

# The Math Behind Riskalyze



We believe that it's important for advisors to fully understand the technology they're using to advise their clients. While many pieces of our technology are proprietary, the mathematical inputs and much of our methodology are not. This technical white paper will give you a solid background for explaining the results to your clients.

## Confidentiality

Please note: this document contains sensitive information about our technology. It is designed only for our customers, in their evaluation and understanding of Riskalyze for use by their firms, and contains material that we consider to be confidential trade secrets. It may not be used for the purpose of attempting to reverse engineer, decompile or clone Riskalyze technology.

## RISK QUESTIONNAIRES

### Establishing the Financial Spectrum

Amounts make all the difference. Humans are not programmed to simply "play the odds." When offered a 50-50 bet with a \$1 million payoff most people would not pay \$300,000 to play the game. Yet, change the game's payoff to \$10 for \$3 at risk and many would not hesitate to play.

Amounts at risk make all the difference. Human bias is to limit pain, and each of us, individually, has our own threshold for financial pain.

Riskalyze offers two approaches to assessing client risk tolerance — our "detailed" approach captures a unique Risk Fingerprint for the client with a high degree of mathematical certainty. The "simple" approach is designed for clients who are perhaps elderly or have simpler needs, and the advisor still wants the actionable insight of the questionnaire.

The advisor can choose, when sending the questionnaire, whether to send the client down the simple or detailed paths, or allow the client to choose.

Both approaches begin with the client's investment amount, and in addition, the detailed approach will ask for an amount representing a "devastating loss" to the client. These variables are foundational to the algorithms that generate the risk questions.

The investment amount typically incorporates an investor's total investable portfolio, or can be specific to a bucket of the client's money, like a 401K account. For example, an investor may have a different risk tolerance for college savings than they will with their retirement portfolio.

“Devastation” means a loss that is completely and totally unacceptable to the client. If you think carefully about the word devastation, pictures of “financial hell” should arise. With that in mind, no self-respecting advisor would ever invest a portfolio where the chance of desperation was possible. However, the “devastating loss” amount is paramount in individualizing the detailed risk questions for the investor.

If the client struggles to establish a “devastating loss” (rare in our experience), one question that advisors often use to elicit that number is to ask “how much would your portfolio have to fall before you would fire me as your advisor?”

Fundamentally, the Riskalyze risk questionnaire will not work unless the investor is testing a real amount of money that is meaningful to them and would be painful to lose. Furthermore, the detailed approach will not work unless the “devastating loss” far exceeds an “acceptable loss” and truly represents a completely unacceptable and terrifying outcome for them.

### **Prospect Theory: Certainty vs. Risk**

Much of our technology is built on top of the academic framework known as “Prospect Theory” that won the Nobel Prize for Economics in 2002. Prospect theory describes the way people use probabilities that involve risk, where the probabilities of the outcomes are known.

The theory states that people make decisions based on the potential value of losses and gains rather than the final outcome, and that people evaluate losses and gains within the context of their financial position. Investors don't simply play the odds.

Prospect theory provides the framework for measuring quantitative information instead of relying on subjective questionnaires. Riskalyze uses objective math, instead of questions subjectively designed and weighted by psychologists. That's why the accuracy of Riskalyze reaches 96% at a high level of definition, while most psychological risk profiling tools claim 85% accuracy at best when placing clients into a small number of buckets.

### **Client Risk Number and Comfort Zone**

The Risk Number is a proprietary scaled index developed by Riskalyze to reflect a "risk score" for both an investor's unique Risk Fingerprint, or for a specific portfolio of investments. As you can see, it's shaped like a speed limit sign, so a higher Risk Number means a higher level of risk and potential return.

An investor's Risk Fingerprint is a multi-dimensional set of variables reflecting the complexity of an individual investor's risk tolerance. On the other hand, the Risk Number is a single-dimension variable designed to approximate the relative risk between people or portfolios. Thus, a "45" portfolio generally has more risk than a "44," but two "45" portfolios may be quite different from each other.



One of the most important drivers of the Risk Number is the measurement of downside risk: either the downside risk in the investor's comfort zone (the range of risk to reward that they approve at the end of their risk questionnaire), or the downside risk in a portfolio as measured by the 95% probability range.

Here are a few examples of the relationship between downside risk and Risk Number:

- Downside of -2%: Low 20s
- Downside of -5%: Low 30s
- Downside of -7%: Low 40s
- Downside of -12%: Low 60s
- Downside of -18%: Low 80s

Our advisors typically consider Risk Numbers to be "acceptable" to each other when they are within 5-10 points of each other. Therefore, a model portfolio with a Risk Number 45 is often used for clients ranging from 40-50, unless the advisor offers another model that is closer.

Riskalyze advisors use the client's risk number as the starting point for portfolio design, which both quantifies the suitability of a portfolio and places it within a client's expectations. However, advisors always adjust the portfolio based on other important and relevant data about the client, such as age, income needs, taxes, economic outlook, etc.

In practice, advisors may recommend a portfolio with a markedly different risk number than the client's risk number as provided by the risk questionnaire. For example, some clients may express a far greater level of risk tolerance than they need, and just because a client can tolerate higher risk doesn't necessarily mean they should do so.

## PORTFOLIOS

## Evaluating Each Investment Individually

As a matter of principle, Riskalyze evaluates each investment choice in a portfolio individually, on its own merits. We do not, as a general rule, assume that one security will operate like another simply because they both belong to the same asset class.

For mutual funds, ETFs and stocks that are publicly traded on US markets, we have data feeds that transmit end-of-day data for each applicable security into our data center. We also work with some asset manager partners to secure data for non-traded actively managed funds or other investment choices.

Because each investment choice is evaluated individually, we must build a return and volatility scenario for each of those choices. You can view the calculated scenario for return and volatility by clicking on and expanding the view of any individual symbol in a Riskalyze portfolio.

The process that we use to build that return and volatility scenario is as follows:

- If the investment choice is publicly traded, we use the raw securities data combined with a data model (as described below) to generate the scenario.
- If the investment choice is not publicly traded, we utilize submitted data from an asset management partner, if available.
- Otherwise, the advisor establishes the return and volatility scenario by specifying a best case / worst case return expectation over the next six months.
- In addition, if the advisor disagrees with the scenario generated by a data model or asset management partner, the advisor can override it with their own custom scenario.

All of the factors used in the creation of return and volatility scenarios, including the existence of any custom scenario established by the advisor, are disclosed on printed reports that advisors may choose to share with clients.

### Data Model: Long Term

For publicly traded securities, our default data model is called “Long Term” and is used by the vast majority of our advisors, who are uninterested in trying to guess what the market will do in the short term, and trust that the market will continue to follow its long term pattern.

There are three components to the model — returns, volatility and correlations.

For returns, we use a long-term slice of market data to model returns — approximately 30 years of return history. We assume that the S&P 500 index will continue to follow that pattern, and we use beta to calculate return assumptions for each security in a portfolio. This approach ensures that we aren't in the business of trying to predict what short term returns will be.

We use return data without dividends to normalize the return scenario for the long term, and then add back in trailing twelve month dividends afterward. This avoids the “washing out” of dividend effects for low beta, high dividend securities.

For volatility and correlations, we believe the value of recency is much greater. We use price action from January 1, 2008 to present to assess those variables for each security.

We chose that timeframe for three reasons: (1) most of the funds popular with advisors have that much data, and many don't have more than that; (2) it's a very diverse timeframe, with the 2008 market crash, 2011 sideways market and 2012-13 bull markets; (3) our backtesting and real world testing has proven to us that weighting recent volatility and correlation data is more robust than the alternatives.

The results speak for themselves. Of the \$2 billion in portfolios built on our platform in 2012 using this data model, the results were far greater than 95% — less than 1.6% of the portfolios broke below projected risk. While there were numerous times that portfolios experienced turbulence throughout the year (e.g. AAPL and GLD-heavy portfolios in the fall), those portfolios were down but largely within range.

We should note that, while we believe in the strength of this long term data model, our core technology is technically data model-agnostic. Any advisor can choose one of our alternative models, or use their own stock market scenario instead (see below). We also allow enterprise partners to substitute their own data models if they prefer an alternative approach to modeling past data.

### **Data Model: Alternatives to Long Term**

For publicly traded securities, you can choose one of three possible alternatives for calculating the return and volatility scenario for each investment choice.

The two short term models use beta for the last six months or twelve months of market history, respectively, to calculate return and correlations. We continue to use January 1, 2008 to present to assess volatility, as we believe that length of time is required for accuracy.

The advisor can also base all of the return and volatility scenarios on a six month scenario for the S&P 500 index. When such a scenario is created, we use historical beta for every holding in the portfolio for January 1, 2008 to Present.

### **Data Model: Dealing with “Young” Symbols**

Riskalyze doesn't allow advisors to add publicly traded securities to a portfolio if they have less than three months of available data. In the case of these “young” symbols, advisors can create a Custom Investment with their own best case / worst case return expectation.

For publicly traded funds with less than five years of data, our preferred methodology when working with partners is to capture the underlying holdings of a fund, and use the actual holdings to develop the return and volatility scenario using the applicable data model. (This approach only works where >80% of the holdings are not also “young” symbols.)

If the “underlying holdings” approach is not applicable, we may constrain the level of anti-correlation that an investment choice offers, to avoid the lack of historical data artificially putting that investment choice in too positive of a light.

## **Submitted Data from Asset Managers of Non-Traded Funds**

Riskalyze partners with some asset management firms who manage non-traded funds, allowing them to submit data about the performance of their funds into the Riskalyze platform. There are two approaches that these partners can use.

Asset managers can choose to submit actual historical performance data, which does not reflect fees or expenses, for the history of their fund. They are typically required to provide a minimum of monthly data points, which allow Riskalyze to calculate return, volatility and correlations for the overall portfolio modeling engine to use.

Asset managers can also choose to track their current underlying holdings. Riskalyze will effectively create a fund-of-funds rollup of the weighted return, volatility and correlations for all of the current holdings, and apply that to the portfolio analysis of the fund as a whole.

## **Overriding Return and Volatility with a Custom Scenario**

For any investment choices where the return and volatility scenario is generated by a data model or by submitted data from the asset manager, the advisor can view and override the return and volatility numbers in any of their portfolios by creating a custom scenario.

A custom scenario can be entered either as a best case / worst case scenario over the next six months, or as a return and volatility scenario over the next six months. Entering either of those inputs will calculate and display the other one.

Custom scenarios are noted in the disclosures on any printed client reports.

## **Custom Investments (Bonds, SMAs, Annuities, REITs, IPO Stocks)**

When Riskalyze has no data with which to evaluate an investment, such as non-traded alternatives like bonds, SMAs, annuities, REITs or IPO stocks, advisors create a Custom Investment.

Creating a custom investment will require a name, a best case / worst case scenario over the next six months, and the selection of a similar asset class for correlation purposes.

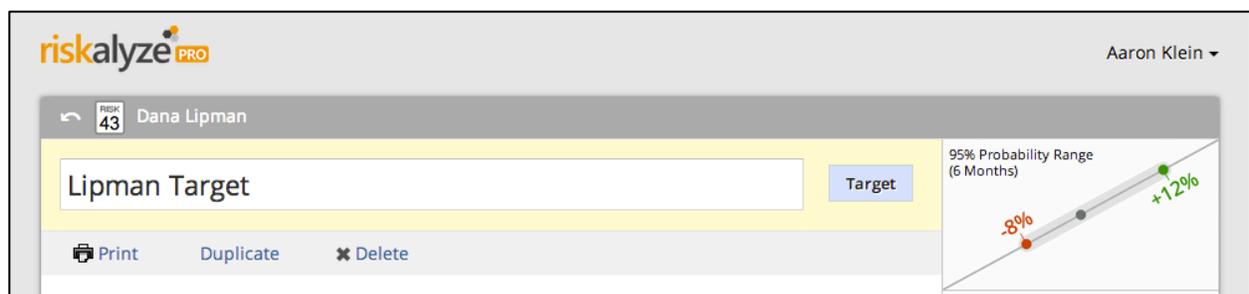
Riskalyze has developed specific recommendations for how to create the best case / worst case scenario for each type of alternative investment on our Knowledge Base. An overview of these recommendations is here: <http://kb.riskalyze.com/post/52767673476/using-alternative-investments-in-a-riskalyze-portfolio>

In many cases, such as bonds and SMAs, advisors can use historical data to reflect the risk and return in those alternatives. In other cases, such as REITs and annuities, advisors will need to determine if they want to include early withdrawal penalties in the calculation.

Ultimately, we recommend advisors not overthink the scenario, but develop a basis for both the best case and worst case numbers used in a custom investment. These investment choices will be noted as involving a custom scenario developed by the advisor in the disclosures on a printed portfolio.

## Calculating the Portfolio Risk Number and Probability Range

For every portfolio in Riskalyze, we calculate a Six Month Probability Range — a range of results that those allocations have a 95% mathematical probability of ending up within six months from today.



Of course, we care far more about capturing the impacts of downside risk in a portfolio. It's our belief that clients looking at the probability range see it as a "95% chance of staying above the downside risk." After all, no client has ever fired an advisor for breaking above the upside potential of a portfolio. Our guiding philosophy is "when in doubt, err on exaggerating the downside potential."

The Probability Range itself does not reinvent the wheel — it's simply a beautiful and understandable way to communicate standard deviation, and the best guidance we've seen from FINRA emphasizes that we are to value understandability over detail. Our choices in analytics and metrics are guided by that.

In using standard deviation to calculate the Probability Range, Riskalyze utilizes the return, volatility and correlation for each individual investment choice, which is arrived at as documented above (data models, submitted data and custom scenarios created by advisors).

The resulting returns and covariance matrix produce a combined return and volatility for the portfolio as a whole. This brings diversification impacts into account, raising and lowering the risk contribution of the various portfolio holdings based on the correlations from the data model.

We then take the return and volatility scenario for the entire portfolio, and we use Value at Risk with a normal distribution (1.64 sigmas) to determine the range which represents a 5% chance of breaking below projected risk.

From the Probability Range, we calculate the Risk Number for the portfolio. Here are a few examples of the relationship between downside risk and Risk Number:

- Downside of -2%: Low 20s
- Downside of -5%: Low 30s
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## Risk/Reward Heatmap

There are several analytical tools on the portfolio screen, but one of the most popular is the Risk/Reward Heatmap. The heatmap is a visual representation of the risk and reward that each individual investment choice is contributing to the portfolio, in the context of the portfolio as a whole.



Green is potential reward, red is risk and yellow is the amount of the risk that is being offset through the benefits of diversification. This allows advisors to accomplish two things: (a) visually see which securities have the most non-diversified risk, which provide the fastest way to drive down the risk in a portfolio; and (b) understand the relative risk of each investment choice, if the advisor is nervous that changing correlations may reduce the level of actual diversification that exists.

The green, red and yellow bars are reflecting the data calculated from the covariance matrix as described above, where we calculate a combined return and volatility scenario for each individual security in the context of the portfolio as a whole. That means that all of the underlying variables — data model, submitted data, custom scenarios and diversification — are reflected in the analytic.

## **Interest Rate Stress Test**

Many advisors are concerned about the unique circumstances of the bond markets in late 2012 and early 2013. Extremely low interest rates, combined with the effects of US Federal Reserve policies over the last few years, have created an unusual long-running bull market in bonds that few advisors expect will continue.

Stress testing a portfolio for changes in interest rates provides an important way to understand if a portfolio is susceptible to significant risk when the bond market outlook changes.

When the interest rate stress test is turned on, the advisor selects a relative change in interest rates to model, and can control which of the investment choices are included in the stress test. (By default, Riskalyze includes any funds which include the words “bond” or “fixed income” in the name.)

For the funds included in the stress test, Riskalyze will use the last six months of historical data to correlate the sensitivity of each fund with that period’s movements in the 10 Year Treasury Index (^TNX).

## **Conclusion**

We hope you’ve enjoyed this summary of the math behind Riskalyze — the inputs and methodology we use to empower advisors to align portfolio risk with client risk tolerance.

If you have additional questions, please don’t hesitate to let us know at [support@riskalyze.com](mailto:support@riskalyze.com). We’re here to help.