of the 4% rule with 1965/66 starting dates. Nothing to worry about, Kitces replied, all you needed to do is to use a very *short-term* bond (1-year T-bills) for the bond allocation, and you sail smoothly during the 1970s. Who would put 40% of the portfolio into 1-year Treasury bills (essentially CD interest rate) rather than trying to harvest the term premium of longer-term bonds? Very easy: someone with 20/20 perfect hindsight who knew that longer duration 10Y bonds will get hammered in the 70s and sink the 4% rule even over a 30-year horizon.

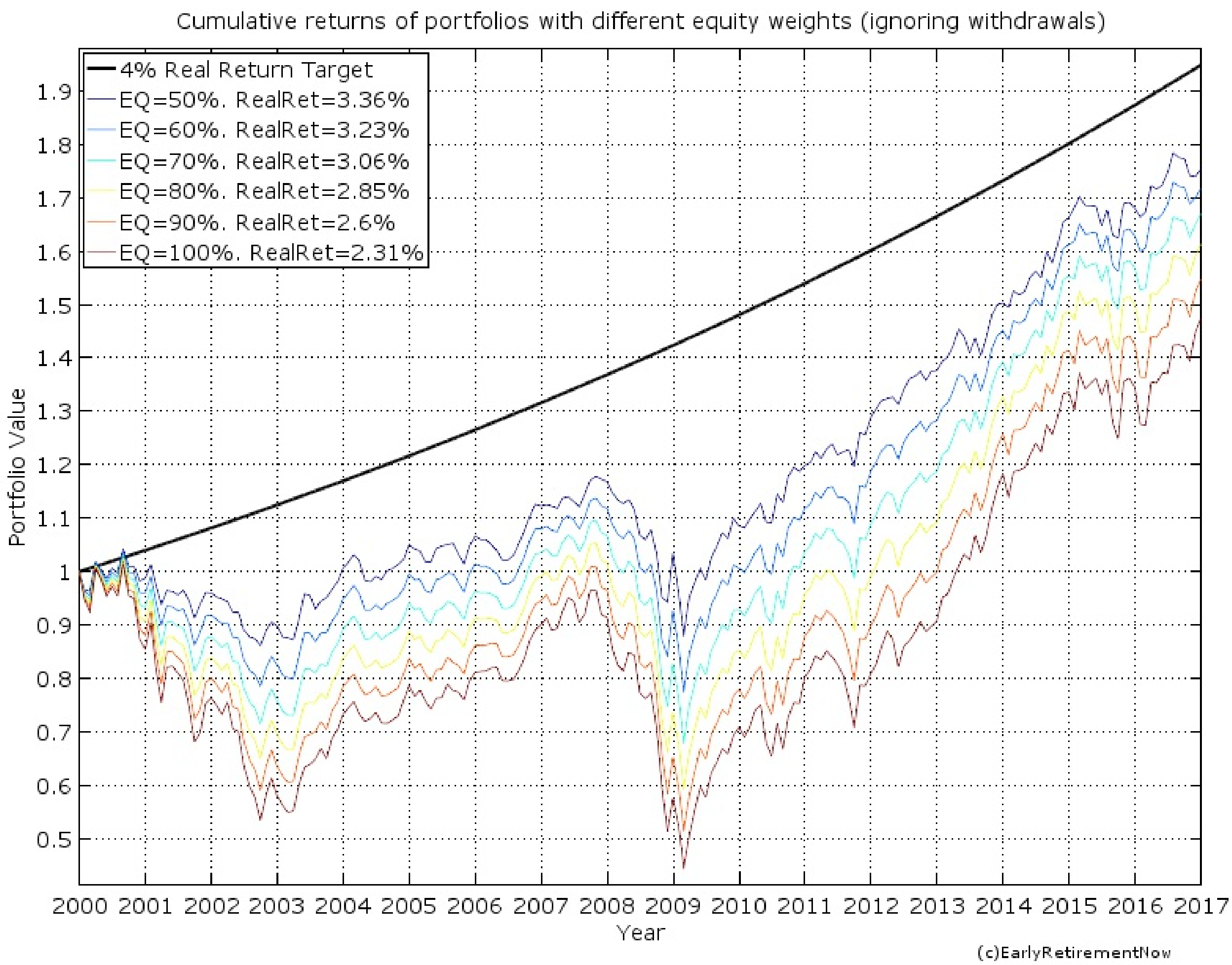
And I just became a little bit more skeptical about the 4% rule even over a 30-year horizon! But there is (at least) one prominent 4% SWR firewall still standing. In countless blog posts, discussions, forums etc. I have heard this quote (or variations of it):

"The 4% rule worked just fine during the Tech Bubble and Global Financial Crisis"

Let's shine some light on that claim.

6.1 Real Returns 12/31/1999-12/31/2016

The first suspicions about the validity of that claim came when I looked at the average returns in equities and bonds since December 31, 1999, and they didn't look so appealing. Equities (S&P500, dividends reinvested) returned only slightly more than 4% p.a. in *nominal* (!) terms, and 2.36% p.a. in real, CPI-adjusted terms. How can that justify a 4% withdrawal rate? Isn't the real portfolio return supposed to be roughly equal to the real rate of return to make this work? Below we plot the cumulative returns (before even withdrawing anything!) of different Equity/Bond portfolio mixes, adjusted for inflation.



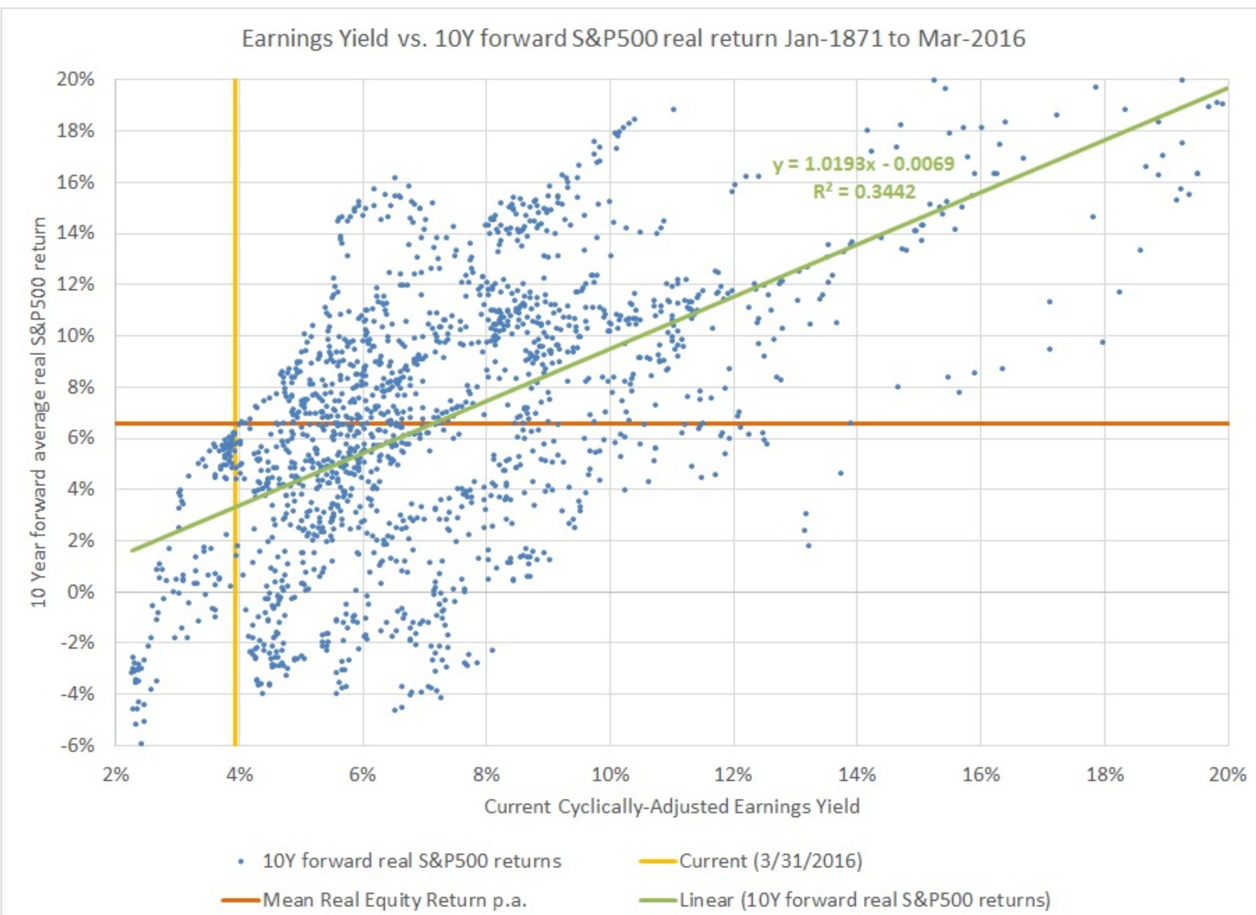
Cumulative real (CPI-adjusted) returns of different S/B portfolios compared to 4% target return.

Note, these are already the returns taking out 0.05% p.a. in ETF expense ratios, hence, the 100% equity portfolio return dropped from 2.36% to 2.31%. None of these portfolios would have stayed even close to a 4% real return target over time. Every month and every year we stay below that black line we dig deeper into the principal. When someone wants to tell me that the 4% did well since 2000, that doesn't even pass the smell test.

6.2 EarlyRetirementNow Simulations

So, without simulating anything I already know that the 4% rule would not have fared very well and you would have wiped out some portion of your principal. How much? Well, let's run the ERN simulations and see for ourselves. Since we started this series I updated the realized returns all the way to December 2016 (Parts 1 through part 5 used realized returns only up to 9/30/2016). Let's see how the 4% rule would have performed under different portfolio allocation assumptions. We also took the liberty to extend the equity and bond returns beyond the first 17 years. As described in our initial SWR post, we assume that future real equity returns are equal to the average real return since 1871 (about 6.6% p.a.). We now assume that the bond return is going to be equal to the 12/31/2016 10Y nominal bond yield (around 2.5%) minus 2% inflation = 0.5% p.a. real for the next 10 years, then also returning to its long-term average of 2.6% real.

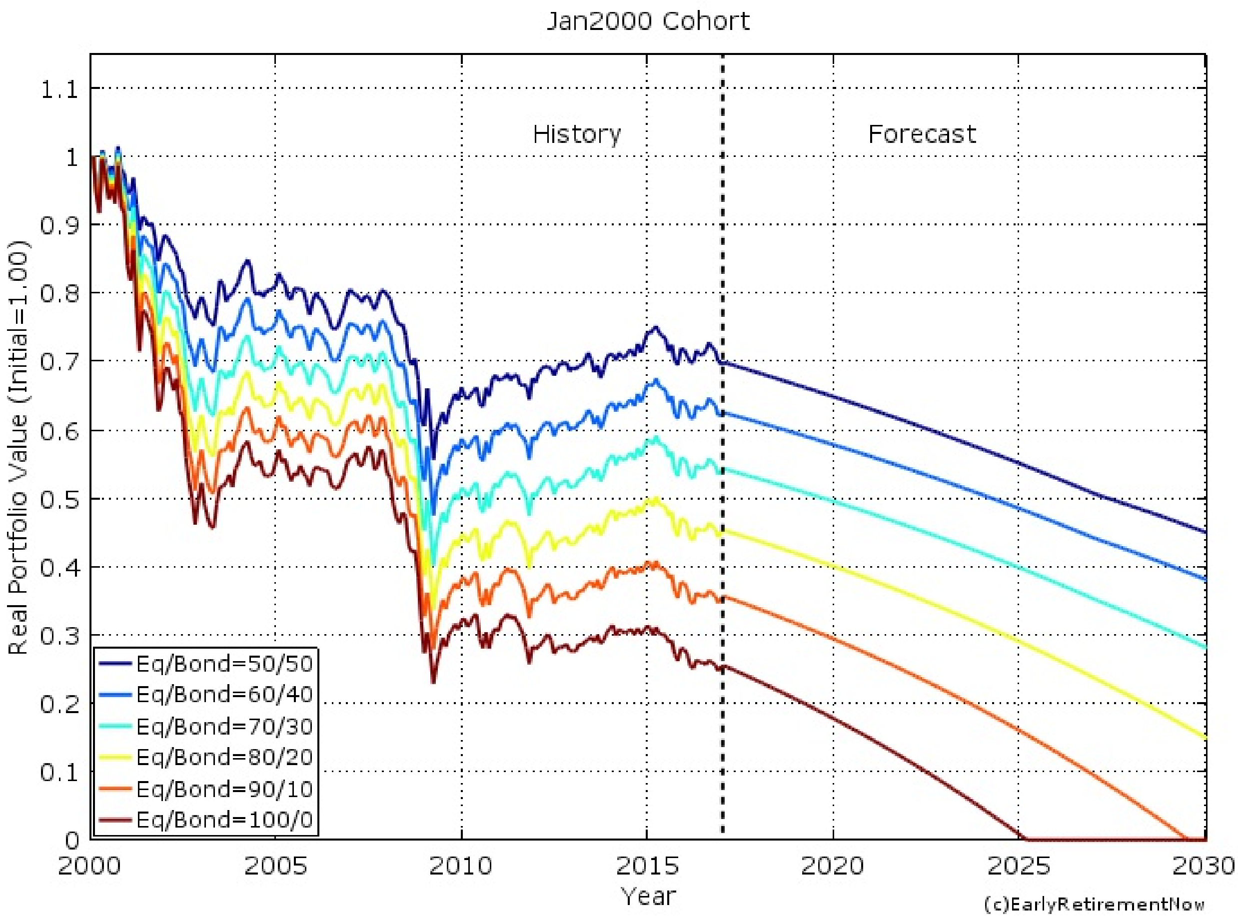
Side note: That's actually a pretty aggressive estimate for future returns given that the CAPE is so high! Recall our post from last year, where we plotted the current CAPE earnings yield (=1/CAPE) vs 10-year forward equity returns: If the CAPE is above 25 (yield <4%) the 10Y forward equity return never exceeded the 6.6% mean real return, see chart below!



CAPE Earnings Yield vs. 10Y forward real annualized returns.

Below is a time series chart of the real portfolio value over time for different equity portfolio shares between

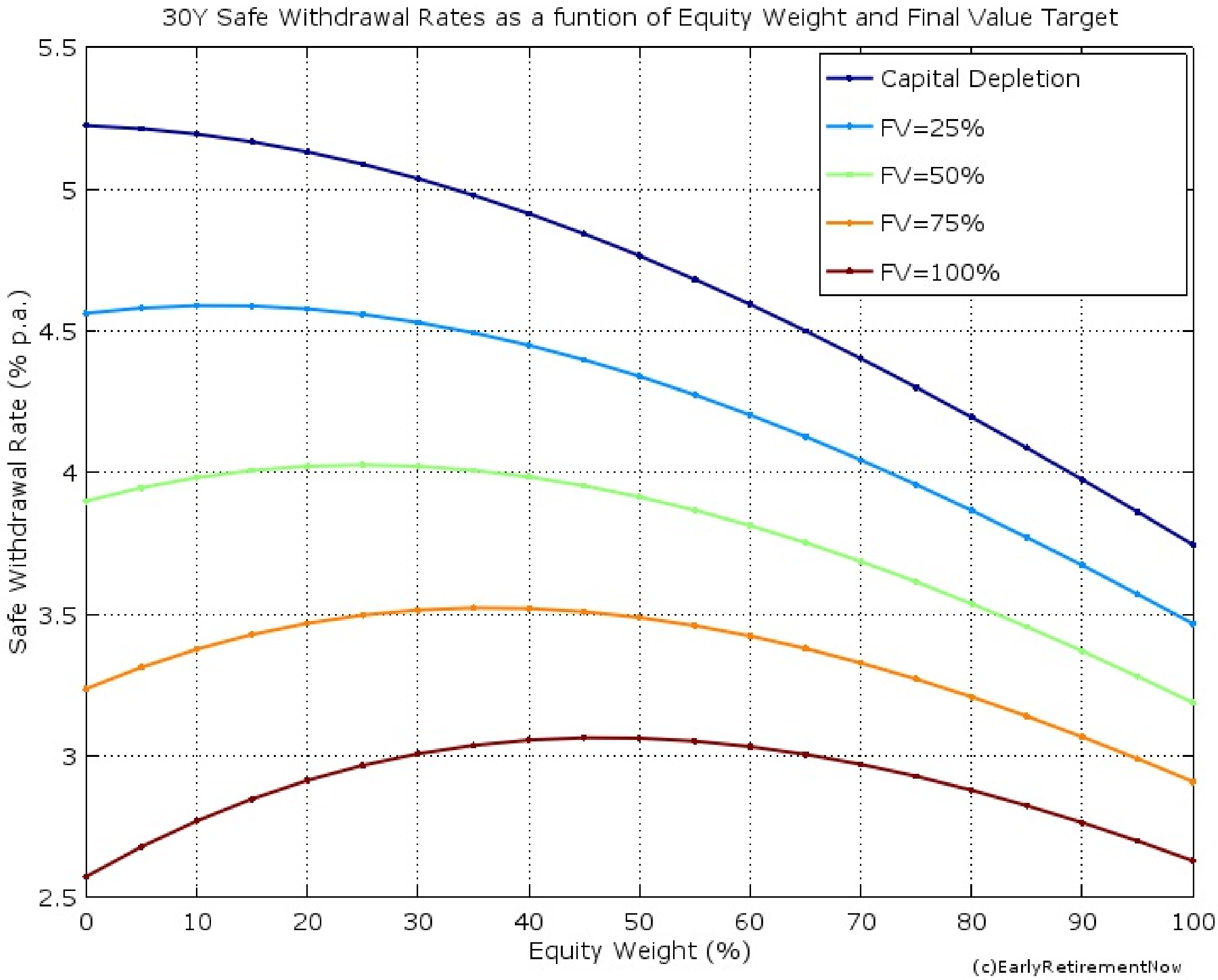
50% and 100%. A portfolio would have taken a serious hit after 17 years: In real terms, the portfolio is down by anywhere between 30% and 75%.



Real Portfolio Value of the Jan 2000 cohort when using a 4% initial withdrawal rate plus CPI-adjustment of withdrawals. Live Equity/Bond returns until Dec 2016. After that: long-term average real return for Equities, 0.5% real return for bonds for 10Y, long-term average after that.

But can the portfolio recover? Well, of course, it can if stocks go up by between 50% and 300% in the next year. But even the somewhat optimistic assumption of 6.6% real equity returns over the next 13 years will only further deplete the portfolio, see the downward-sloping portfolio values starting in 2017.

Next, we can also calculate the SWRs that would have exactly matched a specific final value target after 30 years. Again, that's using the 17 years of actual return data plus the 13 years of return forecast. See chart below:



Safe Withdrawal Rates in January 2000 to exactly hit specific Real Final Value targets in 2030 for different equity weights.

In January 2000, you could have withdrawn 4% or more if you weren't too aggressive on the equity allocation and you're OK with running out of money after exactly 30 years. 4% probably wasn't such a bad assumption for regular retirees who were 65 years old in 2000. But early retirees? You probably want to ensure that you have about 75-100% of the initial principal available half-way through your retirement. Depending on the equity weight, 2.6-3.1% for capital preservation and 2.9-3.5% for 75% capital preservation was all you could start withdrawing in 2000. And that's under the somewhat rosy assumption of 6.6% real equity returns for the next 13 years (despite elevated CAPE ratios) and zero volatility along the way. Not a pretty picture! If anything, the 2000-2016 episode was a worst-case scenario for early retirees. Quite the opposite of the "4% rule did OK" myth.

6.3 Welcome to the Potemkin Retirement Village: Successfully using the 4% Rule since January 2000!

So, how can one still claim that the 4% rule is A-OK after 2000? We'd have to be deceived by a financial Potemkin Village. I gathered some examples below:

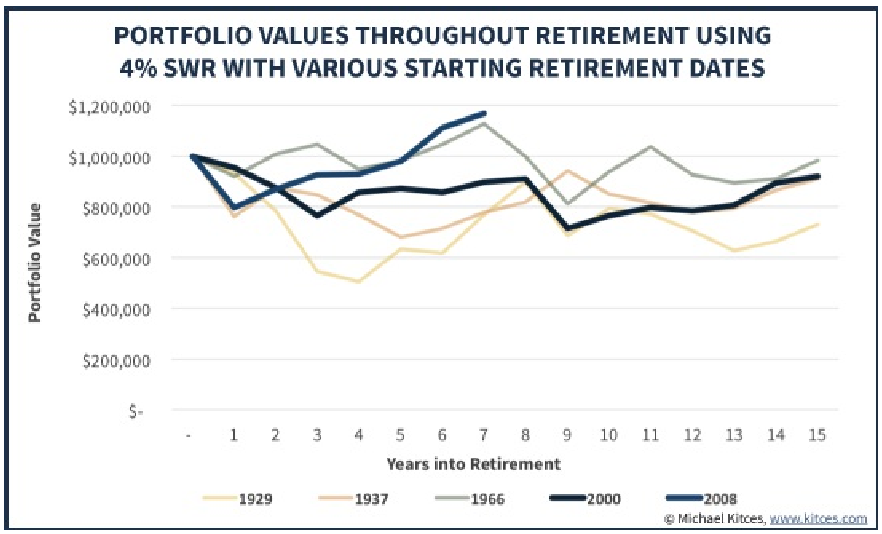
6.4 Potemkin Village #1: Michael Kitces' post on the topic

Just to be clear, I am not saying that Kitces wants to deceive anybody in his post on the 4% rule post-2000. He's obviously an extremely smart guy and puts out very fascinating material. I also found that he's very kind and gracious in replying to questions and requests.

But his post on the matter is still a Potemkin Village. All the pertinent information is in that post. It's all 100% accurate, completely confirmed by yours truly. Everybody who **wants** to get an objective picture of the 4% rule in the 2000-2015 period will walk away with the exact same information that I saw:

- The 4% rule worked probably all right for the **average 65-year-old** who retired in 2000. That person may make it through to 2030, especially considering that the person is now 82 years old and may curb consumption a little bit, in line with losing almost 40% of the real portfolio value. Not so much, though, if there are medical bills piling up and withdrawals actually grow faster than CPI!
- But the **average early retiree** would have trouble making the 4% rule work. By 12/31/2016, only 17 years into the retirement you would have wiped out a big chunk of the portfolio as we show in our calculations above and even then you have to cross your fingers and hope for above average equity returns, something unprecedented when the CAPE is at 28. Good luck with that!

But how about folks who **don't want** to see the faults in the 4% rule? Say, someone who has a predetermined conclusion that the 4% rule worked great in 2000 even for early retirees. If that person reads the Kitces article he/she will come to the exact opposite conclusion. See the following chart, here reprinted with permission:



Source: Michael Kitces at Nerd's Eye View, reproduced with permission.

Kitces used a 60/40 Stock/Bond mix and now it looks like the year 2000 cohort is back to maybe $930,000. Doesn't look so bad, right? That proves the 4% succeeded during that time! Not so fast: read the fine print! This is the *nominal* value. $930,000 in *nominal* terms means that the real value is down to somewhere in the low $600,000s, consistent with our calculations.

Also, right after the Kitces post (July 2015) the portfolio value is trending down, see our time series chart above. Recall, that our calculations take into account the pretty impressive 2016 equity return (12% with dividends!) and we're still continuously melting away our principal! That's because the 4% withdrawal rate has now grown to a 5.7% to 16% withdrawal rate (depending on the equity share). Remember, there's only between 25 and 70% of the portfolio left, so the withdrawals are now higher relative to the principal (4%/0.7=5.7%, 4%/0.25=16%). You will eat into the principal even more during the remaining 13 years (and we are not even taking into account equity volatility and Sequence of Return Risk). It may all still work out for the *traditional* retiree with 13 years to go, but not for the early retiree with 40+ years to go.

6.5 Potemkin Village #2: The Stock/Bond Allocation

Recall the "ratcheting post" from Kitces, written in June 2015? Compare that to the post about the 4% during the post-2000 period, written only a few weeks after that, and you will notice one subtle difference:

- In the ratcheting post, the 4% rule worked during the 1970s because the 40% bond allocation was invested in *short-term* bonds (1-year T-bills).

- In the post on the dot-com bubble and global financial crisis, Kitces uses a 10-year Treasury bond.

If you had followed the advice from the ratcheting post and invested in 40% short-term bonds starting in 2000 you would have lost the beautiful diversification benefit of bonds and you would have missed out on the big bond rally. The nominal portfolio value would have gone down to just under $500,000 in nominal dollars and below $350,000 in real, CPI-adjusted dollars by December 31, 2016. Good luck making that money last until even 2025. If you haven't cut your consumption yet, the annualized rate of withdrawal would be almost 12% now. To bring back the withdrawal rate to a more manageable 4% we'd have to cut withdrawals by about two thirds!

I wonder if all those who tout the 4% rule as so safe realize that in the most optimistic interpretation it will involve timing the bond vs. cash allocation. **Better get your term premium model up and running, everybody!** And the worst possible interpretation is that the success of the 4% rule is based on some pretty blatant data snooping and hindsight bias, even for the traditional retiree with a 30-year horizon.

6.6 Potemkin Village #3: The Trinity Study

Strictly speaking, the Trinity Study indeed covers the DotCom bust and the Global Financial Crisis. And it shows that the 4% rule is safe. But only towards the *end* of their 30-year windows. To my knowledge, the most recent installment of the study is from April 2011 with data covering 1926-2009. Therefore, we don't have any data about the year 2000 retirement cohort yet. Strictly speaking, it will take until December 31, 2029, to get word from the Trinity Study about whether the 4% rule worked with the January 2000 starting date. What if that cohort already runs out of money in 2025? We show that is a real possibility unless stocks return more than their historical average going forward. Will the Trinity Study still be quoted as the defender of the 4% rule for the early 2000s until they actually confirm it didn't work?

6.7 Summary

The often quoted statement above needs a few important qualifiers for us to agree with it:

The 4% rule worked just fine during the Tech Bubble and Global Financial Crisis **IF:**

- You have a 30-year retirement horizon.
- You are comfortable depleting your money at the end of that horizon and/or significantly cutting your real withdrawal amounts.
- You had a relatively low equity portion (60% or less).
- You are not a passive investor but rather have the foresight to time long-term vs. short-term bonds. Specifically, you needed the ability (or dumb luck?) to implement the exact allocation that **didn't work** in 1965/66 and **avoid** the allocation that **did actually work** quite beautifully in 1965/66.

7 A primer on the safe withdrawal rate arithmetic

Initially published as The Ultimate Guide to Safe Withdrawal Rates – Part 8: Technical Appendix on February 1, 2017.

How do we compute safe withdrawal rates in practice? We start with an initial real portfolio value, for simplicity scaled to one, make monthly withdrawals, potentially pay or receive some supplemental cash flows (i.e., consulting income during early retirement, social security and pensions later in retirement, health care expenditures later in life, etc.) and then receive a certain stream of capital market returns over time. Given a withdrawal rate, we can easily calculate the final net worth, simply by iterating forward the portfolio value until the final month. But that's not how we want to compute it. Recall, we target a certain final asset value and desire to calculate the withdrawal rate to exactly match that final value, not the other way around!

One way to calculate the withdrawal rate would be to guess the withdrawal rate, iterate forward, see by how much we miss the target final value and then adjust the withdrawal rate until we hit the desired target. That would work well if we had to calculate one single safe withdrawal rate. But remember: we want to calculate several million safe withdrawal rates (all combinations of starting dates, equity weights, final asset values, retirement horizon, and other parameters), so the trial and error method or even a Newton-Raphson method seem a little bit cumbersome. There is a more elegant method. Much more elegant!

First, let's define variable C_t as the total cumulative return of one dollar invested between the beginning of month t and the final period T, which is the end of the retirement horizon, e.g., 720 months in our case, or 360 months in the Trinity Study. Think of this as an opportunity cost factors, the loss of each dollar of a withdrawal in period t measured in period T dollars. If the (real, inflation-adjusted) capital market returns are $\{r_t\}_{t=1}^{T}$, then we can calculate this as:

$$C_t = \prod_{\tau=t}^{T} (1+r_\tau)$$

So, the C_t are simply the cumulative capital market returns, but moving **backward** rather than forward. Also, note that C_1 is the cumulative return of the initial principal if held over the entire retirement horizon. In other words,

$$\begin{aligned} C_T &= 1+r_T \\ C_{T-1} &= (1+r_{T-1})C_T \\ C_{T-2} &= (1+r_{T-2})C_{T-1} \\ &\dots \\ C_1 &= (1+r_1)C_2 = \prod_{\tau=1}^{T} (1+r_\tau) \end{aligned}$$

We can now calculate the final asset value of a portfolio with initial value of one and withdrawals w every month as

$$\mathrm{FV} = C_1 - w\sum_{t=1}^{T} C_t$$

The first term on the right side is how much the portfolio would have grown in the absence of any withdrawals, and the second term is the total opportunity cost of all withdrawals translated into date T dollars. Notice that even the final month's withdrawal is subjected to a return r_T because the withdrawal comes out at the beginning of the month while the final asset value is marked at the end of the final month.

Now we can easily solve for the withdrawal rate w that generates the final value target as

$$w = \frac{C_1 - \mathrm{FV}}{\sum_{t=1}^{T} C_t}$$

We can also easily expand this analysis to include any sequence of additional cash flows independent of the investment portfolio, $\{p_t\}_{t=1}$, to account for pensions ($p_t > 0$) or even costs in retirement (e.g., kids' college costs, higher health care costs when old, etc.) that need to be funded over and on top of the baseline withdrawals ($p_t < 0$). Translating those additional flows into date T dollars requires multiplying each by its opportunity cost factor and summing up. Hence,

$$\mathrm{FV} = C_1 + \sum_{t=1}^{T} p_t C_t - w\sum_{t=1}^{T} C_t$$

And thus,

$$w = \frac{C_1 + \sum_{t=1}^{T} p_t C_t - \mathrm{FV}}{\sum_{t=1}^{T} C_t} = \frac{C_1}{\sum_{t=1}^{T} C_t} + \frac{\sum_{t=1}^{T} p_t C_t}{\sum_{t=1}^{T} C_t} - \frac{\mathrm{FV}}{\sum_{t=1}^{T} C_t}$$

Notice how all three terms in the safe withdrawal rate are simply additive. Computationally, this is very easy and very quick to handle. For example, for any given retirement start date, horizon, and equity weight (and thus sequence or returns), we have to calculate the terms involving C only once and simply read off the sustainable withdrawal rates for different values of FV with very little computational burden.

One additional complication we can model is to assume that the withdrawals have a specified scaling/shape over time, i.e., $w_t = w \cdot s_t$, where $s_1 = 1$ and subsequent scaling factors $s_t, t = 2, ..., T$ can take any desired shape, e.g., an exponential increase over time (to model COLA=Cost-of-Living Adjustment above the CPI), or an exponential decay (COLA less than CPI), or any other shape over the retirement horizon.

$$\text{FV} = C_1 + \sum_{t=1}^{T} p_t C_t - w \sum_{t=1}^{T} s_t C_t \quad \Rightarrow \quad w = \frac{C_1 + \sum_{t=1}^{T} p_t C_t - \text{FV}}{\sum_{t=1}^{T} s_t C_t}$$

8 A DIY toolkit (via Google-Sheets)

Initially published as The Ultimate Guide to Safe Withdrawal Rates – Part 7: A Google Sheets Toolbox on January 25, 2017.

Here's the Google Sheet Link:

Link to the EarlyRetirementNow SWR Toolbox v1.0

For obvious reasons, the baseline Google Sheet can only be edited by us. If you like to run your own calculations you have to download your own copy. There are at least two ways to do so:

1. **(recommended)** Click on Menu, then "Make a Copy" or "Add to MyDrive" to get a local copy of the spreadsheet in your own GoogleDrive. You can then edit the sheet and use your own assumptions.
2. Click on Menu, then "Download as" then "Microsoft Excel (.xlsx)" to get a copy as an Excel file to store on your own harddrive. It's not really recommended because most of the formatting will get lost. But if you care only about the computations you should be fine.

How our tool is different from cFIREsim?

- We use monthly data, while cFIREsim uses only annual data.
- We project forward return forecasts beyond 2016 year-end so we can calculate SWR for more starting dates. For example, the January 2000 cohort is already far underwater, as we showed a case study last week. Even aggressive return assumptions will still wipe out the portfolio before too long and we like to count those cohorts as 4% SWR failures even before the utter failure is actually confirmed.
- cFIREsim asks you for a specific withdrawal rate and then simulates how that rate would have performed over time for each of the different starting dates. We go the **opposite** route: We specify a final value target and our spreadsheet calculates the **exact** initial withdrawal rate that would have precisely matched the final value target. For every retirement cohort between February 1871 and December 2015 (=1,739 months). The advantage of this procedure is that we can then easily calculate the failure rates of different initial SWR without calculating any new simulations. The failure rate of the 4% rate? Simply calculate the share of ERN-SWRs that are greater than 4%. And redo the same for all rates between 3.00% and 5.00% without ever calculating any new set of simulations as would have been required in cFIREsim.

Step 1: Enter Parameters

Fields with the orange shading are asking for user inputs:

1. The Equity share. We are aggressive and set this to 90%. The residual is invested in 10-year U.S. Treasury Benchmark Bonds.
2. The expense ratio: We currently set it to 0.05% p.a. One-twelfth of this is subtracted from each month's return.

3. Equity projected returns post 12/31/2016. These are real annualized return assumptions. In our SWR simulations we set this to 6.6% but here we are a bit more cautious and set this to a more conservative 5.0%.

4. Bond returns: for the near-term (notice how low current 10Y yields are) and then longer-term. Short-term we use only 0.5% over the next ten years, then going a bit higher to 2.0% real return after that.

5. Same for Cash: We expect pretty low cash returns over the next 10 years (0% real) and then a bit of a bump after that (+1% real).

6. Expected future real return for Gold: We set this to +1%. Historically, gold has returned only about 1.5% p.a. after inflation.

7. The length of the retirement horizon in months (e.g. 60 years = 720 months)

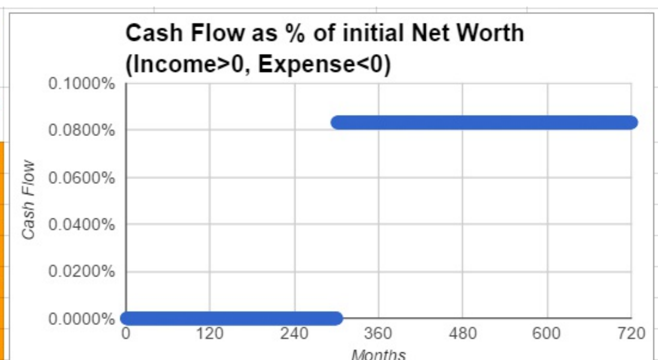
8. The target final asset value as % of the initial portfolio. We set this to 50%.

Parameters:	
Portfolio:	
Stocks	90%
Bonds	10%
Cash (NEW!)	0%
Gold (NEW!)	0%
ExpRatio (p.a.)	0.05%
Project Future Real Returns after 12/31/2016	
Stocks	5.00%
Bonds for next 10Y	0.50%
Bonds after that	2.00%
Cash for next 10Y (NEW!)	0.00%
Cash after that (NEW!)	1.00%
Gold (NEW!)	1.00%
Retirement Horizon (Months)	720
Final Value Target (%of initial)	50%

Simulation parameters, Part 1.

Below the main parameters, you can also set an entire time series of additional cash flow needs (all monthly numbers as % of the initial portfolio value). For example, we predict to get a pension and Social Security worth about 1% of the initial net worth (in 2018 dollars) 25 years into retirement. So, starting in month 301 we set this value to 1%/12=0.0833%.

16	**Supplemental Income/Expenses: Additional Cash Flow in % of initial Net Worth: >0 means income, <0 means additional withdrawal**	
17	**Month**	**Real Cash Flow as % of initial NW**
18	1	0.0000%
19	2	0.0000%
20	3	0.0000%
21	4	0.0000%
22	5	0.0000%
23	6	0.0000%
24	7	0.0000%
25	8	0.0000%
26	9	0.0000%
27	10	0.0000%
28	11	0.0000%



Simulation parameters, part 2: Account for additional cash flows, e.g. pensions and Social Security (>0) or additional costs like college expenses, healthcare (<0).

That's all you need. The computer does the rest for you. It calculates the safe withdrawal rates for each month starting in February 1871 to December 2015 that would have exactly matched the final value targeting the last month of the retirement horizon.

8.1 Results

Some summary tables are in the first tab "Parameters & Main Results." Be patient, depending on the internet connection and computer speed it may take a few seconds to recompute all results!

In the table on the left, we calculate the failsafe safe withdrawal rate both over the entire sample and for retirement cohorts post-1950 as well as the 1st, 5th, and 10th percentile. For example, since 1950, a 3.61% withdrawal rate would have failed 5% of the time and succeeded 95% of the time.

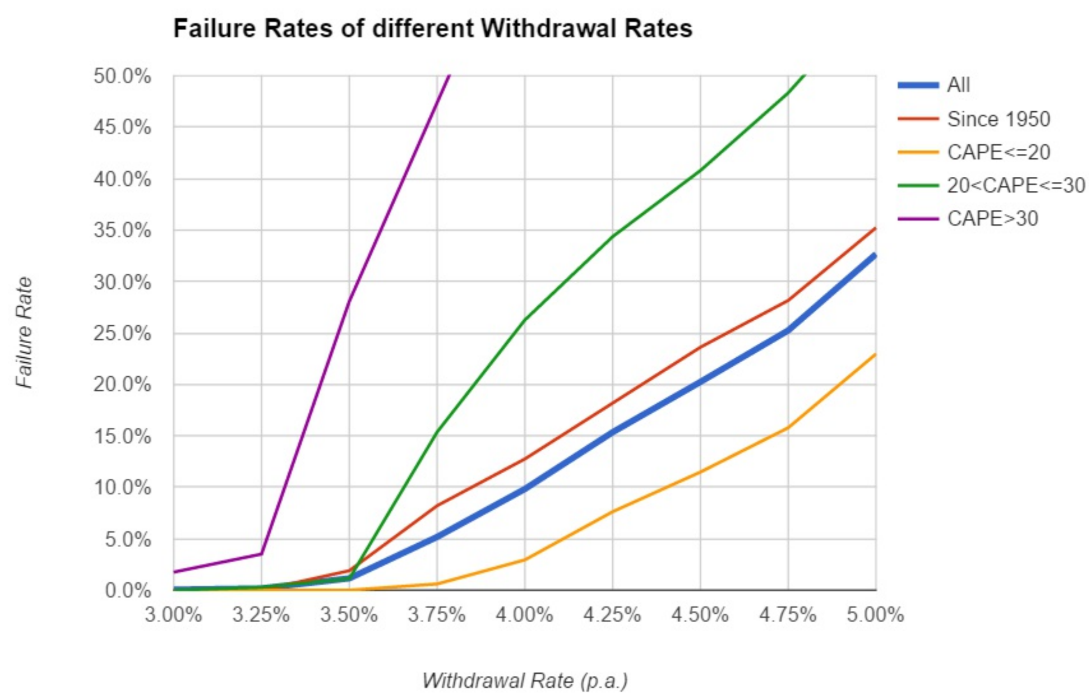
On the right, we calculate the failure probabilities of specific rates between 3% and 5% in 0.25% steps, again over the entire sample and since 1950, but also in the three CAPE regimes (<20, 20 to 30 and 30+). In the CAPE 20-30 regime, notice the big jump in the failure rates once you go beyond 3.5%!

Results:

Percentile	SWR Distribution			Failure Probabilities of different initial withdrawal rates				
	All	Since 1950	SWR	All	Since 1950	CAPE<=20	20<CAPE<=30	CAPE>30
0% (i.e. min)	2.96%	3.26%	3.00%	0.1%	0.0%	0.0%	0.0%	1.8%
1%	3.46%	3.43%	3.25%	0.2%	0.0%	0.0%	0.3%	3.5%
5%	3.74%	3.61%	3.50%	1.2%	1.9%	0.0%	1.1%	28.1%
10%	4.01%	3.85%	3.75%	5.2%	8.2%	0.6%	15.4%	47.4%
			4.00%	9.8%	12.8%	2.9%	26.3%	66.7%
			4.25%	15.4%	18.2%	7.6%	34.4%	75.4%
			4.50%	20.2%	23.6%	11.5%	40.8%	94.7%
			4.75%	25.2%	28.2%	15.8%	48.3%	100.0%
			5.00%	32.7%	35.2%	23.0%	57.8%	100.0%

SWR summary Tables: SWR distribution by percentile (left) and failure probabilities of different initial withdrawal rates for different time periods and CAPE regimes (right).

We also throw in a chart with the data in the right table:



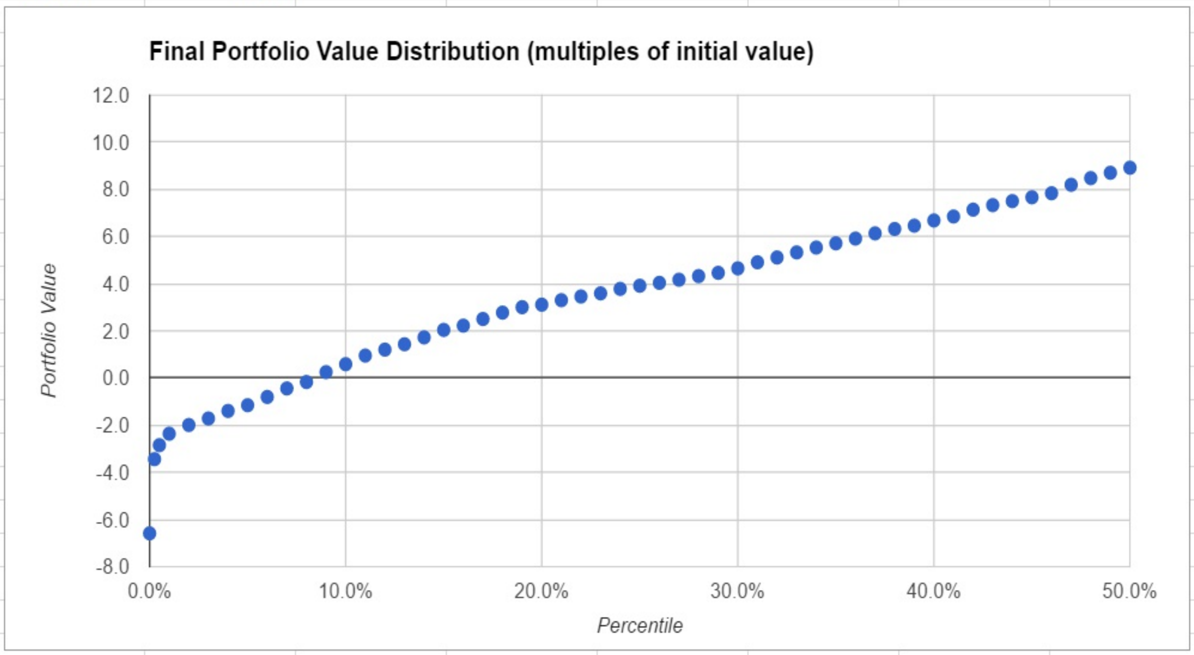
Failure rates of different Withdrawal Rates.

8.2 Distribution of the final portfolio value

In the tab "Distribution of Final Value" we can also specify a withdrawal rate and see the distribution of final asset values (real, CPI-adjusted, as multiples of initial). In the example below, we use the 4% rule. We are mostly worried about the left side of the distribution, so final values between the minimum and median. Note how for the median retirement cohort the investor would have grown the portfolio to 8 times (!) its initial real value. The maximum final value would have been a staggering 62-times the initial value. But at the same time, almost 10% of the retirement cohorts ran out of money!

Specify one fixed withdrawal rate, determine the distribution of final values applying that withdrawal rate:

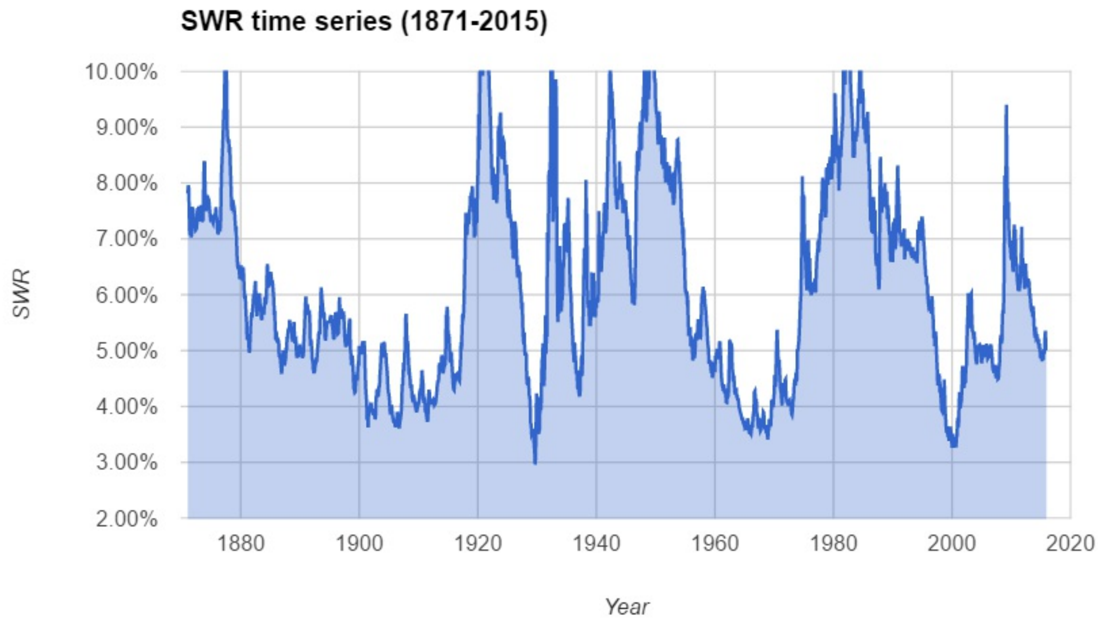
Withdrawal Rate:	
Annual	4.00%
Monthly	0.33%



Final Net Worth Distribution.

8.3 More results

Also make sure you check out the tab "SWR time series," which includes the SWR for all 1,700+ months in the simulation. For a quick look, there's a time series chart as well. Notice how there are quite a few times when the SWR is quite substantially below 4%!



SWR time series (1871-2015).

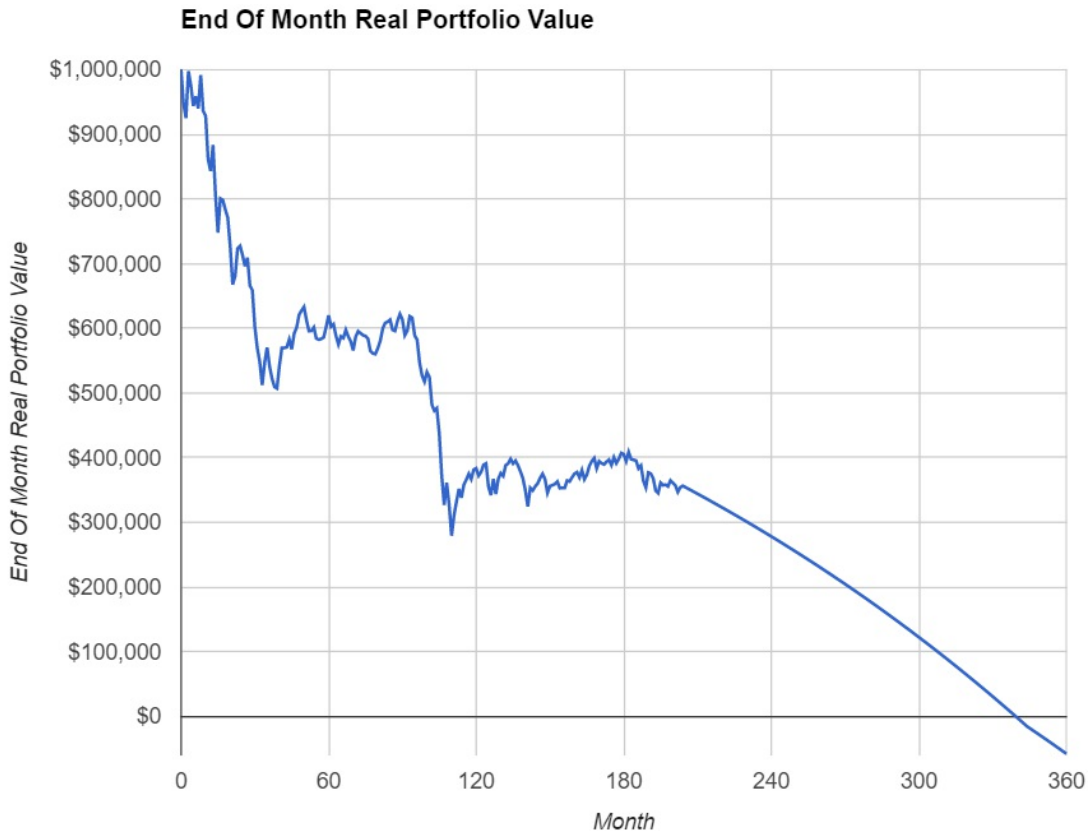
8.4 Case Study

As we just mentioned, in calculating the SWR we never even go through the cFIREsim-style exercise of iterating over months and years and plotting the portfolio value time series. That would be too cumbersome for all 1,739 retirement cohorts and several decades of retirement horizon. But if you were wondering how any particular withdrawal rate would have performed over time **for one specific retirement cohort**, here's the way to do it. Check out the tab "Case Study" where we can add the parameter values, again the orange shaded fields: The retirement start date (year/month), initial portfolio value and the withdrawal rate. And the computer does the rest!

360 Months case study		
Use the same S/B allocation and supplemental income/expenses as in Parameters Tab		
Note: Withdrawal happens at end of the previous month: P(t) = (P(t-1) - W(t)) * (1 + R(t))		
Retirement Start:		
Year	2000	
Month	1	
Initial Portfolio Value	$1,000,000	
Initial Withdrawal		
p.a.	4.0000%	$40,000.00
monthly	0.3333%	$3,333.33

Case Study Parameters.

The time series of portfolio values is in column D and also in the time series chart. This will use the same portfolio allocation and also the same supplemental income/expenses as in the main parameter tab. As we already noted last week, January 2000 would have been a pretty bad starting date for retirees. Not just early retirees!



End of the month real portfolio value. The first 204 months are actual return data, expected return data after that.

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