

Are You Ready for your Retirement?

EDAV Project

Name(UNI): Animesh Verma(av2354), Jiaying Jin(jj2980), Minsu Yeom(my2582)

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General Reader Guide

Before we get into our chosen topic, we wanted to give the user a general layout of flow of the write up. We have divided the write up into two parts. In the part 1, we discuss our topic, the reasoning for choosing this subject and a deep dive into various pertinent aspects of this subject , including an interactive component.

In part 2, we talk specifically about the challenges we faced in gathering data from various vendors, verifying data quality and creating interactive charts. In this part, we also discuss what could be a future version of our research. We talk about some of the simplified assumptions we have made to carry out our research, and how, given more time and bandwidth, we could make it more robust.

Full source codes are uploaded to GitHub. We did not attach source codes to this final report to improve the readability. Here are the links for all of them, each of which you can find at the end of the corresponding section as well.

The source code for Savings section:

https://github.com/my2582/my2582.github.io/blob/master/EDAV_Savings.Rmd

The source code for Investing section:

https://github.com/my2582/my2582.github.io/blob/master/EDAV_Investing.Rmd

The source code for Interactive component:

https://github.com/my2582/my2582.github.io/blob/master/EDAV_Interactive.html

The link for the website Interactive component is running on:

<https://my2582.github.io>

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Introduction

Why this topic?

We have expertise in this topic because all team members have working experience in the asset management industry. Furthermore, we want to inspire readers to prepare their comfortable retirement as early as possible before their “human capital” runs out; you are paid salary (“financial capital”) now because you provide your human capital, but you should *solely rely on* your financial capital after retirement.

What if your human capital runs out, due to aging or disease, before your personal wealth is not accumulated yet enough to secure your life in retirement? Can you keep your current standard of living after retirement? How much do you need to save now to get it? Are you fully aware of why you should start investing early than later? Have you ever thought of how much investing-late would hurt your life in retirement? It hurts more than you could ever imagine.

We hope that readers take this report as an opportunity of being willing to start to save now than later for their happy retirement. It matters to everyone because most of readers are expected to live another 30 years or so after their retirement. It's such a long time!

Team members and contributions

- Animesh Verma(av2354): Executive Summary; Description of Data & Analysis of Quality of Data; Investing; Conclusion
- Jiaying Jin(jj2980): Saving; Description of Data & Analysis of Quality of Data; Conclusion
- Minsu Yeom(my2582): Interactive Component; Future Work; Introduction; Editing and fine-tuning of final report

Part I

Executive Summary

Why is it that fewer than half of Americans are making good or excellent progress toward their savings goals?

A recent survey by The Consumer Federation of America and the American Savings Education Council found the following shocking facts:

- Just over half of Americans (51%) aren't even saving 5% of their income
- Only 66% reported saving at least some of their income
- About 40% of people do not even have enough savings to cover an emergency such as a doctor visit or car repairs

What can we do about it?

While it is a non-trivial thing to cause mass behavioral change, we believe, a great first step towards the goal of encouraging people to save more is to showcase the benefits of compounding. Compounding, or any nonlinear phenomenon, lends itself beautifully towards visualization.

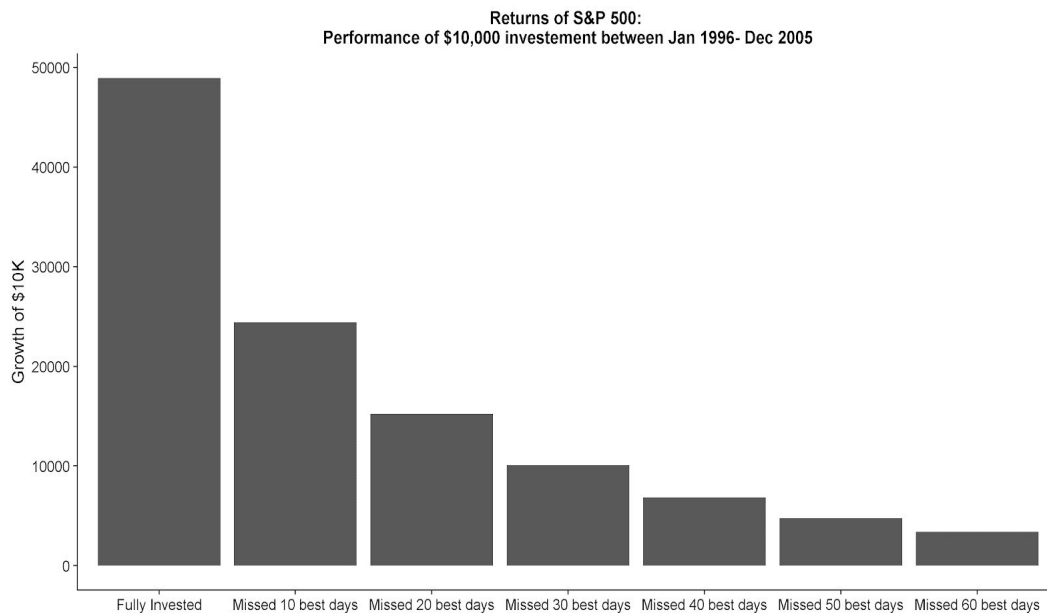
Project focus

Our research provides compelling arguments and visuals to demonstrate that almost anyone can afford a comfortable retirement as long as they start saving and investing early. We recognize that this is a very complex topic, with many moving parts, such as “longevity risks” and risk of healthcare inflation, but for the purpose of this project, we are solely focusing on investment shortfall risk, or risks of not being able to maintain the same standard of living in retirement.

We have divided our project into three sections:

1. **Savings:** In this section we show visually show the impact of starting savings early. We demonstrate the adverse impact of withdrawing retirement savings account before retirement age on the nest egg. We also include a checkpoint graphs which act as a savings guideline based on age and household income levels.
2. **Investing:** In this section, we tackle the common misconceptions about investing and show the adversarial impact of not being invested in the markets. We also show the eroding impact of inflation on savings and argue that sitting on cash is a poor long term investing strategy.
3. **Interactive Tool:** This is where it all comes together! In this section, we marry the savings and investment parts of our project. Based on user's age and Household Income (HHI), the tool dynamically outputs the corpus at retirement. Alternatively, the tool also has the ability to show the amount of savings needed based on targeted standard of living at retirement.

If there is one visual that we want the reader to take away from this project, it would be this chart. The visual highlights the importance of staying invested in the markets, regardless all its ups and downs.



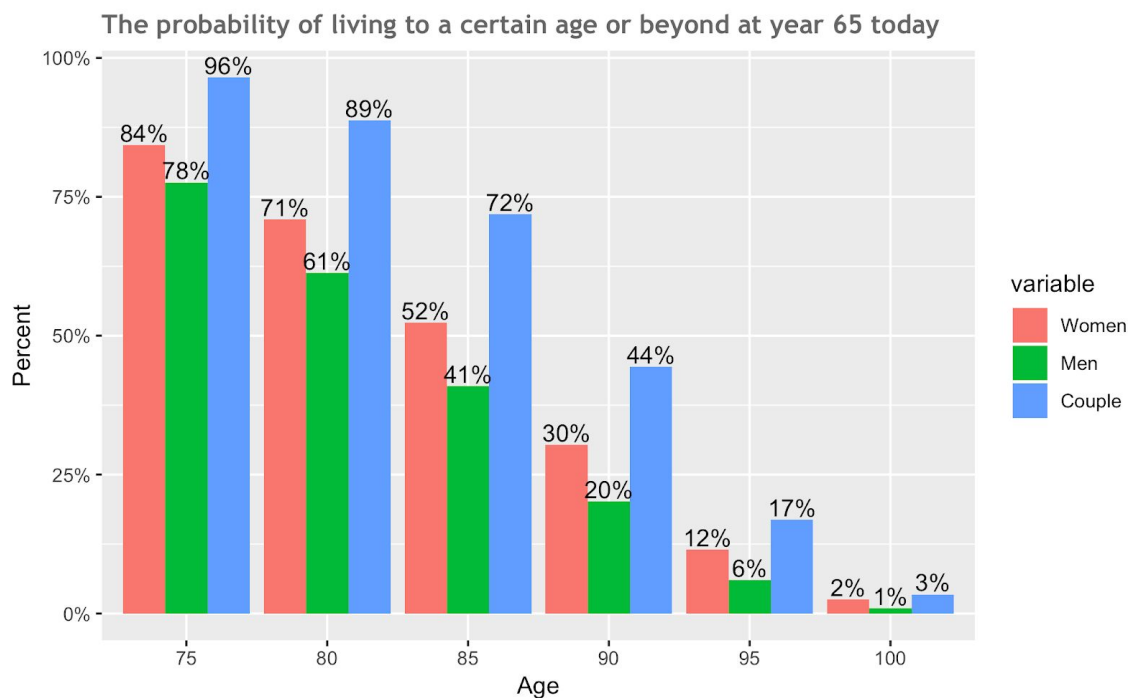
Exploratory Data Analysis

Saving

Retirement landscape

"How many years do you think you will live after retirement? How are you going to finance yourself/ your household after retirement for those years?"

When presenting with those questions, many people have misconceptions. Common ones include - Some people underestimated their life expectancy thus do not prepare enough money to support similar living standard after retirement; Some people overestimated their working ability, thinking they will continue to work after retirement (age 65) while only 23% did.



This is a projected period life tables by single year of age, gender, and calendar year for years 2016-2095

Chart: Social Security Administration, Period Life Table, 2016(published in 2018)

<https://www.ssa.gov/oact/HistEst/PerLifeTables/2018/PerLifeTables2018.html>

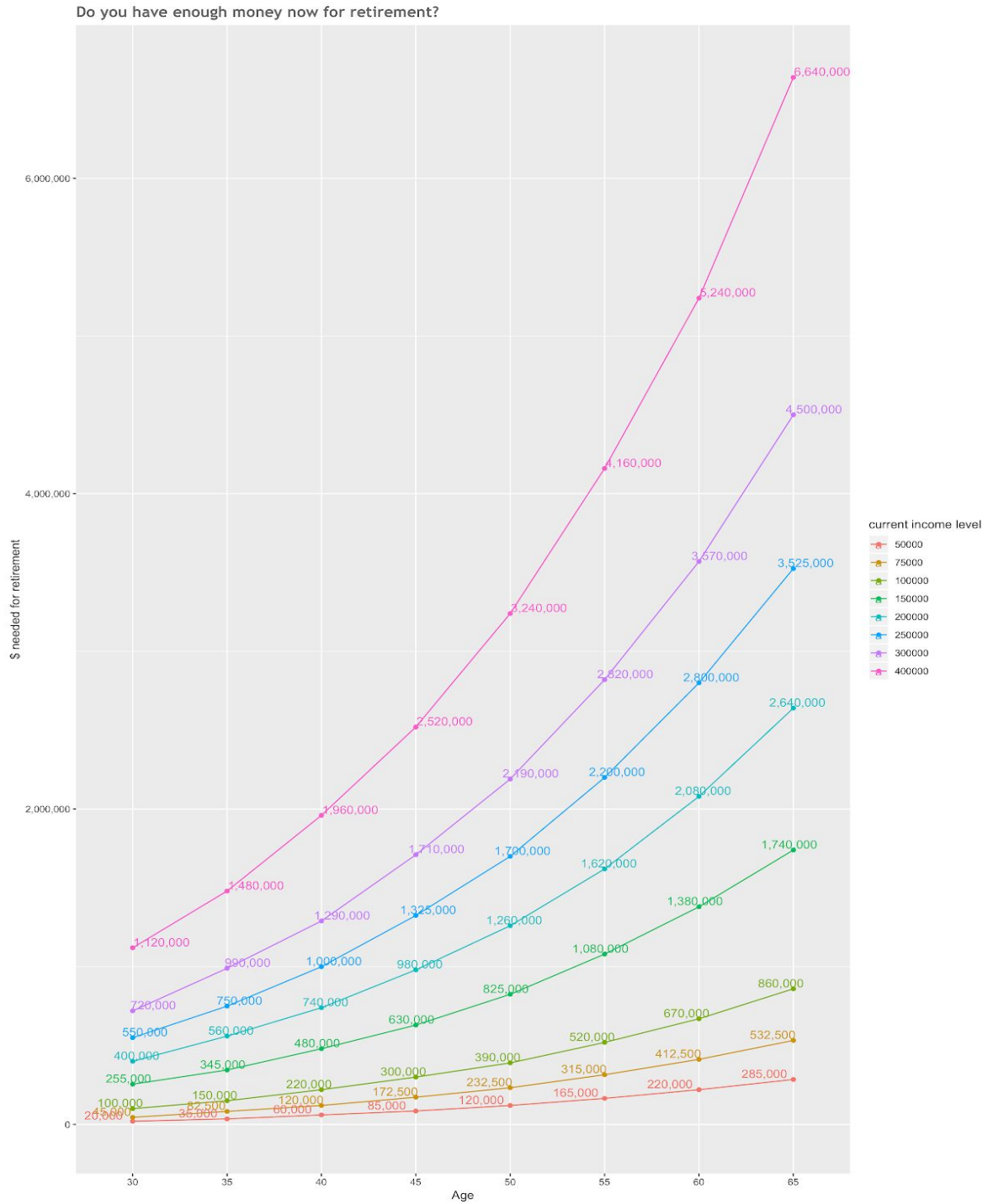
A woman is 84% likely to live to age 75 and beyond and 52% of chance to live till age 85 and beyond.

The chances for couples to live till 75 and beyond and 85 and beyond is as high as 96% and 89%!

With time being, people's life expectancy is increasing. What would you live on for those 15+ years after retirement? Do you care how much money you would like to have in your bank account at retirement to make sure you have the same living standard until 80, 90 or even 100 years old?

The most obvious answer is saving, but have you saved enough now? Below we present a visualization of how much saving one needs at different age and different household income level to check how well one has saved.

Retirement checkpoint

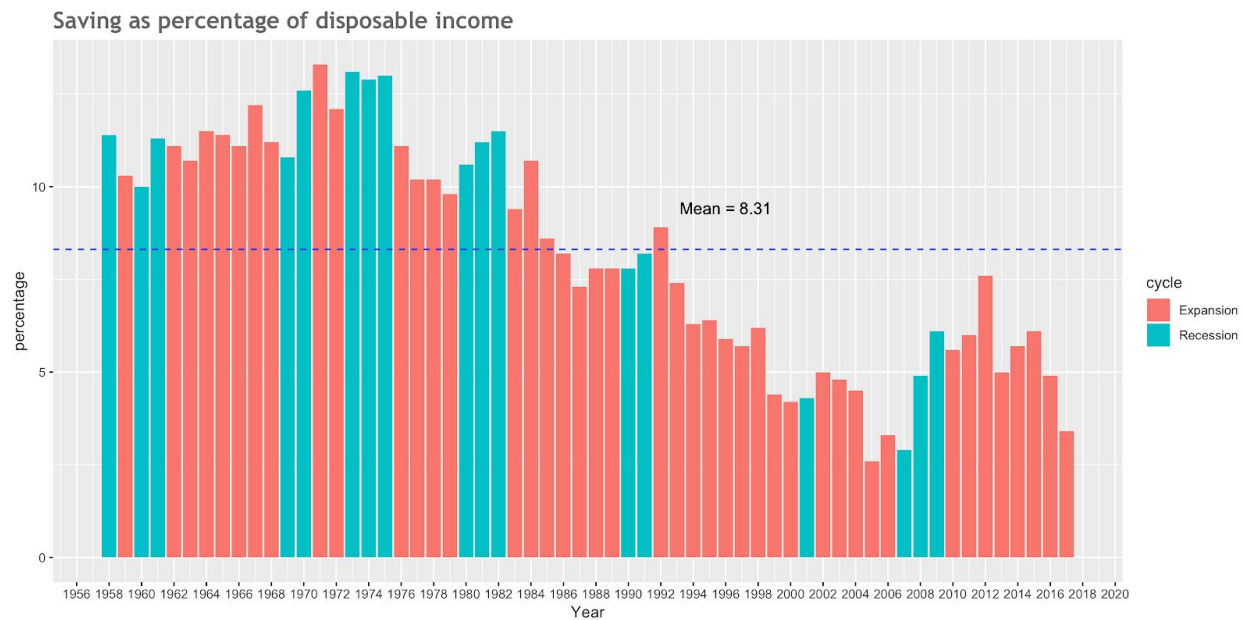


Line charts with multiple annual income levels to visualize the amount of saving needed at different ages are shown above.

The assumptions for this model is that pre-retirement investment return is 7%; post-retirement investment return is 5%; retirement age is 65; years in retirement is 30; wage growth rate is 2.5%; confidence level represented is 80% and assumed annual contribution rate is 5%.

The higher one's current income is, the higher income multiplier is ($\text{income multiplier} = \text{savings needed} / \text{current income}$) to maintain similar living standard at retirement. At relatively early age, lower income group is possible to have income multiplier less than one, meaning it's manageable for those certain people to have saving less than annual income. However, at higher end of age group, the income multipliers are all bigger than one, meaning that people need to have savings more than their annual income.

U.S. savings overview



This chart visualizes U.S. personal saving as percentage of personal disposable income in the past 60 years.

The trend of U.S. personal saving as percentage of disposable income was as high as 10-12% during 1958-1984, then dropped gradually to ~3% in 2005-2007 era. The saving rate rebounded due to financial crisis but dropped back again in 2017.

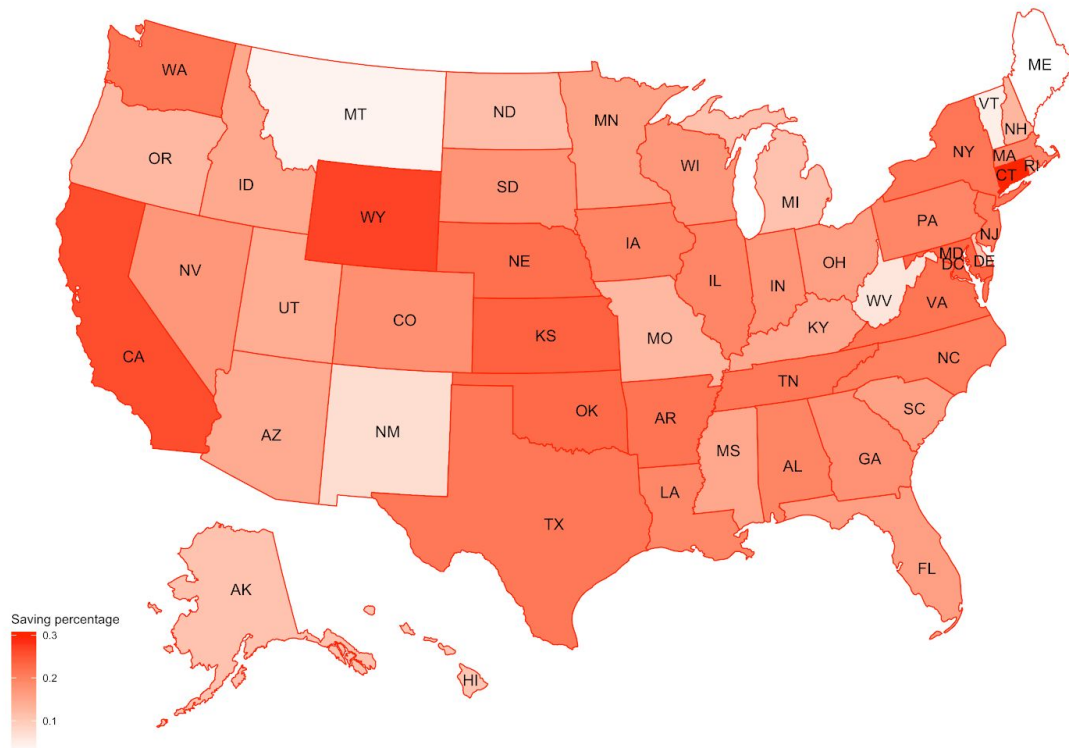
The average saving rate in past 60 years is 8.31%. Currently in year 2018, we are at one of the lowest saving rate historically.

People's saving rate tends to increase in recession comparing to end of previous expansion and decrease in expansion comparing to end of previous recession. The reason behind is that during recession, unemployment increases, GDP growth rate decreases, people reduce their spending to prepare for recession, cutting out spending on durable goods and save more money, thus saving rate tends to increase. However, during expansion, everything seems to be promising, people have tendency to assume their income level will grow at same rate in the next 30 years and tend to calculate less on spending. In addition, inflation rate

increases during expansion, which means one dollar will worth much less tomorrow than today and than in recession. Thus, people are willing to spend more now due to time value of money. To have enough money to transit into retirement life with same living standard, one good way is to save. To beat the inflation with time being, investing using saved money is a best way.

Relative saving rates across states

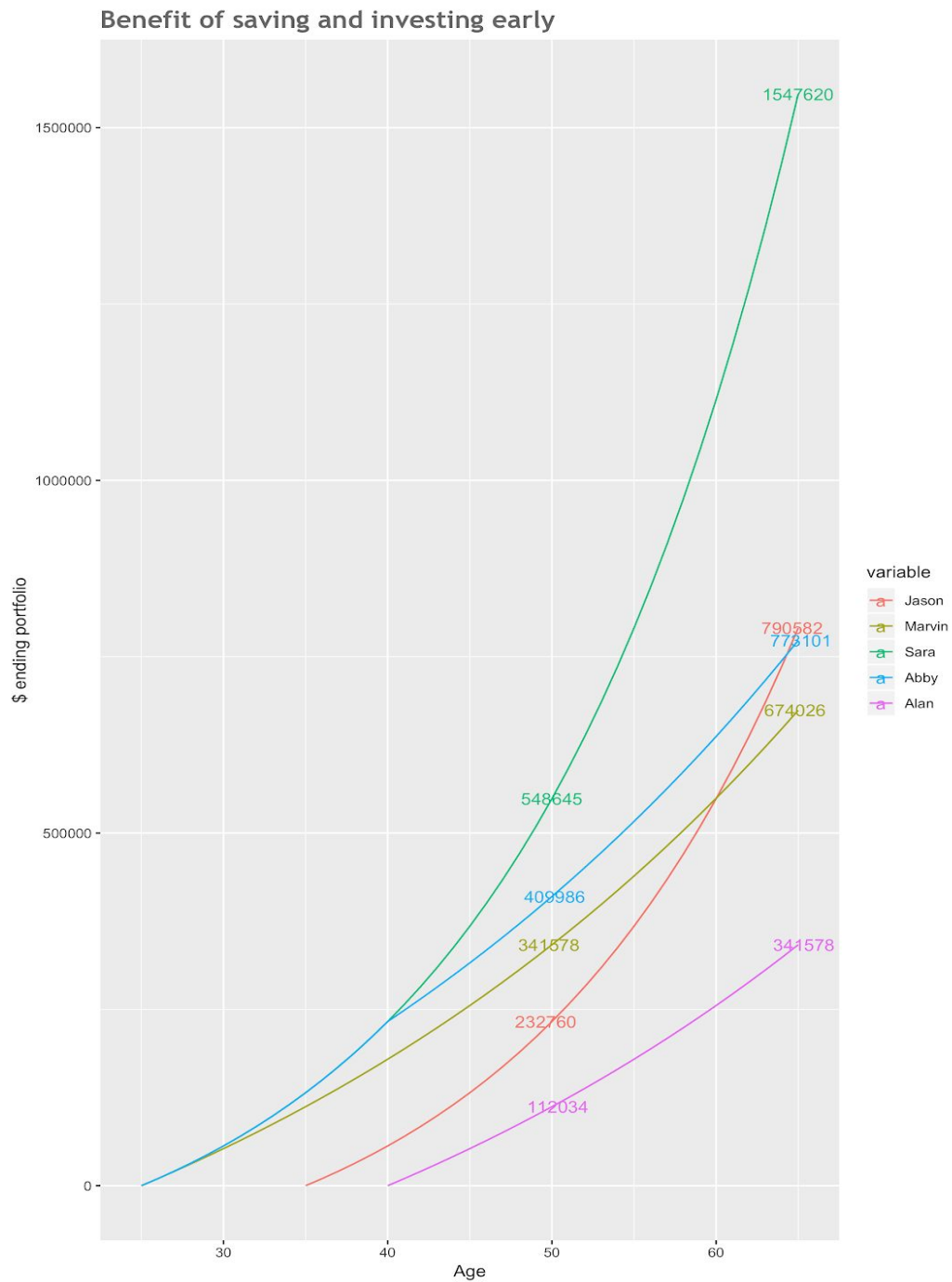
2016 saving as percentage of disposable income by state



The heatmap for estimated saving as percentage of disposable income by state shows the relative saving rate for different states within the U.S. for year 2016 (the latest year we have data so far). Since there is no official data for saving rate, it is estimated by $(1 - \text{Personal Consumption Expenditure by State} / \text{State annual personal income})$. We focus on the relative comparison of saving rates across different states than the absolute number of saving rate in this section.

Maine has lowest saving rate, followed by Montana, then New Mexico and West Virginia. Connecticut has the highest saving rate, followed by Wyoming and California.

Saving & investing early



The above chart shows benefit of investing and saving early.

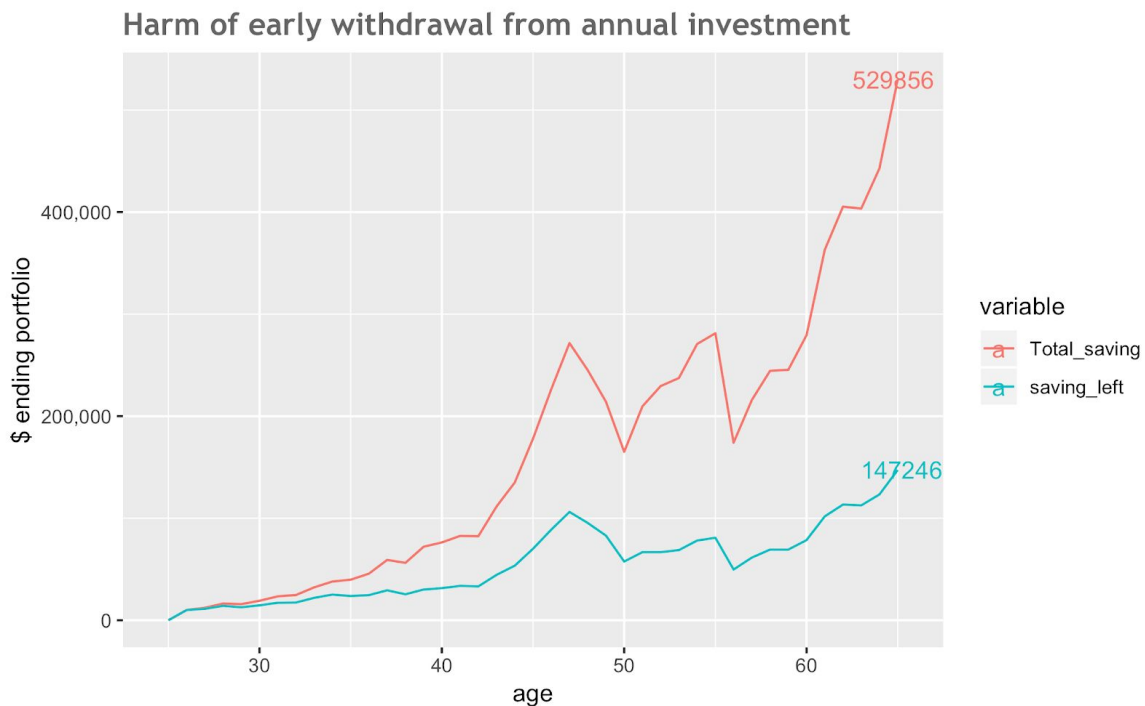
The assumption is as below:

Jason starts investing at age of 35; Marvin saves age 25-65; Sara invests age 25-65; Abby invests age 25-40 and saves 40-65; Alan saves 40-65; Assume investment return is 6% per year and saving return is 2.5% per year; 10000 is invested/saved annually.

Sara obviously has the highest total asset at retirement for two reasons: 1) she starts investing as early as 25, and 2) she invests instead of saves, enabling her to have higher return on average. On the contrary, Alan has the lowest total asset at retirement as he starts saving later in life and did not take risk to invest.

Interestingly, the ranking of total asset and growth is consistent before age of 60 but Jason surpassed Marvin and Abby after age 60. The reason is that, although Jason starts later, the higher return brought by investment surpasses the lower return from saving after certain time period. Another way of saying this is that the power of compounding beats the power of longer time period after certain amount of time.

Early withdrawal damage



Harm on total potential portfolio value of early withdrawal/ loan is shown in the above chart. Assume yearly contribution is 10000 and the contribution is purely invest in S&P 500 index age 25-65 (year 1979-2018). The blue line represents withdrawal of 2000 age 35-39 at end of year and withdrawal of 6000 age 50-52 end of year.

The final portfolio value is 380000 less with only $2000 \times 5 + 6000 \times 3 = 28000$ withdrawal within 40 years!

Being consistent and persistent in annually contribution when investing saved money for retirement is vital as with withdrawal you might miss great opportunities when stock market goes up thus damage your total return at retirement if you are a passive investor (instead of a professional stock investor)!

The source code for this section:

https://github.com/my2582/my2582.github.io/blob/master/EDAV_Savings.Rmd

Investing

Invest for long-term growth potential and consider investing in a broader mix of assets. Financial risks don't end when careers do. Individuals planning for a long, rewarding retirement must anticipate and overcome the obstacles that are likely to arise along the way.

With this section we hope to convince the reader that with a longer term investment horizon (10 years+), investing is a no brainer, and saving in cash alone is not enough, given the eroding nature of inflation. We further emphasize the importance of investing with compelling visualizations showing the adverse impact of being underinvested.

Common Misconceptions

“The market is too volatile. I’m going to sit on the sidelines for a bit so I don’t lose money.”

- Don’t avoid investing in volatile times. It can cause you to miss out on potential market rallies.
- Set specific retirement goals upfront-and keep focused on the long term during periods of volatility and uncertainty.

“I should invest conservatively so I don’t run the risk of losing my retirement assets.”

- Retirement-age investors have potentially long time horizons, due to rising life expectancies. By maintaining an exposure to equities in retirement, you may better keep pace with rising prices, protecting your standard of living throughout retirement.
- A well-diversified portfolio may provide a smoother ride over the long term.

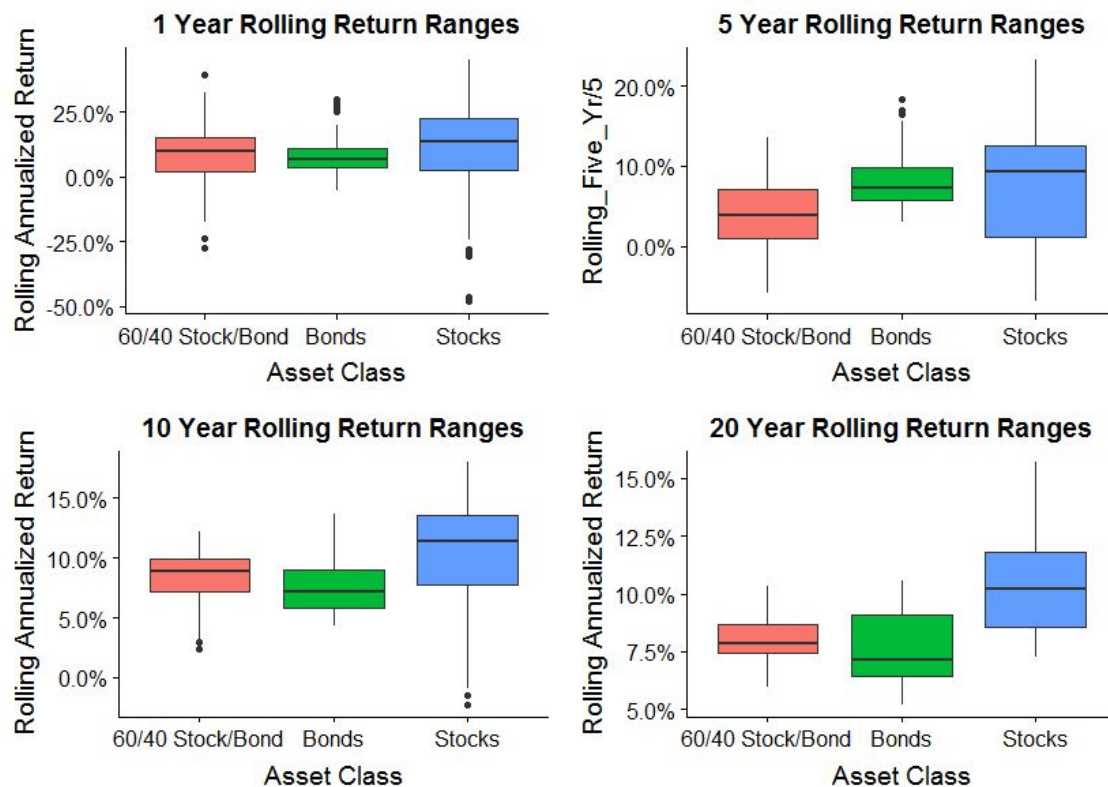
Source: Guide to Retirement, 2016 edition, JP Morgan Asset Management

Investment Return Ranges

Over longer terms, investing in the capital markets almost always results in positive return rates. We illustrate the growth of some of the common asset class returns.

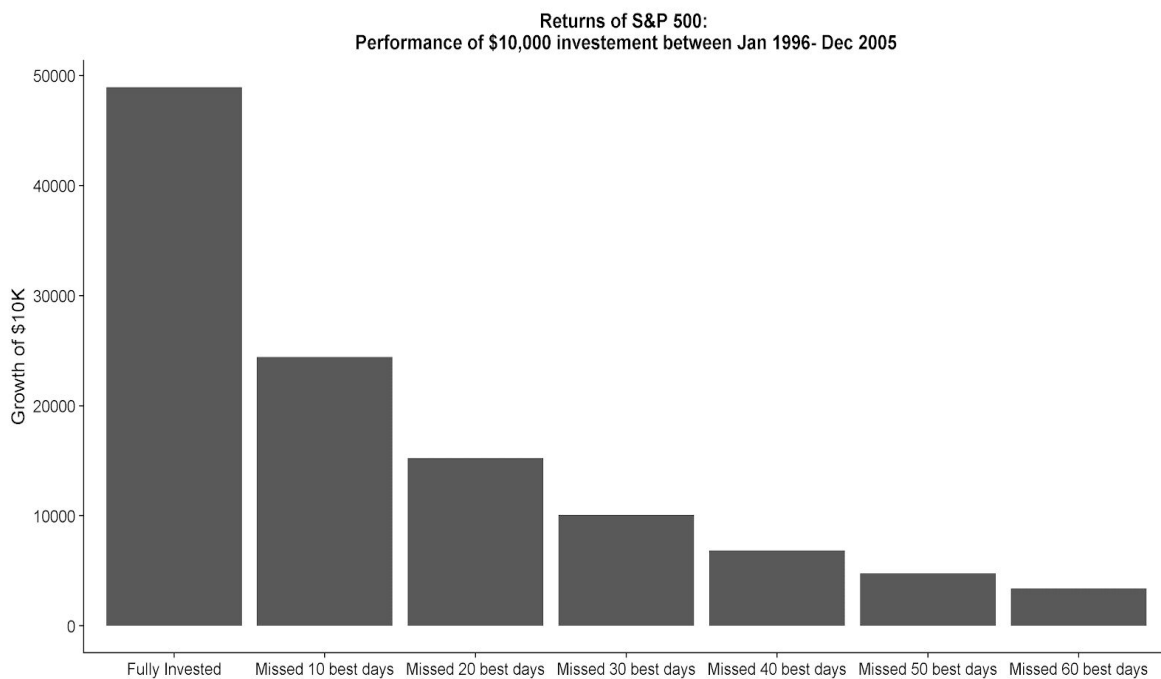
- The ranges of rolling annual returns of Stock Markets (S&P500 Index), Bond Markets (Bloomberg Barclays Aggregate Bond Index) and a 60%/40% balanced mix has resulted in attractive returns historically between 1970 and 2015.

Rolling Return Ranges of Major Asset Classes 1970-2015



Impact of being out of market

- Trying to time the market is extremely difficult. Market lows often result in emotional decision making. Investing for the long term while managing volatility can result in a better retirement outcome
- Six of the 10 best days occurred within two weeks of the 10 worst days
- And perhaps most shockingly, missing out just the 10 best days of S&P 500 Index in 20 years, the resulting portfolio value would be half, compared to being completely invested.

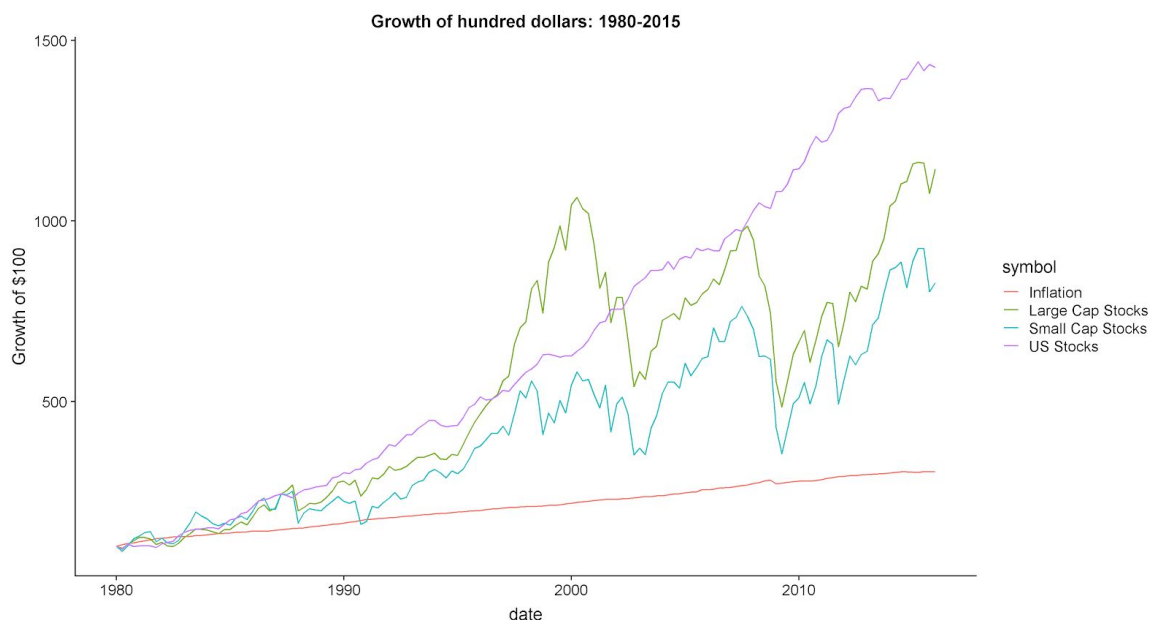


Major asset classes vs. inflation

Inflation, the silent wealth thief, erodes the value of savings if not invested. In the exhibit below, we can see that the decline in purchasing power of money.

Present US \$250, will only purchase \$100 worth of goods in 1980. Moreover, we can also see how other asset classes do relative to inflation.

- In just 30 years, \$100 invested in US stock markets would have turned to about \$1500, outpacing the eroding effects of inflation
- We can see the same trend across various Global Equity Markets as shown below
- With a longer term investment horizon, investing in Equity Markets is the best way to offset inflation



The source code for this section:

[https://github.com/my2582/my2582.github.io/blob/master/EDAV Investing.Rmd](https://github.com/my2582/my2582.github.io/blob/master/EDAV%20Investing.Rmd)

Interactive Component

The link to this interactive component: <https://my2582.github.io/>

We wanted the reader/user to viscerally feel the impacts of compounding that we feel so passionately about. So, we designed a cool tool to that would answer the following questions(note that the return assumptions that displayed clearly in the tool interface itself, and all the assumptions were based on long term historical returns):

- Based on your age and Household Income(HHI), how much do you need to save for a comfortable retirement.
- Given your current rate of savings, what is your shortfall dollar amount at retirement, and how much more do you need to save annually to meet your goal.
- How much better off you would be, in dollar terms, if you start investing sooner rather than later.

What the tool computes

We mainly calculated data based on our expertise in finance. This interactive component computed :

- Total amount of money needed at retirement.
- A wealth curve; this is a total value of your retirement portfolio from an input age until retirement.
- Retirement checkpoints; this is the only external data used in this component. This table takes inputs of age and household income and outputs a required amount of money you should have today to meet your current standard of living in retirement.

How does it work?

We take four values as inputs: age, household income, annual savings, and current savings. After discussion with team members, we fixed the number of user inputs to be as small as possible. If not, user engagement is expected to significantly drop and it might take user's interest away.

Once a user clicks the start button, the component plots a red circle. This is the required amount of money to meet your standard of living in retirement. Let me call value the goal through section. Then, a green line is gradually plotted. This is an expected value of your retirement portfolio, or “wealth curve”.

You will rely on this, and you should expect the wealth curve to hit the goal at an age of 65, implying that you would enjoy your life without financial difficulties! By introducing animation on this wealth curve, we expect that users can get some excitement (or disappointment) that it would hit the goal or now while it is being drawn. Finally, users can decode the numbers shown on the chart because we explain it. User-friendly texts are shown to go over the result.

Technical aspects

Technical execution

Most of the parts are implemented using D3. We made our slide bars for user inputs using an external library at [Martin Chorley's Block](#).

We need a website to run our code because of file loading. We chose GitHub's personal website for this purpose, and you can find it at <https://my2582.github.io/>

We will discuss technical difficulties in implementation in Part II.

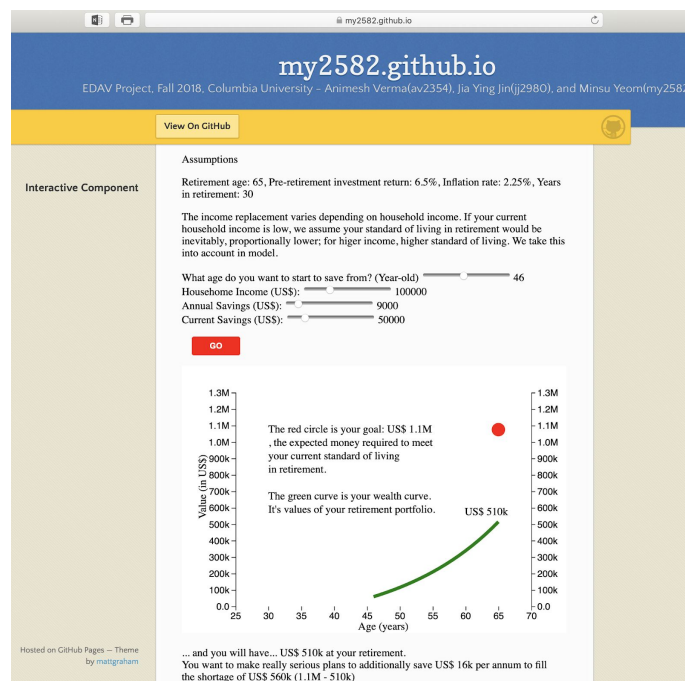
Future works

This interactive chart can be improved by removing the start button. Instead,

whenever a user clicks on a slide bar the interactive chart immediately outputs its result. This can be more than just a simple design change because it would provide a much convenient way of comparison with, for example, different ages, or different annual savings.

We wanted to put our texts on the chart at a more sophisticated location as a graph is plotted differently. Also, annotations would provide a better experience to users as they guide them to understand what we intend to mean. In particular, annotations looked more difficult than I initially thought, and we decided not to have them in our interactive component in order to focus on write-ups.

Relaxation on assumptions to calculate would be considered as well. However for this case, there would be a trade-off between the new flexibility and more inputs from users as discussed early in this report. I chose not to relax the assumptions, but a good design may enable us to achieve both goals while minimizing the trade-off.



A screenshot of the interactive component

Part II

Data Acquisition, Quality Checks & Challenges Faced

Our choice of topic made it relatively easy for us to gather data. Most of the finance and savings data are very well curated and can be had in “csv” format. For data related to markets, we relied heavily on the “Rblpapi” package, which provides functions to pull data from Bloomberg terminal, given that the work is done on a Bloomberg workstation.

We did face a fair amount of challenges(as stated below) while designing our interactive component. Below, we have summarized the data sources and challenges faced briefly by the section

Savings data

We have used a number of sources for data on savings. Most of the data is publically available on websites of government agencies such as BEA and NBER. In addition, there are some data in the report constructed from hypothesis made according to historical data and current market condition as well as group members’ working experience, such as average investment return and saving rate. Some scenarios are constructed below as well, with data generated based on hypothesis and detail explained in the report. We have annotated the websites used for gathering all the savings related data below.

State annual personal income

<https://apps.bea.gov/regional/histdata/>

BEA(Bureau of Economic Analysis) is well known for providing a huge database for economic analysis. Users can access to its data in a various way such as downloading directly as csv files, exploring and see as a table first and then

download it, and, noticeably, APIs. Sometimes data is not “tidy”. For example, years are column-headers. However, it did not a big issue and we understand that the format used provides a better human-readability. Footnotes for data are in very details and downloaded as a separate file, so that we can see data sources and assumption used. We obtained economic data from this source and they are all equally commentable.

Personal Consumption Expenditure by State

<https://apps.bea.gov/regional/histdata/releases/1017pce/index.cfm>

The above two data sets were used to estimate saving rate for different states in 2016 in saving section in the report.

The calculation provides a rough estimation for saving rates, which is better to be used on relative comparison basis (comparing relative saving rates across different states instead of focusing on the absolute saving rate in one single state). The reason is that there is no public source for saving rate by state and the estimation is a simplified one while having the same calculation method for all states.

National Bureau of Economic Research data on business cycle:

<https://www.nber.org/cycles.html>

This dataset gives years for economic expansion and recession, which is a source for the saving rate chart in saving section in the report.

It comes in an inconvenient format such as a non-downloadable table and pdf. However, it’s short in length. Importantly, this is the most respected source widely accepted in the industry for the U.S business cycle.

Social Security Administration, Period Life Table, 2016 (published in 2018)

<https://www.ssa.gov/oact/HistEst/PerLifeTables/2018/PerLifeTables2018.html>

This data provides projected period life tables by single year of age, gender, and calendar year for years 2016 through 2095.

Retirement checkpoint data :

<https://www.businessinsider.com/retirement-savings-guide-2014-3>

This data provides checkpoint data so as to calculate the amount of money one should have saved today (checkpoint x current salary).

Bureau of Economic Analysis, National Accounts NIPA archive

<https://apps.bea.gov/histdata/fileStructDisplay.cfm?HMI=7&DY=2018&DQ=Q1&DV=Second&dNRD=May-31-2018>

Data on saving rate in the states in past 60 years

Bloomberg Data

In terms of Bloomberg data, to be able to use the Rblpapi package, one needs Bloomberg terminal installed on your PC. Columbia Business School has a few terminals but the access is quite restrictive. Fortunately, we had access to Bloomberg terminal through one of our team mate, who got permission from their work place to utilize Bloomberg data for this purpose.

Another problem we faced is that the Rblpapi package is not supported by Bloomberg, as it was developed by a third party. So lots of functionality that is generally available on the terminal or using Bloomberg's excel API say were not available to us.

Example of one problem that we had to face while gathering data for the project was that the R package does not provide dividend adjusted price, which is an important factor in long term asset return. So we had to manually adjusted our asset class returns based on historic averages and estimates.

Interactive component

Some of the key issues faced were :

Gradually drawing a line, i.e., path in D3's term, was most difficult because one function named `getTotalLength()` was moved from `SVGPathElement` onto `SVGGeometryElement`.

<https://www.w3.org/TR/SVG/changes.html#masking>

This was a critical issue because all external libraries I searched used this function to animate a line chart. External libraries look running on the block builder, but not on my laptop, my local server, and GitHub personal webpage. There were issues with backward compatibility.

Few other difficulty we faced were the following :

- Running it on a website. I searched ways of running it and block builder looks a good option. However, I decided to choose a website because we as a team wanted to make it looking nicer. Studying how to make a website on GitHub was not tricky, but took some time.
- Debugging. I had to use `console.log()` everywhere to see where it goes wrong. It got messier as the number of lines increase.
- Drawing a simple path on a chart. I calculated a path all right, but it did not appear on screen. It turned out that it was attached under a wrong place.

How I resolved the difficulties

A simple trick was used. I made my stroke dashed so that it could look like a line is gradually being drawn. Since a dash is so long, it does look so to human's eyes.

I should give a credit for this idea to CSS-Tricks at

<https://css-tricks.com/svg-line-animation-works/>

Other difficulties I mentioned above were generally a matter of time because there were difficult to implement because I made a mistake in implementation.

Future Work

Remained problems

We identified two major problems to address as future works while working on this project: longevity risk and health care inflation in finer details. Although we assumed that one retired at an age of 95, one may live even longer than this age, and life expectancy may vary due to a various factors. We averaged out all those factors into rather simpler assumptions. In addition, Americans' spending in health care may increase even more than our expectation. Since the spending accounts for a significant percentage of individual income, we take this as the second factor to consider to address. We notice that these two factors are intertwined together, i.e., people who spend more in health care would probably live longer.

Expected challenges

We were not able to incorporate the two problems and address them because of the limited period of time, many assumptions required due to the nature of life expectancy, and data availability. This led us to focus on financial aspect of one's risk at retirement while keeping assumptions simple such that one may live 30 years after retirement at an age of 65 and health care spending may not dramatically change. Finally, interactive components would have improved even more. They may admit more user inputs such as their spending in health care and their health status, or their preferred target of standard of living. We decided to take just four user inputs, i.e., current age, income, annual savings, and current savings, because we were unable to find a good technical way to take more inputs from user, and at the same time to make it sure not to bother users to input every numbers so that they do not just close this window or leave the website.

Conclusion

With higher modern life expectancy, it is important to plan one's financial saving/investment carefully from an early age. People tend to save less in economic expansion and save more in economic recession with average saving rate of 8.2% in past 60 years while current saving rate well below the historical average. Saving rates across states varied as well. Maine has lowest saving rate, followed by Montana, then New Mexico and West Virginia. Connecticut has the highest saving rate, followed by Wyoming and California.

Saving/ investing at an early age are preferred for higher accumulated wealth at retirement. Investing at later age, while having higher risk, might outrun the benefit of saving at early age too. Consistency and persistency in saving/investment on regular basis is vital for retirement financial success too.

Withdrawal at periods is possible to have huge negative impact on total portfolio amount if people miss out some good years of the market.

Through our analysis, we have shown that the even an average US household with an income of US\$60,000, can save up to a million dollars in retirement, if they start saving early (at 25) just about 5% of their income. One of the key takeaways here is that for a sound and comfortable retirement, it is imperative to stay invested, regardless of the ups and downs of the market. As we have shown in chart, just by missing best 10 days of US equities market during 1995-2015, the resulting principal would have halved, compared to someone who was invested throughout the period.

We are hoping that the project prods the reader to start saving early, invest wisely and realize that time invested in the markets more important than timing the markets. In conclusion, we think there is hope yet! With proper education about benefits of saving early and investing in the markets, even the average can hope to have a comfortable retirement.