Data Science Approach to Retirement Planning

Tidewater Big Data Enthusiasts
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November 17, 2019

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1 Introduction

Retirement planning is a serious topic and should not be undertaken lightly. That said; I am not a financial planner, nor do I play one on television. I do like to play with numbers, and so I undertook to see how retirement planning could be viewed using ideas from Data Science in order to better understand the goals of trained, official, and professional financial planners.

This report documents how I worked to answer the question: what will our financial life be like after retirement?

The Excel spreadsheet embedded in this file at the end of this document enabled my wife and I to sleep easily at night while we were working, and to enjoy our lives after we retired.

2 Acknowledgments

Thank you to Lane Cartledge and Tapan Amin for getting me off "top dead center" to write this report. And to Mary, who allowed me the time necessary to tease apart the ideas we were taught, and to organize them in a way that made sense for us.

3 Intended readers

Looking back at my life; and remembering conversations that I have had with people of different ages, interest in retirement planning seems to follow this kind of trajectory:

20s – who cares about retirement planning, that is too far away for me to care about.

30s – I know that retirement planning is supposed to be important, but I too busy right now.

40s – half of my career is behind me, and I don't have a lot of time left to accumulate all the money that people say I will need.

50s – I'll need to save like crazy to have anything to live on when retirement is forced upon me.

60s – my fate is sealed, and I can read the handwriting on the wall.

70s – I'm OK, or I'm in trouble.

If you are young, then do these things:

1. Invest as heavily as you can comfortably afford into the stock market (something like a no-load index fund),

2. Print out the directions on how to run the embedded Excel file, and file it away so that you can find and read it when you are older,

3. Save this document, and the attached files onto CD or other long term durable medium (a thumb drive is not a durable medium),

4. Finally, when you get older, dig out the hard copy and the CD, and you will better appreciate your decision to invest early.

When I was young (in my 20s), I unknowingly made the best financial decision for my wife and I. I joined the US Navy Reserves. When I was less young (in my 30s); I lusted for another computer, and my wife said that if I wanted one then I would have to look to the Reserves to pay for it. As I got older (in my 40s), I realized how much a pension (when translated into a funded annuity) was really worth. Now (in my 60s), I look back and appreciate how lucky my wife and I are to have made as long as we did without a real plan.

Our plan started to take shape in my 40s, based on the convergence of three unlikely events. The events were:

1. The realization that I would never get the "corner office." This implied that I could use past income to predict future income.

2. Somehow getting onto the retirement planning circuit, where financial planners will offer you a meal in return for sitting through their sales pitch.

3. A chance e-mail from Bob Williams (a co-worker) about 10,000 marbles and Saturdays.

While my wife and I may have gotten to our good place without these events, looking back, they seem instrumental.

4 Background

4.1 Retirement planning circuit

When my wife and I started to attend the retirement planning dinners (really sales pitches from salesman trying to make a living), we started taking and keeping notes about the various products being pitched. After a while, we got to the point where we would spot trends in the retirement planning market. Some were rather vanilla, and others were more than a little bizarre. We also kept seeing the same diagrams and plots regardless of the presenters.

After listening to many of these presentations, in different formats, and in different venues, we came to understand that the salesmen were touting answers to three specific questions. And, that they were the only ones how could answer those questions for us, as the attendees. The questions were:

1. How much money do you have to retire on?
2. How much money do you need to live on?
3. How long will your money have to last?

Some of the salesmen offered what sounded like good advice, and claimed to have "the best product" for our needs. Because one of the questions seemed easy to answer, I decided to try my hand at answering all three. I felt that regardless of the "product" that we purchased, the salesman did not have "skin in the game" if things went wrong. Only my wife and I did, hence the quest to answer the questions for ourselves. That quest led to this report. Now to general answers to the questions:

1. How much money do you have to retire on?– Can be answered fairly simply, if you make a few assumptions:
   (a) Your past pay raises are an indication of future raises.
   (b) Your past 401K/IRA contributions are an indication of your future contributions.
   (c) Your past 401K/IRA performance are an indication of your future performance.
2. How much money do you need to live on?– Almost too hard to estimate, so I took the easy way out, and said "All of it."
3. How long will your money have to last?– Very hard to answer. If you were to come up with an absolutely perfect plan with you living until you were 86, what happens if you live to 87? I made the decision to make plans where I would live to be 105. It is very unlikely that will happen. So if my plan works to that age, than my "early" termination will be financially OK.

After spending sometime working on a spreadsheet that would answer the question: What will our financial life be like after we retire? We went and saw a couple of financial planners.

The first planner presented a "product" based on a series of interlocking spreadsheets. When we asked him questions about the assumptions in the spreadsheets that he wasn't able to answer, we politely said that we'd think about it and get back to him. Some time later we met with the second planner. By that time, we had our spreadsheet up and running fairly well so we understood the ins-and-outs of the planning process. We told the planner what our near and far term financial objectives were, they went away, and came back with a detailed plan complete with pretty charts and fancy graphics. The numbers they gave us, in terms of what they brought to the table, and the services they could provide us, were very close to our homegrown spreadsheet. We didn't go with them because they didn't offer us any more than what we had come up ourselves. (The second planner was later indicted for fraud.)

In the end, I updated the spreadsheet on a yearly basis. I ensured that all the predictions were reasonably close to reality, and waited for the "plan" to bear fruit.

4.2 Marbles and Saturdays

The way I remember it, it Bob Williams' e-mail was about 10,000 Saturdays, closer examination may have been only 1,000. Here is one version of the story from Lori Allen, "1,000 Marbles Story: Change Your Saturdays From Now On" (`https://www.greatescapepublishing.com/articles/become-a-travel-writer/1000-marbles-story-change-your-saturdays-from-now-o`

> "It's the first day of a new year and the last thing I want to talk to you about today is productivity, goal setting, and resolutions.
>
> So instead, let's talk about Saturdays.
>
> We have one coming up tomorrow. And barring anything tragic, we have one coming up every week from now until the day we die.
>
> A few years ago, my mentor sent me a story about 1,000 marbles that I think might change your Saturdays from here on out.
>
> The story has been passed down many years now so I'm not sure of its origin. But it goes something like this
>
> It was a warm Saturday morning in sunny South Florida when, flipping through the channels on an old ham radio, he stumbled on a voice that was so crystal clear and attractive, it felt like the broadcaster on the other end was speaking directly to him.
>
> The voice, like my mentor, cherished his Saturdays. It was time he spent with his family. Time he didn't have to work. Time he took to relax, read, and reflect. And so he did some math
>
> If the average person lives to be 75, the mysterious voice said, and there are 52 weeks in each of those 75 years, that's 3,900 Saturdays in a lifetime.
>
> He went on to add that 2,800 of those Saturdays were already gone by the time he realized this. So with just about 1,000 Saturdays left, he went out in search of 1,000 marbles to represent each of his remaining special days.
>
> Three toy stores later, he brought every single marble he collected home and put them inside of a large, clear plastic container. Then, every Saturday, he took one out and threw it away.
>
> He found that by watching his bunch of marbles diminish, he could focus more on the really important things in life. That there was nothing like actually watching your time run out to help you get your priorities straight.
>
> Then he said something startling. He announced that today, this very special Saturday, he took his very last marble out of the container and threw it away.
>
> If he makes it until next Saturday, he figured, he'd have been given a little extra time. And the one thing we can all use is a little more time.
>
> So yes, make your resolutions and set your goals for the New Year today. Do whatever makes you happy.
>
> But don't forget about your Saturdays.

2016 is going to be a great year and I'm excited to spend it with you."

The effect on me by this apocryphal story was: to compute the number of Saturdays until age 85, (2) go out and buy a large glass vase, and (3) buy enough marbles to make it to age 85. Every Monday I would remove one of the marbles. One at a time, the change in the level of marbles was almost imperceptible. But over time, the drop was noticeable. The dropping level was a visible reminder that time was passing, that the "end" was drawing near, and that I needed to be ready for it.

People who saw the vase and asked about the marbles, almost universally thought I was more than a little strange. But it was a constant reminder that time was passing, that even if I felt better today than yesterday it wouldn't last, and that I (we, my wife and I) would have to live out whatever the plan was, and that the plan needed to be the best that we could make it.

5 Analysis

Long term financial planning does not have to be mysterious, or intimidating for an individual. What is needed is a basic understanding of how a few numbers work together, what things are too hard to predict, patience, and focus.

If you have worked in a particular company, or organization for a number of years without a significant change in position, or responsibility then you can assume that things will remain the same for the foreseeable future. The effect of that will be that your salary will increase just a little bit above the current inflation rate (usually the consumer price index [CPI], as reported by the Bureau of Labor Statistics [BLS][1]). I believe this is a reasonable assumption because, an organization:

1. Needs to keep its costs under control, thereby maximizing profits for its owners, and
2. Is under a practical obligation to pay its employees just enough to keep them, and not a cent more.

If the previous assumptions are true, then it is easy to construct a plot showing how your individual pay raises relate to the yearly CPI (see Figure 1 on the following page). Assuming there is an almost linear relationship between the CPI and your pay raise, then you can predict your near term pay raises. In this context, near term is in the single digit year range. Predicting pay too many years into the future can be very problematic because outside factors can come into play (change in business direction, technical obsolescence, lower paid competition, etc.) that are too difficult to predict.

CPI data is available from the Bureau of Labor Statistics (BLS), and can be looked at over time (see Figure 2 on page 7). The historical data from about 1970 through 2019

[1] `https://www.bls.gov/data/`

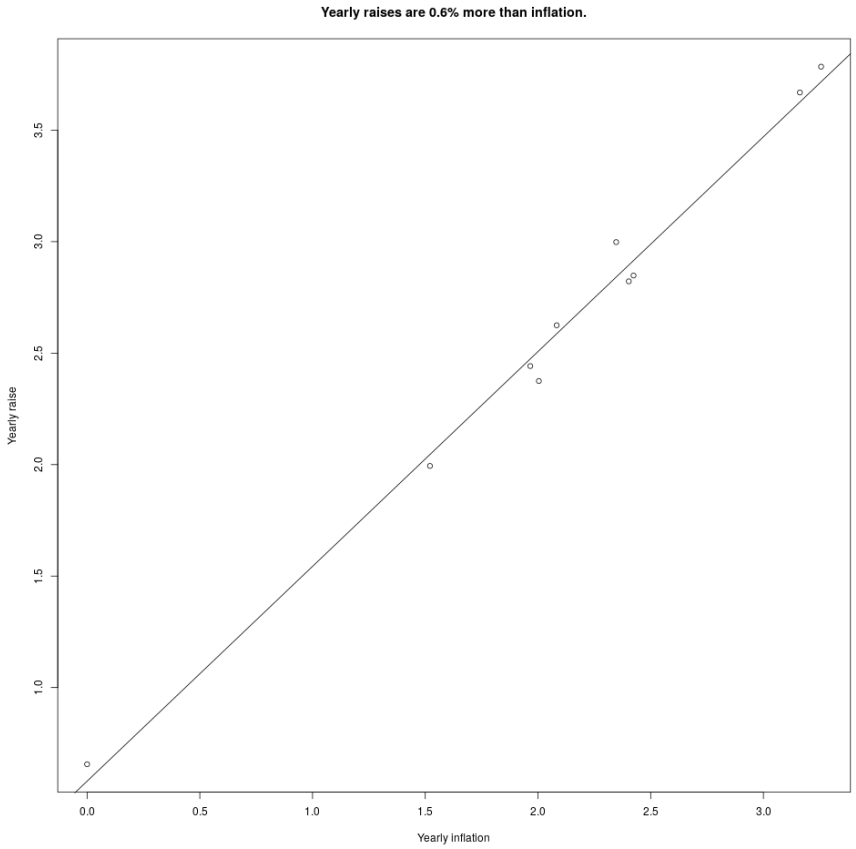

Figure 1: Notional pay raises versus CPI. Artificial CPI and pay raise data showing a linear connection between CPI and raises.

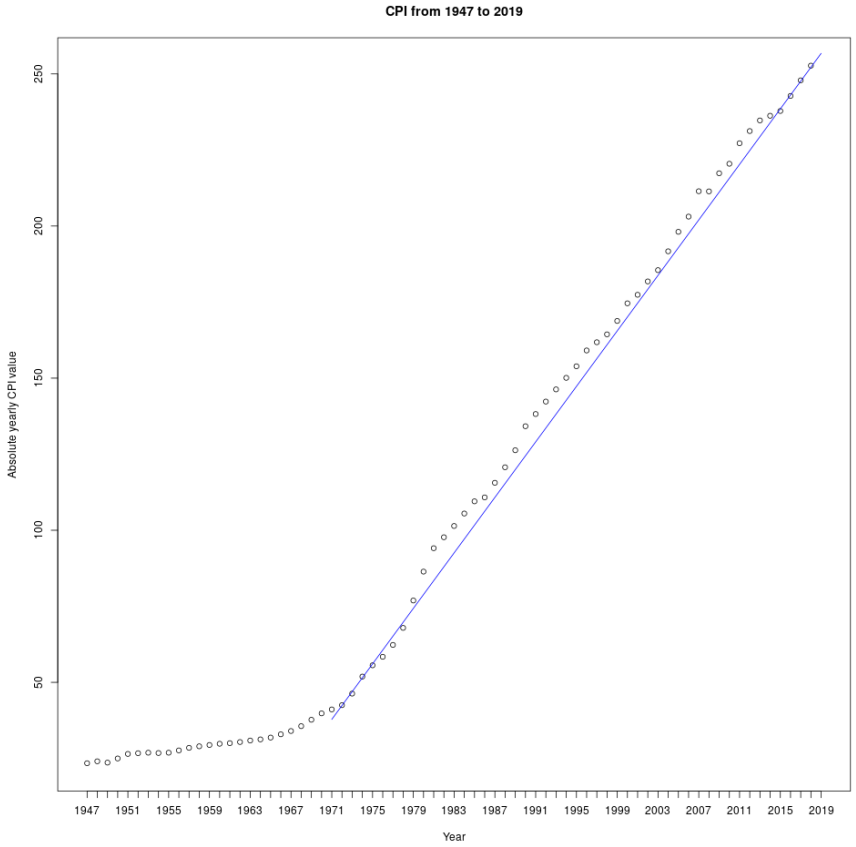

Figure 2: Absolute historical CPI values. The reasons for the "knee" around 1970, and the significant jumps around 1979 are beyond the scope of this report. The blue line is a robust linear fit for the CPI data from 1970 until 2019. The slope of the line is 4.56, meaning that is the annual increase for the period. Because the increase is constant (for that time period), the percentage increase decreases as the CPI increases.

appears nearly linear, and therefore amenable to simple predictions. For this analysis, data before 1970 will be considered as too old to affect our planning process.

While the historical CPI data is interesting in its own right, we are really interested in the long term trends, in the hopes that things like the vagaries in the 1970's do not reflect how the real economy works (see Figure 3 on the following page). Historical Dow Jones Industrial Average (DJIA) stock market data is available[2]. DJIA monthly adjusted monthly closing value for 1 January 1985 to 6 July 2019 is used as a proxy for the entire stock market (see Figure 4 on page 9). While absolute closing values are interesting, the more important part is the general long term trend (see Figure 5 on page 10).

[2] `https://finance.yahoo.com/quote/%5EDJI/history/`

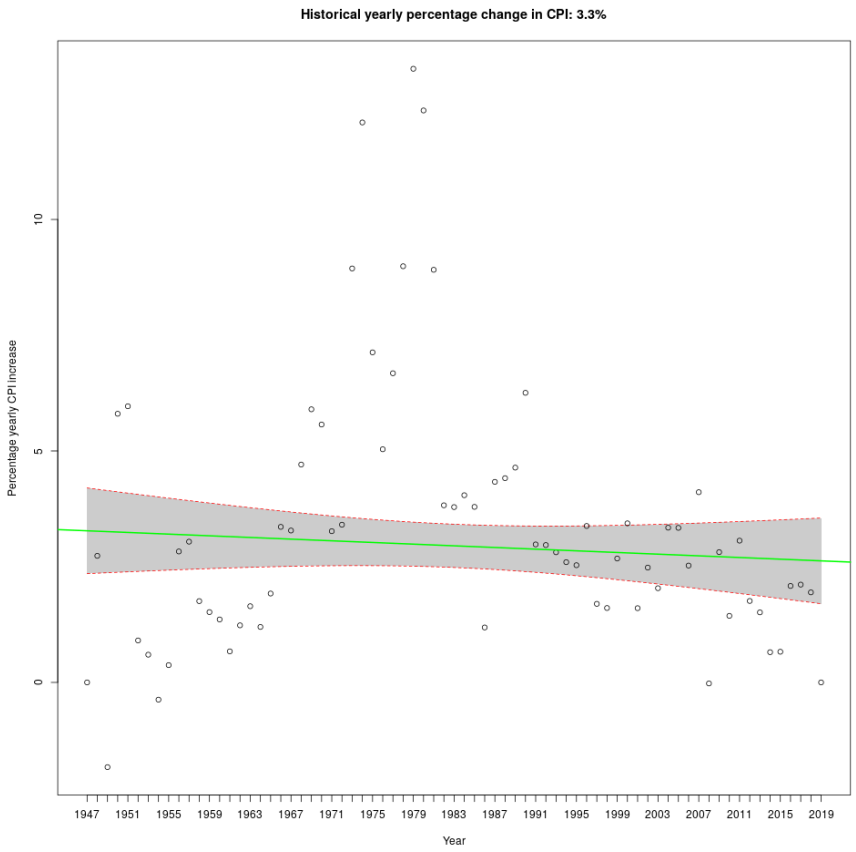

Figure 3: Historical percentage CPI changes. Over the entire range of CPI data, the annual change has been almost constant, with a small downward trend (-0.009020393% per year). The shaded area represents the 95% confidence interval. The green line represents the slope of the data after robust least square modeling.

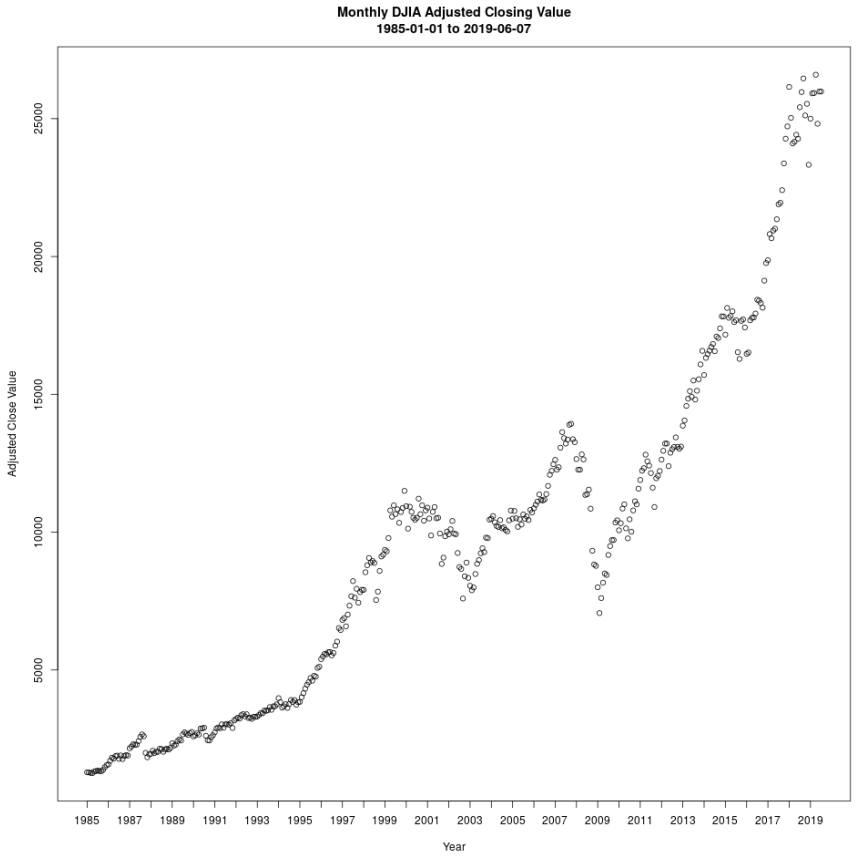

Figure 4: DJIA monthly adjusted closing 1985 – mid 2019. Adjusted closing price amends a stock's closing price to accurately reflect that stock's value after accounting for any corporate actions. It is considered to be the true price of that stock and is often used when examining historical returns or performing a detailed analysis of historical returns.

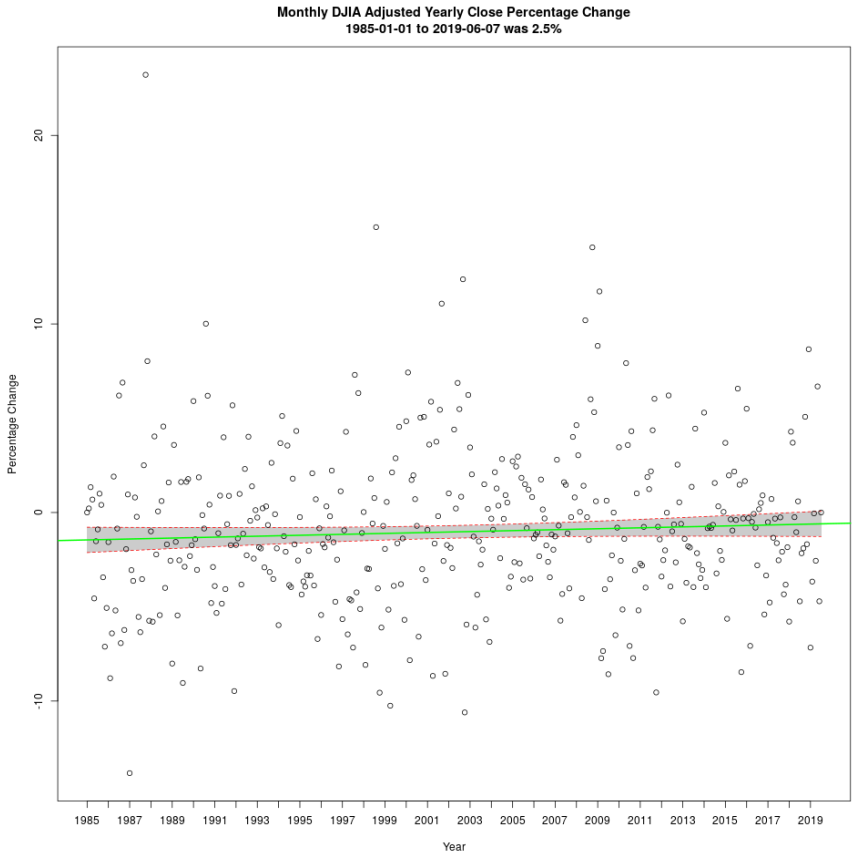

Figure 5: DJIA monthly adjusted closing increase 1985 – mid 2019. Over the entire range of DJIA data, the annual change has been almost constant, with a small upward trend (0.002059454 per month). The shaded area represents the 95% confidence interval. The green line represents the slope of the data after robust least square modeling.

Table 1: Topics that affect retirement computation. Some of these data are from external sources, while others are personal.

Topic	Value	Source
Annual Pay increase	–	Personal payroll data
Annual stock market performance	+2.5%	https://finance.yahoo.com/quote/%5EDJI/history/
Annual CPI change	+3.3%	https://www.bls.gov/data/
Life expectancy	85	http://www2.census.gov/library/publications/2011/compendia/statab/131ed/tables/12s0107.xls?#
When to draw retirement?	–	Based on personal choice and circumstance.

Life expectancy is a harder number to quantify. The US Census Bureau has estimates based on various assumptions (birth year, gender, race, income, occupation, etc.), and how the life expectancy will change in the future. One table that can be used is[3], and an interesting poster is included in this report.

The US Social Security Administration (SSA) has a sliding scale to determine when a person is eligible for full SSA benefits based on the person's birth year. A full description can be found[4], but is often generalized to 65, or 66, or 67 years of age. You can also delay receiving benefits after full retirement age up until age 70.

Based on the historical and other data (see Table 1), we have enough information to estimate what a gross retirement income would be under a range of circumstances.

From a 50,000 view, estimating retirement purchasing power is relatively easy (see Algorithm 1 on page 13). There are a number of additional factors that might be added. These include:

1. Increasing the purchasing power by adding the contribution by a spouse.
2. Increasing the purchasing power by adding any pensions that will be paid.
3. Changing the ending balance to something greater than 0 to model leaving something in the estate at death.
4. Use something like Newton's method to change the percentage vice simple percentage changes.
5. Use a small number vice 0.0 to terminate the draw down after retirement.

[3] http://www2.census.gov/library/publications/2011/compendia/statab/131ed/tables/12s0107.xls?#

[4] https://www.ssa.gov/planners/retire/agereduction.html

6. Artificially limit investment draw down to a fixed percentage, or dollar amount.

7. Quite likely other ideas and modifications as well.

Embedded in this report is an Excel spreadsheet that implements the algorithm (see Algorithm 1 on the next page). Detailed instructions on how to use the spreadsheet can be found in the embedded PowerPoint presentation as well.

Algorithm 1: Estimating retirement purchasing power in today's dollars.

initialization;
$age \leftarrow$ current age;
$retired \leftarrow$ retirement age;
$salary \leftarrow$ current salary;
$balance \leftarrow$ retirement account balance;
$death \leftarrow$ death age;
$contribution \leftarrow$ Retirement contribution percentage;
$raise \leftarrow$ Expected annual salary increase percentage;
$retirementGrowth \leftarrow$ Expected annual stock-market ROI;
while $\underline{age < retired}$ **do**
    $salary \leftarrow salary * (1 + raise)$;
    $balance \leftarrow balance + salary * contribution$;
    $balance \leftarrow balance * retirementGrowth$;
    $age \leftarrow age + 1$;
end
$percentage \leftarrow 0.10$;
$originalBalance \leftarrow ballance$;
$originalAge \leftarrow age$;
repeat
    $balance \leftarrow originalBallance$;
    $age \leftarrow retired$;
    while $\underline{age < death}$ **do**
        $balance \leftarrow balance * retirementGrowth$;
        $balance \leftarrow ballance - percentage * ballance$;
        $age \leftarrow age + 1$;
    end
    if $\underline{balance == 0}$ **then**
        break;
    end
    if $\underline{balance > 0}$ **then**
        $percentage \leftarrow percentage + 0.1 * percentage$
    else
        $percentage \leftarrow percentage - 0.1 * percentage$
    end
until $\underline{ballance == 0}$;
$cashEquivalent \leftarrow \frac{originalBalance * percentage}{(1+CPI)^{(death - originalAge)}} + SSA$

6 Conclusion

There are a number of things that this exploration revealed. Some of which any financial planner worth his salt will tell you.

Perhaps the most important lesson to take away from this exercise is that: there are no second chances to get this right. You get exactly one chance, if your assumptions are too optimistic, you can not reset the clock and have a do over. Be careful. Be thoughtful. Be responsible. Some decisions that you make in haste, you may regret in your leisure.

A Files

1. retire-modified-02.ppt – Detailed instructions on how to use the retirement Excel spreadsheet
2. retire-modified-02.xls – The retirement projection spreadsheet
3. raises.R – An R script to generate raise vs. inflation, and yearly CPI plots
4. SeriesReport-20190609124534_50d1fe.xlsx – Consumer Price Index from 1947 through 2018. Data downloaded from the Bureau of Labor Statistics (BLS) `https://data.bls.gov/timeseries/CUSR0000SA0?output_view=pct_1mth`
5. DJI.csv – Historical Dow Jones Industrial values from 1935 through 2019. Data downloaded from `https://finance.yahoo.com/quote/%5EDJI/history/`
6. paa19_medina_sabo.pdf – Living Longer: Historical and Projected Gains to Life Expectancy, 1960-2060, poster from the US Census Bureau downloaded from `https://www.census.gov/content/dam/Census/library/working-papers/2019/demo/paa19_medina_sabo.pdf`
7. 12s0107.xls – US Census Bureau Table 107. Expectation of Life and Expected Deaths, by Race, Sex, and Age: 2008, Excel spreadsheet downloaded from `http://www2.census.gov/library/publications/2011/compendia/statab/131ed/tables/12s0107.xls?#`