How Standard Deviation Works

by David Harrell

Last week, we discussed some of the various risks that investors face. Starting this week, we'll take an in-depth look at some of the ways that investment risk can be quantified. We'll start with one of the most popular methods—standard deviation.

Standard deviation is probably used more than any other measure to describe the risk of a security (or portfolio of securities). If you read an academic study on investment performance, chances are that standard deviation will be used to gauge risk. It's not just a financial tool, though. Standard deviation is one of the most commonly used statistical tools in the sciences and social sciences. It provides a precise measure of the amount of variation in any group of numbers—the returns of a mutual fund, rainfall in Costa Rica, or the weight of professional football players—that make up an average. If you're math-phobic, the equation may seem foreboding, but it's really not that bad.

\[
\text{Standard Deviation} = \sqrt{\frac{\sum_{i=1}^{n} (x_i - \bar{x})^2}{n}}
\]

Introducing the Smiths and the Joneses

To understand how standard deviation is calculated, let's work through a couple of very basic examples. We'll use two families, the Smiths and the Joneses. Both families have three children, and for both families, the average age of the children is 10. However, the range of the children's ages is quite different for the two families. The Smiths have an eight year old daughter, a 10 year old son, and a 12 year old daughter. The Joneses have a one-year old son, a nine year old daughter, and a 20-year-old son. Both sets of children have the same average age, but we can use standard deviation to measure the variance around that mean, or average.

To calculate standard deviation, we first find the average of the children. We then subtract each child's age from the average age. Then, we square the resulting number. (By squaring the numbers, we eliminate any negative numbers from the equation.) For the Smith family, we end up with:

\[
\text{Average Age} = \frac{8 + 10 + 12}{3} = 10
\]

\[
(10 - 8)^2 = 4 \\
(10 - 10)^2 = 0 \\
(10 - 12)^2 = 4
\]
We then add these numbers together, divide by the total number of children, and take the square root of the whole thing:

$$\text{Standard Deviation} = \sqrt{\frac{4+0+4}{3}} = 1.63$$

Same Average
Greater Deviation

As it turns out, the standard deviation of the ages of the children in the Smith family is relatively low, 1.63. We would have expected such a result, given that the three Smith children were all quite close to the age of 10. However, for the Jones children, we would expect a higher standard deviation, given the greater range in their ages:

$$\text{Average Age} = \frac{10+9+20}{3} = 10$$

$$(10-1)^2 = 81$$

$$(10-9)^2 = 1$$

$$(10-20)^2 = 100$$

The standard deviation for the age of the Jones children is 7.79.

$$\text{Standard Deviation} = \sqrt{\frac{81+1+100}{3}} = 7.79$$

To take our example to the extreme, let's add a third family--the Browns. Mr. and Mrs. Brown are the proud parents of ten-year old triplets. We don't need to calculate the standard deviation of the triplets' age to know that it is zero, because there is no deviation at all from the average age of 10.

Standard Deviation for Mutual Funds

When used to measure the volatility of the performance of a security or a portfolio of securities, standard deviation is generally calculated for monthly returns over a specific time period--frequently 36 months. And, because most people think about returns on an annual, not monthly, basis, the resulting number is then modified to produce an annualized standard deviation. The standard deviation that is shown on Morningstar.com Quicktake pages is an annualized standard deviation based on a fund's performance over the past 36 months.

Technically speaking, standard deviation provides a quantification of the variance of the returns of the security, not its risk. So why is it so commonly used as a risk measure? After all, a fund with a high standard deviation of returns is not necessarily "riskier" than one with a low standard deviation of returns. Just as the Brown triplets had a standard deviation of zero, a mutual fund that lost 1% each and every month would also have a standard deviation of zero. A fund that alternately gained 5% or 25% each month would have a much higher standard deviation, but it would surely be a preferable investment.

As it turns out, while it's mathematically possible to have a high standard deviation of returns while exhibiting no downside risk, in the real world, the larger the swings in a security's return the more likely it is to dip into negative territory. Though standard deviation measures volatility on both the upside and the downside, it's a good proxy for measuring the risk of loss with any security. Mutual fund examples bear this out. The range of standard deviations for ultra-short term bond funds is a mere 0.14 to 1.32, with an average 0.67. The standard deviations for precious metals funds range from 17.58 to 37.23, with an average of 25.74.

One of the strengths of standard deviation is that is can be used across the
board for any type of portfolio, with any type of security. The calculation is the same for a portfolio of bonds as it is for a portfolio of growth stocks as it is for a portfolio of real estate (if you can get frequent price quotes on it).

Standard deviation does, however, have a drawback—it's not necessarily intuitive. A standard deviation of 7 is obviously higher than one of 5, but an investor contemplating such a fund doesn't have a reference point. Because standard deviation is not a "relative" measure, it may not make much sense unless you compare a fund's standard deviation to that of similar funds.