Russell Investments

Russell Research

By Richard K. Fullmer, CFA

OCTOBER 2009

Mismeasurement of risk in financial planning

A lesson in risk decomposition

Financial planning is complex. Modeling tools have proliferated as a way to help wade through the complexity and facilitate sound decision making processes. The selection of the risk measure in these tools is all important. Poor decisions can result if the risk measure is faulty or incomplete.

A brief history of financial planning tools

Early attempts at financial planning models asked the individual to specify values to assume for important variables such as the rate of return on the portfolio and the rate of inflation. These assumptions would then be used to project forward the portfolio balance, after accounting for withdrawals taken from it to fund the individual's spending plan. Planners quickly realized that these "deterministic" models were wholly inadequate. One problem was that the individual may have little knowledge with regard to the values that were reasonable to assume. Another problem was that the inherent nature of the capital markets meant that even if reasonable values were selected, the future could—and certainly would—turn out quite differently than assumed. Yet another problem was that the success or failure of the financial plan was subject to "path dependency." Even if the capital markets did deliver the assumed average rate of return over the planning period, the plan could still fail if the returns came about unevenly rather than smoothly. If returns were poor early and good late, the investor might run out of money in the middle of the planning period, before the market had a chance to recover. Deterministic models were dangerous because they did not measure risk, at least not in any comprehensive and meaningful way.

To address these shortcomings, deterministic models were replaced by "probabilistic" models. These typically used a technique called Monte Carlo simulation, which projects out numerous (hundreds or thousands) potential paths that could unfold over time for variables such as portfolio returns and inflation. Dividing the number of paths under which the plan fails by the total number of paths simulated gives the probability of failure. This was a significant improvement that could address all three of the problems described above.[1]

Beware the risk measure

Simulation models are wonderful tools if used properly. Unfortunately, that is not always the case. Think about the purpose for using such a model in the first place. In the case of financial planning, it is to help individuals assess a suitable saving rate, retirement date, spending budget, investment strategy, etc. Of course, this requires an understanding of the investor's risk tolerance as well as the risk of ruin inherent in the investor's financial plan.

This leads us to consider exactly what "risk" means in this context. How is it defined? Well, many financial planning tools define it as the probability that the plan may fail (e.g., that the individual runs out of money). The conventional guidance is that investors should plan using a low (e.g., 5% to 10%) probability of failure, although the suitable probability threshold for any particular individual will depend on his or her risk tolerance.

The problem with this definition and treatment is that the probability of failure is not a complete measure of risk. Just as *not* measuring risk can be dangerous, so too can *mis*measuring it.

A brief history of probability theory

The 17th century mathematicians Blaise Pascal and Pierre de Fermat are widely regarded as the founders of probability theory. One might think that such a discovery would encourage the inventors to further their work to see what other interesting and useful things they might discover next. The effect of the discovery on Pascal, however, was quite different. He began to turn away from mathematics and toward philosophy. Why?

Pascal began his work on probability theory after receiving a most interesting and challenging puzzle from Antoine Gombaud, the Chevalier de Méré. The challenge went something like this: Suppose two players are in the middle of a game and have to stop play early, before the game is finished. Given the current situation of each player at the time, how should they divide the stakes?

The answer depends on each player's probability of winning at the time the game prematurely ends. At the time, no one knew how to calculate this.

After he and Fermat solved the Chevalier's puzzle, Pascal soon realized that its solving led to a remarkably profound thought. As useful as probability theory might be, it was not so much what it said, but what it didn't say. The probability that an event might occur was an exceedingly useful thing to know, but it was only half of the story. The other half was the consequence of the event, should it actually occur.

With that thought, Pascal began to turn his mind from the subject of probability measurement to the subject of risk measurement and what it means in the context of living one's life. He realized that the consequences matter—sometimes a little, and sometimes a lot. In other words, the *magnitude* of the consequences is an important element of risk measurement.

[1] Of course, no model of the future is perfect. Probabilistic models are still subject to forecasting error, sampling error, etc.

Risk decomposition

Having now established that the probability of an event occurring and the magnitude of the consequences of it occurring are both important, the natural next question is, "Which is more important?" The answer is: neither.

To see why, let's decompose risk in terms of these two factors. The decomposition goes like this:

Total Risk = Probability x Magnitude

Risk is simply the product of the two—their importance is equal. An event with high probability and low magnitude may have an equivalent overall risk exposure as an event with low probability and high magnitude.

Consider the following example. Insurance companies are in the business of risk transfer. They agree to accept certain risks in exchange for a premium payment. How much is the risk transfer worth?[2] The answer is revealed by the formula. It is a function of the probability of claims occurring and the potential magnitude of claims that occur. More specifically, it can be found by multiplying the frequency by which claims may occur (the probability) by the potential size of the claims that may occur (the magnitude).[3]

Here is another example. Say that the fine for a speeding ticket is $100 when the driver's speed is less than 15 miles per hour over the speed limit and $1,000 when the driver's speed is more than 15 miles per hour over the speed limit. You plan to drive on a road for which the posted speed limit is 50 miles per hour. Clearly, the risk to you of driving 67 miles per hour on this road is much greater than the risk of driving 63 miles an hour. This is true even if the probability of getting caught is exactly the same.

Getting back to the topic of financial planning, models that measure only the probability of failure ignore one side of the risk equation completely. This is not to say that Monte Carlo simulation should be scrapped. Simulation models actually lend themselves very well to proper risk measurement—if only the modeler takes care to measure both the probability of failure and the magnitude of the failure cases that occur. In this context, the magnitude is the total amount of desired spending and bequeathing that does not occur because the portfolio ran out of money—often referred to as "shortfall."

Just as the insurer/insured both need to understand the total amount at risk when pricing/purchasing an insurance policy, so too does the individual investor need to understand the total amount at risk when making financial planning decisions. Thus, planning tools that use this type of risk measure:

Shortfall Risk = Probability of Shortfall

have it wrong. A better risk measure is:

Shortfall Risk = Probability of Shortfall x Magnitude of Shortfall

Having said that, the probability statistic may be good enough as a quick check on whether or not a particular spending plan is reasonable. However, it is inadequate when it comes to actual decision making. In fact, the choice of risk measure can have a significant impact on financial planning decisions, especially with regard to asset allocation.

[2] In other words, "What is the actuarial price of the risk exposure?" For a variety of reasons, this price may be different than the premium actually charged by the insurance company—the need to also cover operating expenses is one reason.

[3] Technically, the risk equation should consider the entire set of potential claim sizes along with the corresponding probability that each claim size may occur. The magnitude component of risk, then, is best measured as a probability distribution rather than a single average number. The magnitude component is, of course, conditional on a claim actually occurring. To be more accurate, then, we could write:

Total Risk of Loss = Probability of Loss x *conditional probability-weighted* Magnitude of Loss.

Technicalities aside, the point being made here is simply that claim size is just as important as claim probability. The concept holds true of any situation where risk is to be measured.

Illustrations

The significance of the risk measure to financial planning can be illustrated by using Monte Carlo simulation and showing the results separately for each component of risk. The following hypothetical illustrations are for a retired investor planning at a 30-year horizon. Retirement spending is modeled as an inflation-indexed withdrawal rate from the portfolio. The horizontal axis displays selected withdrawal rates from 3% to 8%, in ¼% increments. The vertical axis displays the risk measure. The risk of shortfall (running out of money) for five different asset allocations is then plotted. These allocations range from 20% equity to 100% equity, in 20% increments. The percentage of the portfolio not allocated to equity is invested in bonds. The magnitude of shortfall refers to the amount of desired spending that does not occur because the portfolio ran out of money.

Figure 1 plots the risk measure as the probability of shortfall. Notice the pattern of the asset allocation lines, which "cross over" in the 4½% to 5½% range. Conservative portfolios have an unambiguously lower probability of failure at the lower withdrawal rates to the left of the crossover range. Aggressive portfolios have an unambiguously lower probability of failure at the higher withdrawal rates to the right of the crossover range—although at these withdrawal rates, the risk is quite high no matter what allocation is used.

Figure 2 plots the risk measure as the average magnitude of shortfall in the cases where a shortfall actually occurs. This chart reveals a similar pattern, but the crossover range occurs much further to the right and is much wider than under the probability-based measure. Here, the crossover occurs in the 5¾% to 8% range. Conservative portfolios have an unambiguously lower magnitude of failure at the lower withdrawal rates to the left of the crossover range. Aggressive portfolios have an unambiguously lower magnitude of failure at the higher withdrawal rates to the right of the crossover range—although, again, at these withdrawal rates, the risk is quite high no matter what allocation is used.

Figure 3 plots the risk measure as the holistic measure of total shortfall risk, computed as the probability of shortfall times the magnitude of shortfall.[4] Not surprisingly, this chart reveals the same type of pattern and its crossover range occurs somewhere between the crossovers shown in Figures 1 and 2. Here, the crossover occurs in the 5% to 6½% range. Conservative portfolios have an unambiguously lower total risk of failure at the lower withdrawal rates to the left of the crossover range. Aggressive portfolios have an unambiguously lower total risk of failure at the higher withdrawal rates to the right of the crossover range—although as before the risk is quite high no matter what allocation is used.

Table 1 summarizes the data in these figures by showing the minimum-risk portfolio at each withdrawal rate under each risk measure. Here, "minimum-risk" refers to the asset allocation (among the five allocations tested) with the lowest level of shortfall risk according to each risk measure.[5] At lower withdrawal rates, each risk measure points to the same conservative (20% equity) portfolio. At higher withdrawal rates, each risk measure points to the same aggressive (100% equity) portfolio. For the in-between withdrawal rates, however, different measures result in different portfolios.

For these in-between withdrawal rates, you can see that the probability measure can lead to an overly aggressive asset allocation decision because it does not consider the magnitude component of risk, which tends to be greater for more aggressive portfolios. On the other hand, the magnitude measure can lead to an overly conservative asset allocation decision because it does not consider the probability component of risk,

[4] This value is also known as the "expected shortfall", since it represents the mean probability-weighted amount of shortfall in the plan.

[5] If all possible asset allocations were tested, the minimum-risk portfolio at the lowest withdrawal rates would be a 100% TIPS portfolio that is duration matched to the required future cash flows.

which tends to be greater for more conservative portfolios (in this range of withdrawal rates). Only the total risk measure can help lend itself to an appropriate asset allocation decision.

For perspective, the last column in Table 1 shows the probability of failure for the portfolio identified as the minimum-risk portfolio under the total shortfall risk measure. This shows that higher withdrawal rates are extremely risky, even under the "minimum-risk" portfolio. The risk level is also relatively high within the crossover range—the 4¾% withdrawal rate at the lowest end of the crossover range has a nearly 1-in-3 chance of failing.

Implications

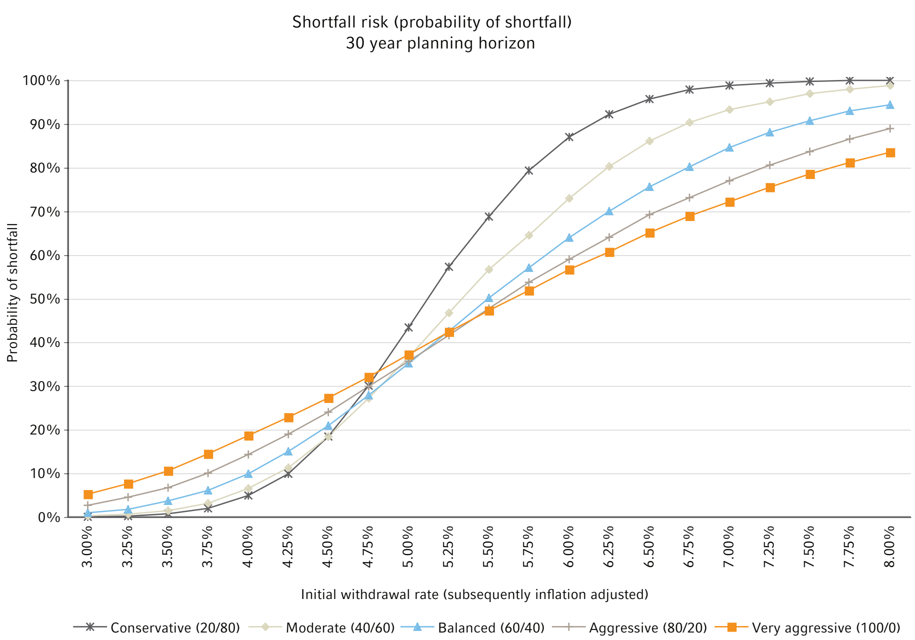
By focusing solely on the probability component of risk, the full extent of the risk goes unmeasured. This is as true in financial planning as it is everywhere else in life. This mismeasurement of risk may lead the investor to select an inappropriate portfolio.

When measuring risk as the probability of failure, the asset allocation decision will typically err on the side of too aggressive. This is a direct result of ignoring the magnitude of failure. As in the speeding ticket example, if all risks (spending shortfalls or traffic fines) are treated the same regardless of their magnitude, then aggressive actions (higher equity allocations, higher driving speeds) will not appear as risky as if the magnitude of the consequences of the taking the action is also considered.

This observation holds regardless of whether the investor is risk averse (and therefore interested in a low-risk portfolio/plan) or relatively risk tolerant (and therefore interested in a portfolio/plan with the potential to generate greater upside). It holds regardless of the investor's age, gender, marital status, retirement date, planning horizon. It holds regardless of whether the investor has bequest goals. It holds regardless of whether annuities and other insured products are considered in the asset allocation decision. Getting the risk measure correct is vitally important.

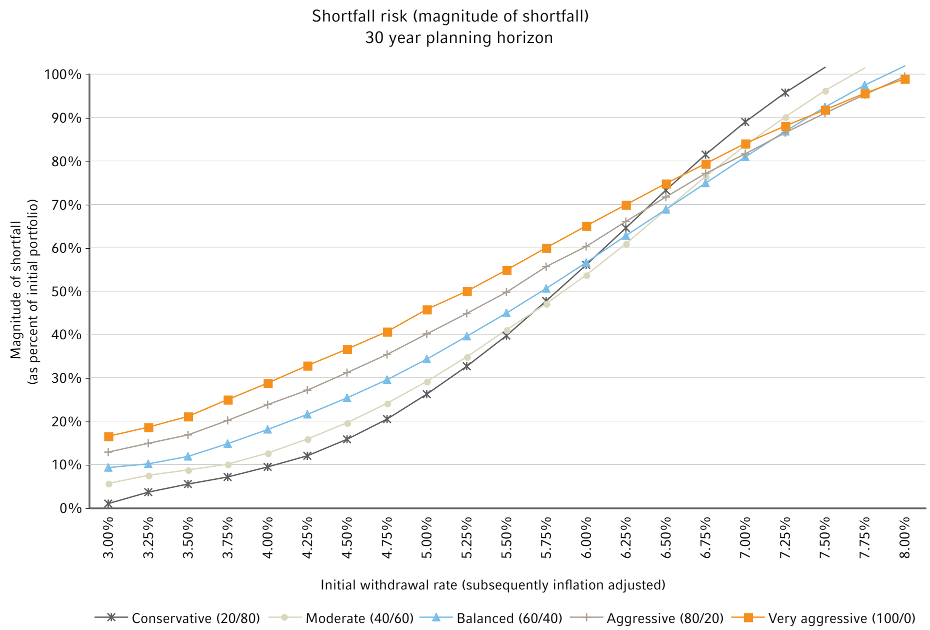
Tables and figures

FIGURE 1: PROBABILITY OF FAILURE



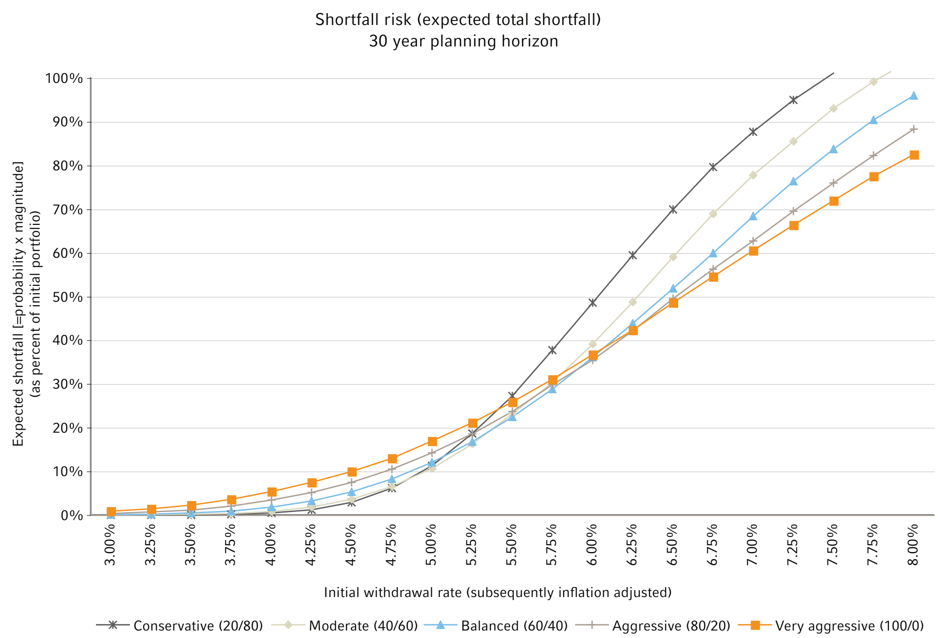
This hypothetical example is for illustration only and is not intended to reflect the return of any actual investment. Investments do not typically grow at an even rate of return and may experience negative growth. Please see Methodology disclosure for more information.

FIGURE 2: MAGNITUDE OF FAILURE



This hypothetical example is for illustration only and is not intended to reflect the return of any actual investment. Investments do not typically grow at an even rate of return and may experience negative growth. Please see Methodology disclosure for more information.

FIGURE 3: TOTAL FAILURE RISK = PROBABILITY OF SHORTFALL x MAGNITUDE OF SHORTFALL



This hypothetical example is for illustration only and is not intended to reflect the return of any actual investment. Investments do not typically grow at an even rate of return and may experience negative growth. Please see Methodology disclosure for more information.

TABLE 1: MINIMUM-RISK PORTFOLIO BY WITHDRAWAL RATE AND RISK MEASURE

Initial inflation-adjusted withdrawal rate	Equity allocation for portfolio that has the lowest…			Probability of shortfall (PR) for minimum total-risk (TS) portfolio
	Probability of shortfall (PR)	Magnitude of conditional shortfall (CM)	Expected total shortfall (TS) = PR x CM	
3%	20% equity	20% equity	20% equity	< 1%
3¼%	20% equity	20% equity	20% equity	< 1%
3½%	20% equity	20% equity	20% equity	1%
3¾%	20% equity	20% equity	20% equity	2%
4%	20% equity	20% equity	20% equity	5%
4¼%	20% equity	20% equity	20% equity	10%
4½%	20% equity	20% equity	20% equity	18%
4¾%	40% equity	20% equity	20% equity	30%
5%	60% equity	20% equity	40% equity	37%
5¼%	80% equity	20% equity	40% equity	47%
5½%	100% equity	20% equity	60% equity	50%
5¾%	100% equity	40% equity	60% equity	57%
6%	100% equity	40% equity	80% equity	59%
6¼%	100% equity	40% equity	80% equity	64%
6½%	100% equity	40% equity	100% equity	65%
6¾%	100% equity	60% equity	100% equity	69%
7%	100% equity	60% equity	100% equity	72%
7¼%	100% equity	80% equity	100% equity	75%
7½%	100% equity	80% equity	100% equity	79%
7¾%	100% equity	80% equity	100% equity	81%
8%	100% equity	100% equity	100% equity	84%

Methodology disclosures

The charts present data for a retired investor desiring a specific inflation-indexed annual rate of withdrawal for 30 years.

The risk of shortfall is shown using three different risk measures. "Shortfall" is defined as failing to achieve the desired withdrawals from the portfolio over the 30 year horizon.

"Risk" is defined in three ways:

1. Probability of shortfall (Figure 1): the number of failing scenarios divided by the total number of scenarios.
2. Average conditional magnitude of shortfall (Figure 2): the average of the shortfall amount for those scenarios that result in failure.
3. Expected total shortfall (Figure 3): the product of the probability of shortfall and the average conditional magnitude of shortfall.

A Monte Carlo simulation process is used to determine the probability and average conditional magnitude of shortfall by generating thousands of possible scenarios for portfolio returns, interest rates, and inflation. These simulations depicted in this article are created using the following broad based asset class return assumptions for equity returns, fixed income returns and inflation. They are hypothetical in nature and do not reflect actual investment results and are not guarantees of future results. The results may vary with use and over time.

Hypothetical assumptions:

			Correlations		
	Expected return	Standard deviation	Equity	Fixed income	Inflation
Equity	8.5%	15.4%	1.00		
Fixed income	6.0%	5.5%	0.25	1.00	
Inflation	3.0%	4.0%	0.16	0.15	1.00

It is important to remember that this process is based on assumptions that may not reflect the behavior of actual events. For example, Monte Carlo Simulation may not fully account for certain rare and extreme market catastrophes which fall outside normal expectations.

A different set of assumptions would create a different probability distribution. Expert opinion regarding expected returns, volatility and market trends vary widely.

IMPORTANT: The projections or other information generated by the Monte Carlo Simulator regarding the likelihood of various investment outcomes are hypothetical in nature, do not reflect actual investment results and are not guarantees of future results. Other investments not considered may have characteristics similar or superior to those being analyzed.

Different methodologies will produce different results.

The portfolios were selected in increments of twenty percent exposure to equity, as follows:

Conservative: 20% allocation to equity
80% allocation to fixed income

Moderate: 40% allocation to equity
60% allocation to fixed income

Balanced: 60% allocation to equity
40% allocation to fixed income

Aggressive: 80% allocation to equity
20% allocation to fixed income

Very aggressive: 100% allocation to equity

The following asset classes are included in the Monte Carlo analysis:

Equities: Investment in stocks. Stock represents ownership and control in a corporation and may pay dividends as well as appreciate in value. The value of a stock will rise and fall in response to the activities of the company that issued them, general market conditions, and economic conditions.

Fixed Income: A government, municipal or corporate bond that pays a fixed rate of interest until the bond matures; or a preferred stock that pays a fixed dividend. Bond investors should carefully consider risks such as interest rate risk, reinvestment risk, call risk, and default risk.

For more information visit www.russell.com or call 800-787-7354.

Standard Deviation is a statistical measure of the degree to which an individual value in a probability distribution tends to vary from the mean of the distribution. The greater the degree of dispersion, the greater the risk.

First used October 2009.

CORP 5858