

# PORTFOLIO SELECTION WITH SHORTFALL RISK

Risk perception is critical to portfolio selection. But risk has different dimensions. Portfolio risk is the risk perceived in relation to portfolio assets, and it is most commonly defined by standard deviation – a measure of volatility around the expected return. Standard deviation is used to plot portfolios that offer the highest return for each level of risk along an efficient frontier. Optimizing investors select a portfolio from the efficient frontier based on their risk tolerance.

Goals-based and liability-driven investors may also consider shortfall risk, which is the risk of failing to fund goals or liabilities. Shortfall risk measures include shortfall probability and magnitude. Taken together, portfolio risk and shortfall risk provide a more complete view of risk to help investors select portfolios.

Building on our 2017 research article "[Surplus Assets and Shortfall Risk](#)," we illustrate the interplay of portfolio risk and shortfall risk on portfolio selection. Exhibit 1 displays Northern Trust's capital market assumptions for U.S. investment-grade bonds and global equity.<sup>1</sup> The efficient frontier of these two asset classes spans the minimum-risk portfolio composed of 4% stocks and 96% bonds, the moderate-risk portfolio of 60% stocks and 40% bonds in the middle of the frontier, and the maximum-return portfolio of 100% stocks. We evaluate portfolio risk and shortfall risk (using Monte Carlo simulation) across these three portfolios for a high-net-worth investor with a \$600,000 annual consumption goal over 35 years funded by an initial \$10 million investment portfolio.<sup>2</sup>

## EXHIBIT 1 — CAPITAL MARKET ASSUMPTIONS

	EXPECTED RETURN	STANDARD DEVIATION	CORRELATION
U.S. Bonds	3.0%	3.4%	
Global Equity	7.5%	15.0%	0.05

Source: Northern Trust Investment Policy Committee

<sup>1</sup> The expected return displayed is the arithmetic mean return.

<sup>2</sup> For simplicity, we make no adjustments for taxes or inflation.

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January 2020

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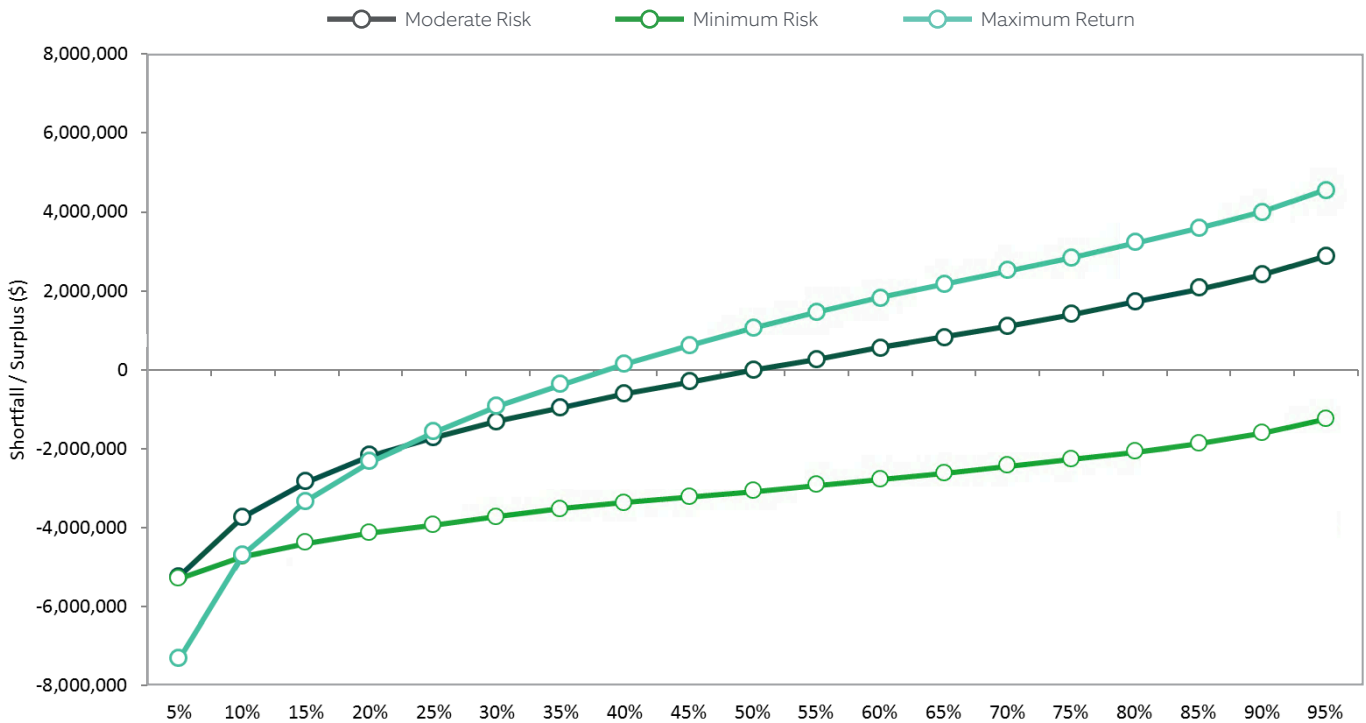
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Risk tolerance, including perceived portfolio risk and shortfall risk, is an essential consideration for goals-based portfolio selection.

An optimal portfolio to fund this consumption goal might be defined as the asset mix that minimizes portfolio risk while successfully funding the goal on average. This is a rational portfolio for a risk-averse investor with a high-priority goal. In our example, that turns out to be the moderate-risk portfolio (60% stocks and 40% bonds), which offers an expected return of 5.7% and portfolio risk of 9.2%. Exhibit 2 shows the simulated funding outcomes for the moderate-risk portfolio, displayed as dollars of surplus or shortfall today.

Shortfall risk includes both the probability of having insufficient assets and the magnitude of the funding gap between assets and liabilities.

EXHIBIT 2 — OPTIMAL PRE-TAX AND AFTER-TAX ALLOCATIONS



Source: Northern Trust Research

There is no expected surplus/shortfall at the 50<sup>th</sup> percentile outcome with the moderate-risk portfolio, indicating that the investor expects to be funded. But the investor also has a shortfall probability of 50%, and the magnitude of shortfall can be large in certain potential outcomes. The 5<sup>th</sup>, 10<sup>th</sup> and 20<sup>th</sup> percentile outcomes for the moderate-risk portfolio in Exhibit 2 show shortfalls in current dollars of \$5.2 million, \$3.7 million and \$2.2 million, respectively. Another view is extreme shortfall (5% CVaR), which is the average shortfall across the 0 to 5<sup>th</sup> percentile outcomes (essentially a one-in-twenty likelihood). Extreme shortfall is \$6.9 million.

Perhaps the investor is highly risk-averse and prefers the 3.3% portfolio risk of the minimum-risk portfolio (4% stocks and 96% bonds). Exhibit 2 also shows the simulated outcomes of this scenario. The lower 3.2% expected return of the minimum-risk portfolio makes the \$10 million insufficient to fund consumption and shortfall probability is effectively 100%. Extreme shortfall is \$5.9 million, which is less than the \$6.9 million of the moderate-risk portfolio, but perhaps that is a small consolation given the high shortfall probability. Although this is the minimum-risk portfolio from a portfolio risk perspective, it may not be perceived as the lowest-risk portfolio from a shortfall risk perspective.

Some investors are willing to trade higher portfolio risk for higher expected return to create a buffer of surplus assets. Exhibit 2 includes the simulated funding outcomes for the maximum-return portfolio (100% stocks), which has a portfolio risk of 15%. Its high expected return of 7.5% results in an expected surplus of \$1.1 million and a 39% shortfall probability.<sup>3</sup> But the lower shortfall probability is offset by higher magnitudes of potential shortfall. The 5<sup>th</sup>, 10<sup>th</sup> and 20<sup>th</sup> percentile outcomes for the maximum-return portfolio show shortfalls in current dollars of \$7.3 million, \$4.7 million and \$2.3 million, respectively. Extreme shortfall is \$12.1 million, which is significantly worse than the other two scenarios. Without an inflow of external assets, the funding gaps that arise in these shortfall scenarios would be resolved with far less consumption than \$600,000 per year (or far fewer than 35 years of consumption at \$600,000 per year).

Portfolio risk and shortfall risk are important views of risk that can aid portfolio selection. A rational starting point for risk-averse investors is the asset mix that minimizes portfolio risk while successfully funding goals on average. But each investor has a unique perception of shortfall risk which drives portfolio selection. If portfolio risk or shortfall risk are unacceptable, there is always the option to modify goals. Adaptation is a key feature of goals-based investing.

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Structuring an asset mix that minimizes portfolio risk and successfully funds goals is a logical starting point for risk-averse investors.

<sup>3</sup>We note that the \$1.1 million expected surplus cannot be reallocated to fund other goals if the objective is to retain the lower shortfall probability.

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