The University of Chicago Booth School of Business

Business 36106-02/03/85
Managerial Decision Modeling
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Financial Planning with Your Retirement Portfolio

Excel files used in this case:

- retirement.xlsx
- retirementRisk.xlsx
- retirementRiskGoal.xlsx
- retirementTIAA.xlsx

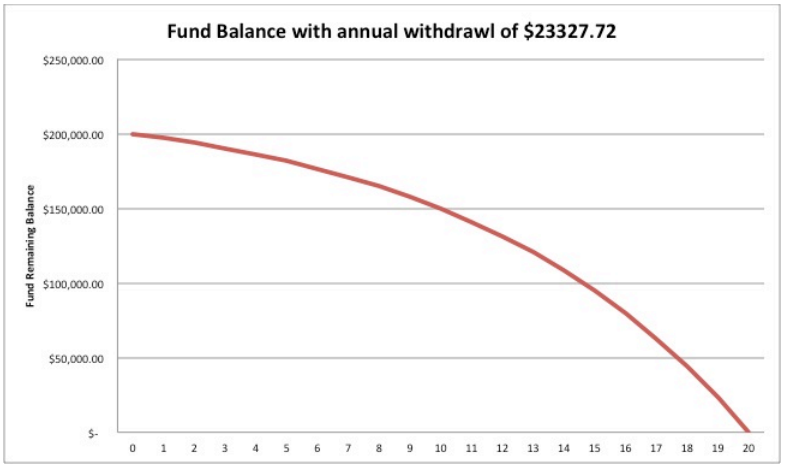
Today is January 1, 2014. After 35 years of working, you retired yesterday (on Dec 31, 2013) at age 65 with $200,000 in your 401K retirement account with TIAA-CREF. You expect to live another 20 years. To manage your expenses after retirement, you want to withdraw equal amounts per year for the next 20 years until the fund is depleted with zero balance. For example, assuming the annual return of your retirement fund is 0 and if you withdraw $10,000 per year, you will deplete your account balance after 20 years.

Your retirement fund at TIAA-CREF tracks S&P 500 index and hence, is expected to have the same performance of S&P 500 index. From 1926 to 2012, the average annual return of S&P 500 index is 11.55% per year with standard deviation 20.62%. You expect the performance of your retirement fund in the future will be similar to its performance in the past.

Deterministic Analysis

Based on your retirement account balance and projected life of expectancy, financial planners provide the service for finding the equal withdraw amounts per year for you. Traditionally, the calculation done by the financial planners assumes the annual return of the retirement fund is constant and completely ignores the fluctuation of annual returns; that is, the decision is purely based on expected return per year. Assuming that the annual expected return of your retirement fund is a constant 11.55% per year for the next 20 years, how much can you withdraw per year so that you deplete your retirement fund after 20 years?

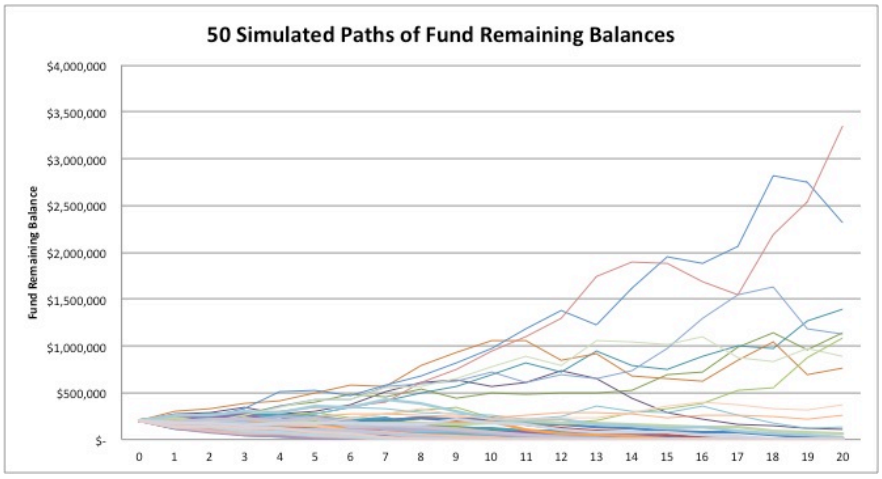
The Excel workbook **"retirement.xlsx"** contains a cash flow model and uses Excel Goal Seek to find the annual withdraw amounts. If you withdraw $23,327.72 per year, the balance at the end of Year 20 is 0. The remaining account balance in the next 20 years based on the annual withdraw of $23,327.72 is shown in the figure below.



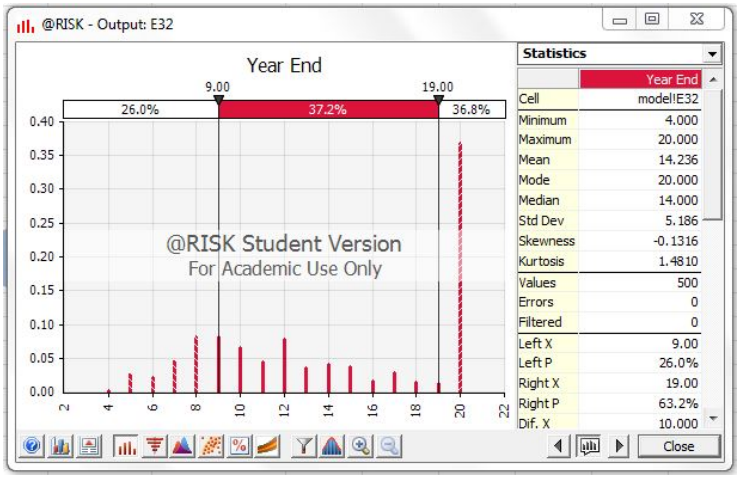
The deterministic analysis approach described above is based on the assumption that annual return is a constant 11.55%. The issue with this traditional approach is that the annual returns did fluctuate over the period from 1926 to 2012 and will fluctuate in the future. The consequence of ignoring the fluctuation of the annual return of the retirement fund is demonstrated using a simulation model.

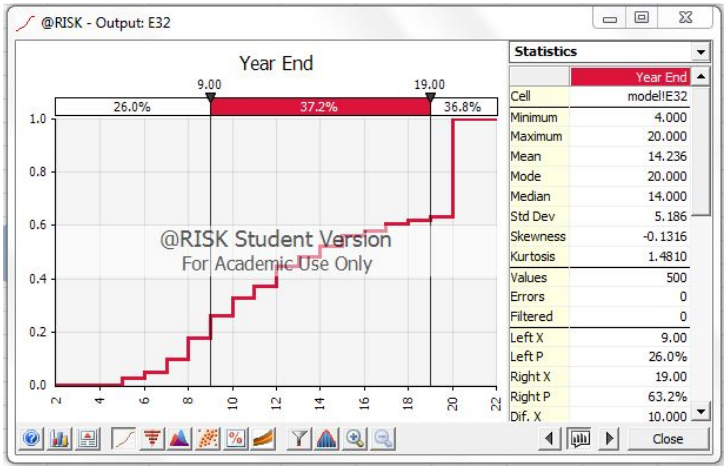
Simulating the Reality. To take into account the uncertainty of future returns, we assume that annual return in the next 20 years is normally distributed with mean 11.55% and standard deviation 20.62% (the mean and standard deviation are estimated from historical S&P 500 index from 1926 to 2012). Draw the annual return year by year for 20 years using the distribution information specified above to evaluate the performance of your retirement fund with the withdraw amounts per year $23,327.72 (found previously using the deterministic analysis approach). How often is your retirement fund depleted before the end of 20 years?

The Excel workbook "**retirementRisk.xlsx**" has a simulation model with uncertain future returns. The simulated paths of remaining balances in the retirement account are shown in the figure below. While there are some paths that will give you positive balance at the end of 20 years, other simulated paths indicate your retirement account will be depleted early.



The figures below show the distribution of the last year with positive balance in your retirement account if you withdraw $23,327.72 per year. Your retirement fund will last for, on average, 14.24 years before it is depleted. Furthermore, there is a 63% probability that you deplete your retirement account before Year 20. Even worse, there is an approximately 26% probability that your retirement fund will be depleted (and your retirement life will be ruined) by Year 9!



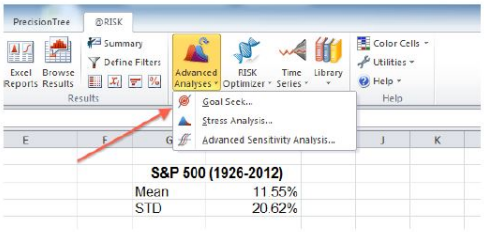


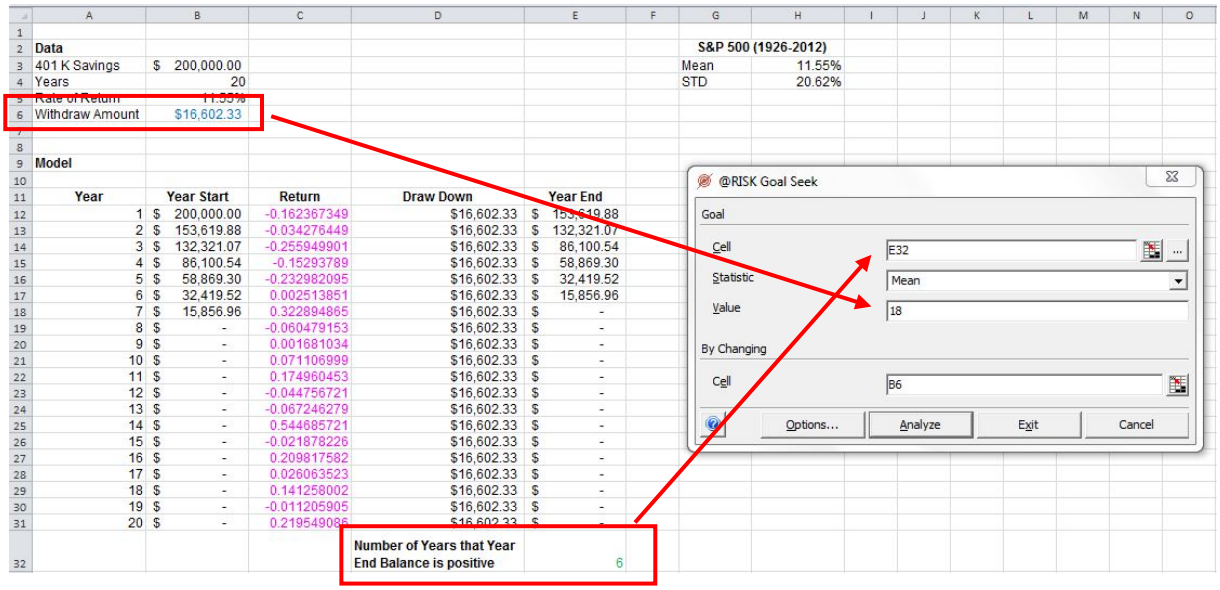
Risk Analysis

The exercise above illustrates that analysis using only average (or expected) return and ignoring the uncertainty can lead to misleading conclusions. Surprisingly, analyses provided by most retirement funds before late 1990s were largely based on using average/expected values. Ideally, we would want to incorporate uncertainties in the financial planning with our retirement portfolio. There are two ways to do so.

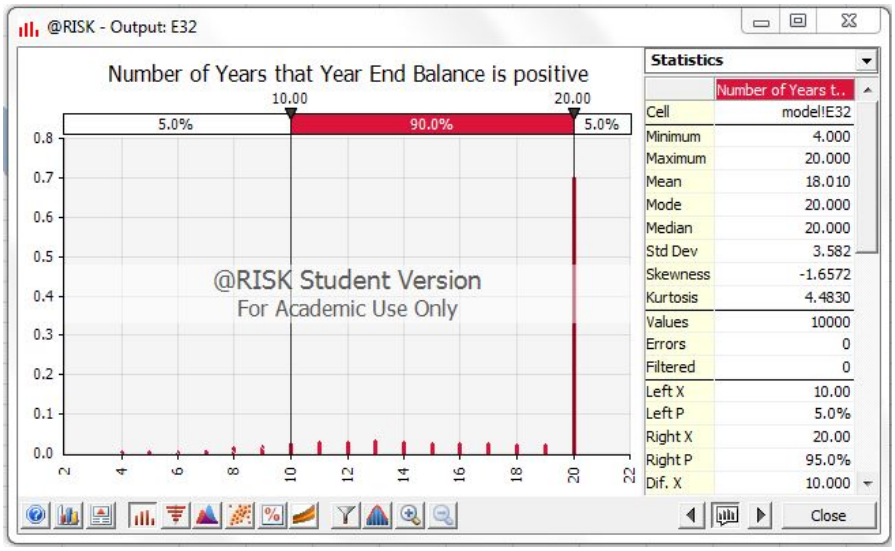
@Risk Goal Seek

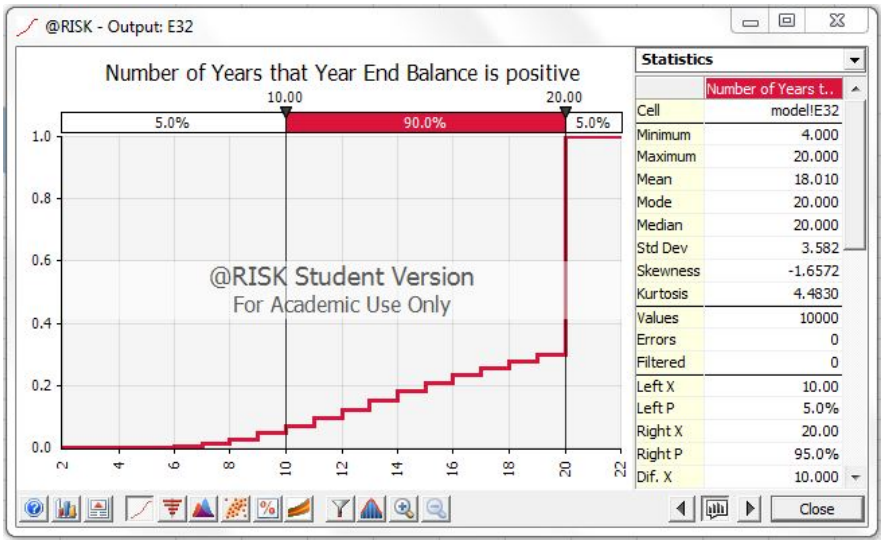
The first type of risk analysis is similar to deciding the equal withdraw amounts per year in the deterministic analysis. However, when we calculate the withdraw amount per year, we need to take into account future returns being uncertain. Given uncertain future returns, the requirement that the retirement fund will last for 20 years for all future scenarios is too strict. Hence, we need to relax that requirement and consider another criterion that is a less restrictive, for example, the retirement fund will last on average (approximately) 18 years before it is depleted. The @Risk Goal Seek (under Advanced Analysis) allows us to perform this type of analysis. See the Excel workbook "**retirementRiskGoal.xlsx**" for the model that uses @Risk Goal Seek.





@Risk Goal Seek tells us that we could withdraw equal amount of $16,602.33 per year. On average, our retirement fund will last for 18 years. Furthermore, there is a 70% probability that our retirement fund will last for 20 years (and 30% probability that the fund will be depleted before Year 20). The worst case outcome from the simulation is that the fund can last for only 4 years.





@Risk Target Value. The second type of risk analysis that incorporates uncertain future returns has been implemented and provided to customers by most financial services organizations nowadays. For example, the following report has been provided by TIAA-CREF to their clients.

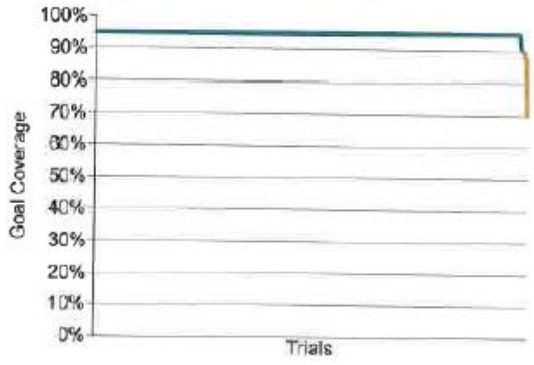
Current Plan and Life Expectancies to Age 100/Mod. Aggressive

The following graphs illustrate the likelihood of reaching your financial goal. We evaluated the results of 500 hypothetical market simulations ("trials") reflecting various possible market conditions. This assessment helps to determine whether there could be a shortfall in the amount required for you to reach your goal in any given year.

The analysis is performed to simulate a number of possible financial outcomes, rather than assuming an average return year after year. The greater the number of successful trials, the greater the likelihood you will achieve your goal. For this analysis, we define success as being able to cover 90% or more of your goal in at least 450 trials.

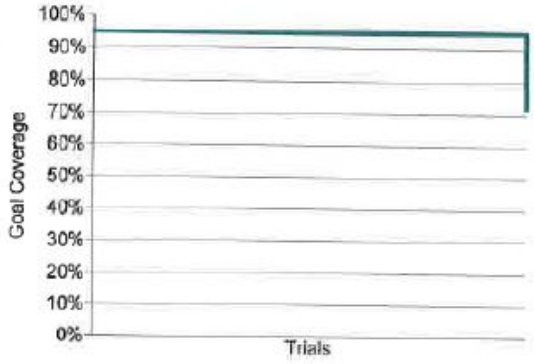
Likelihood Of Achieving Your Goal

Current Plan



- In 494 trials, 90% or more of your goal was covered.
- In 6 trials, 65 - 90% of your goal was covered.
- In 0 trials, less than 65% of your goal was covered.

Life Expectancies to Age 100/Mod. Aggressive



- In 499 trials, 90% or more of your goal was covered.
- In 1 trials, 65 - 90% of your goal was covered.
- In 0 trials, less than 65% of your goal was covered.

Three key points (highlighted in yellow) in this report are:

1. We evaluated the results of 500 hypothetical market simulations ("trials") reflecting various possible market conditions.
2. The analysis is performed to simulate a number of possible financial outcomes, *rather than assuming an average return year after year.*
3. For this analysis, we define success as being able to cover 90% or more of your goal in at least 450 trials.

In what follows, we develop a model that performs the simulation analysis done by TIAA-CREF. Suppose that your goal is to withdraw X dollars every year for N years and be left with Y dollars after N years:

- X : a number selected by the user, for example $30,000 per year
- Y : a number selected by the user, for example $50,000
- N: life expectancy minus retirement year.

The objective is to find out how often we meet 90% or more of our goal.

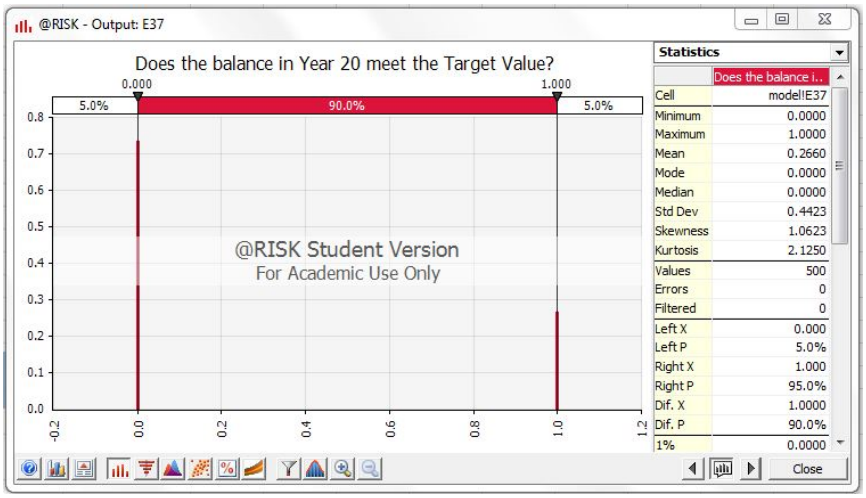
We will use the following data:

401 K Savings	$200,000
Years (N)	20
μ	11.55%
σ	20.62%
Payment Goal (X)	$25,000 per year
Horizon End Goal (Y)	$50,000
Goal Percentage	90%

One key question we need to address before we build the model is what TIAA-CREF means by meeting 90% or more of the goal in the report. We assume it means that:

1. For each of the 20 years, there are sufficient funds to withdraw $25,000
2. After 20 years, we have **at least** 0.9*50,000 = 45,000 dollars in the account.

See the Excel Workbook "**retirementTIAA.xlsx**" for the model. The number in cell E34 is the end balance after 20 years. If the number in this cell (C34) is higher or equal to the Target Value $45,000, then we meet our goal (and set the value in cell E37 to 1). Otherwise, we do not meet our goal (and set the value in cell E37 to 0). Click "Add Output" for cell E37 (so that @Risk collects and reports simulation outcome for the 0/1 index in cell E37) and run 500 iterations in the simulation.



The mean of this output index in cell E37 over 500 iterations (trials) in the simulation is 0.266 (cell E38 using RiskMean(E37,1)). Since there are only two possible values, 0 and 1, for the index in cell C37, the mean is calculated as

(# of times we meet the goal*1 + # of times that we miss the goal*0)/500 = 0.266.

Hence, the number of times that we meet the goal over 500 iterations (trials) is 0.266*500 = 133 (see cell E39).

Acknowledgement. This case is based on a series of examples developed by Professor Kipp Martin at University of Chicago Booth School of Business.