TODO: Perform analysis with historical data from 2008 through 2018

TODO: Add links to the application

TODO: Replace graphs with graphs from the application

TODO: Add links to Wikipedia for Mathematical concepts

TODO: Add links to Vanguard etc. to back investment assumptions

TODO: Alter Volatility Section

# Choosing Investments Based on Retirement Goals

Estimating the chance of successful goal attainment based on uncertain investment results and cash needs

* Demonstrate the approach using a fictional narrative
* Provide links so you can input your own goals and investment assumptions into the calculator by following these instructions

**The Client:** Mabel is a single 65-year old retired school teacher who is considering how to invest $400,000. Her pension and social security cover her basic needs, such as housing and groceries. Therefore, her goal for the discretionary portfolio is to enjoy retirement. She intends to spend $40,000 in inflation-adjusted dollars each year for at least the next 10 years on travel, restaurants, remodeling her home, and leasing a luxury car.

Mabel meets with her financial planner, Carla, to determine how to invest the $400,000. Mabel informs Carla that she is only comfortable investing in stocks and annuities because she does not understand other investments.

**The Financial Planner:** Carla simulates the performance of $200,000 invested in each stock and annuities using the Probicast software. Each simulated year, a $40,000 withdrawal is subtracted from the invested amount. If the portfolio value is insufficient to cover the withdrawal, then the life-time simulation is a failure. Otherwise, it is counted as a success. Carla generates 1000 life-time simulations and only 19% successfully cover the required cash flows. Mabel wonders if a different allocation would yield a better result. Carla repeats the calculations for various portfolios as indicated in Graph 1.

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***Graph 1: Probability of Goal Attainment (Bubble Size) vs Amount Invested in Stocks (Y Axis) and Years Invested (X Axis) based on a budget of $400,000, initial cash outflow of $40,000, and 2% inflation.***

Investing in 100% stocks seems to be the best choice since it results in the highest probability of success for 10 years. However, she only would have a 2.6 % chance of success of meeting the cash flows over 30 years. This seems low to Mabel. She wonders: what would happen if they adjusted the cash flows to be $20,000 instead? Graph 2 summarizes these results.



***Graph 2: Probability of Goal Attainment (Bubble Size) vs Amount Invested in Stocks (Y Axis) and Years Invested (X Axis) based on a budget of $400,000, initial cash outflow of $20,000 and 2% inflation***

This scenario presents a dilemma. Additional amounts invested in the annuity increase the probability of meeting cash flows after ten years but come at the cost of increasing the chance of not meeting cash flows at year 30. If Mabel is more concerned about meeting cash flows over the next 10 years, she might consider allocating 50% or 75% of her funds to the annuity.

**The Investment Analyst:** To create the above analysis, Carla relied on forecasts from Chris, an investment analyst. In particular, she needed a long-term forecast for stocks. Chris started with historical data for the S&P 500 as a baseline and then altered the estimates based on his judgment to create a realistic prediction. First, he collected daily stock market gains and losses from 12/1/2007 to 12/1/2017. He resampled these with replacement 1000 times for 252 simulated trading days to approximate annual performance. Table 1 summarizes the results:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Minimum | 10th Percentile | Median | 90th Percentile | Maximum |
| -48.7% | -16.3% | 8.9% | 40.0% | 120.3% |

***Table 1: Annual summary statistics from resampled gains and losses from 12/1/2007 through 12/1/2017 (Daily Gains and Losses from Yahoo Finance)***

To alter this baseline forecast to fit his beliefs, he performed the following steps:

1. *Assumed the most likely scenario is equal to the median.*
2. *Adjusted the historical minimum and maximum to be symmetrical:* He changed the Minimum scenario to be -50% and the Maximum to 50%.
3. *Estimated the average investment gain:* Chris spent a great deal of effort on this assumption. He reasoned that the stock market should outperform treasury bonds over the long term. Therefore, the current yield of 3% on 10 Treasuries might constitute a lower bound for the long-term expected gain of stocks. At the other extreme, US stocks have historically performed extraordinarily well. The historical analysis indicates the average gain on stocks over the past 10 years is approximately 10% a year. Chris believes this is overly optimistic for the future. He consulted the following [Vanguard paper for other methods](https://personal.vanguard.com/pdf/s338.pdf). The CAPE ratio of 33 indicates a 3% long-term gain. Forward price-to-earnings of 18 suggests 5.6%. At last, he estimated a 5% long-term expected gain, which is roughly the 10 year treasury yield plus the target inflation of the Federal Reserve.
4. *Estimated Volatility:* Chris referenced the VIX. It was at 11.7, which is near historical lows (~9). The historical data indicates a volatility (Standard Deviation) of 25. Since the historical period contained an abnormally volatile period and the current volatility is well below historical norms, Chris estimated a volatility of 16.
5. *Estimated Gain vs Loss Asymmetry:* Although the historical period resulted in a positively asymmetrical profile (.54 Skewness), it is late in the business cycle; consequently, Chris projects a slightly negative asymmetry of future gains and losses relative to the average gain (-.28).
6. *Estimated Frequency of Extreme Gains and Losses:* The historical data exhibit more frequent extreme gains and losses than the normal distribution (Excess Kurtosis of .9). Chris references [a paper indicating that financial data is more chaotic than Modern Portfolio Theory acknowledges.](https://www.jstor.org/stable/2350970) With this in mind, he estimated more frequent extreme events (.54 Excess Kurtosis) than the “bell-curve” would suggest.

**The Investment Software:** After performing these steps, Chris enters his estimates into the Probicast software. The software draws the probability distribution shown in Graph 3:



***Graph 3: Estimated annual long-term forecast for the stock market assuming a current price of 100. The software generates the above graphs based on the input scenarios and interpolating straight lines between each scenario.***

Each scenario is connected to the next with a straight line. Probicast generates 1 million random numbers meant to simulate probabilities and maps them to simulated prices based on the above graph. For example, simulated probabilities of 0, .5, and 1 would map to 50, 105, and 150, respectively. It then transforms the simulated investment performance into the results Carla presents to Mabel.

**Input Your Own Assumptions:** The above narrative provides the default inputs for this investment calculator. You can upload your own cash flow and investment assumptions by following these instructions. The calculator is free to use and requires no personal information. Please feel free to share your modifications in the comments section below as well as any questions you may have.