

Alpha, beta, R-Squared, Standard Deviation, and Sharpe Ratio are components of Modern Portfolio Theory (MPT). These statistical measures are based on past performance. Although past performance is not a guarantee of future result, the historical data at least gives you a sense of what to be expected in the future.

This article provides a brief overview of the five measures. In addition, the article describes how to use these statistical measures to evaluate a fund or an ETF in your portfolio.

## Alpha and Beta

Alpha and beta are risk and return measures of the investment. Alpha represents the unsystematic risk while beta is used to measure systematic risk. In broader terms, the total risk is the combination of unsystematic risk and systematic Risk.

### Alpha — Unsystematic Risk

Unsystematic risk is specific to the company and/or the specific industry. Following are examples of unsystematic risks:

- Company specific financial risk: i.e., a company taking on too much debt, increasing debt-to-equity ratio
- Sale and/or profit deterioration due to competition or change in consumer behavior or government policy
- Issues with company specific labor force or supply chain
- Poor management decisions leading to business risk for a specific company

### Beta — Systematic Risk

Systematic risk typically affects the entire market or entire segment of the market. Following are examples of systematic risks:

- **Inflation risk** or deflation risk affecting purchasing power
- Interest rate changes affecting the market

- Market risk resulting in volatility and uncertainty (Example: 2008 financial crisis, March 2020 Pandemic)
- Geopolitical Risk
- Trading Policy Changes

So the combination of unsystematic risk (alpha) and systematic risk (beta) gives you perspective of the total risk of an investment.

Now let's dig in.

### Alpha $\alpha$

Alpha is one of the statistical measures in Modern Portfolio Theory (MPT).

Simply put, alpha is the difference between the actual return of an investment over its expected return based on its beta. In other words, alpha is used to measure the performance of an investment on a risk adjusted basis.

The base alpha score is "zero" meaning investment return matched return of the benchmark index. So in general,

- If  $\alpha = 0$ , investment return is in line with the return of the benchmark index
- If  $\alpha = +$  number, investment is outperforming the benchmark index
- If  $\alpha = -$  number, investment is underperforming the benchmark index

For example, if a fund returns 10% and its benchmark index return 8%, the fund's alpha score is +2. Conversely, if a fund returns 7% and its benchmark index return 8%, the fund's alpha score is -1.

The goal of the active fund managers and hedge fund managers is to "seek" the alpha. In other words, active managers expect to outperform the benchmark index. Hence, the "value" added by the fund manager.

However, it is a challenge to consistently outperform the market over a long period of time. According to this **CNBC article**, almost 92% of

active managers underperform S&P 500 over a 15 years period.

#### % of large-cap funds that underperformed S&P 500



Source: S&P Dow Jones Indices - Get the data - Created with Datawrapper

## Beta ( $\beta$ )

Beta is another statistical measure in Modern Portfolio Theory (MPT).

It represents systematic risk. It is the measure of the sensitivity of an investment relative to the benchmark index. In other words, beta is a measure of volatility relative to the benchmark index.

The beta of the benchmark index is 1.0. So in general,

- If  $\beta = 1$ , investment moves in tandem with the benchmark index
- If  $\beta < 1$ , investment is less volatile than the benchmark index
- If  $\beta > 1$ , investment is more volatile than the benchmark index

Let's look at some examples of Beta. You can get beta of a stock from [morningstart.com](http://morningstart.com) or [finance.yahoo.com](http://finance.yahoo.com).

Wells Fargo (WFC):

- WFC's beta is 1.06, meaning Wells Fargo's stock is 6% more volatile than the S&P 500 Index. So if the S&P 500 rises 10%, WFC is expected to rise 10.6%. Conversely, if the S&P Index drops 10%, WFC is expected to fall 10.6%.

Johnson and Johnson (JNJ)

- Johnson's and Johnson's beta is 0.69, meaning JNJ is less volatile than the S&P 500 Index. So if the S&P 500 index rises 10%, JNJ is expected to rise 6.9%. Conversely, if the S&P 500 Index drops 10%, JNJ is expected to fall 6.9%.

Similarly, you can find the beta for mutual funds.

Vanguard Total Stock Market Index Fund (VTSAX)

- VTSAX beta is 1.04, meaning VTSAX is 4% more volatile than the S&P 500 Index. Hence, it would closely track the performance of the benchmark index.

Vanguard Small Cap Index Fund (VSMAX)

- VSMAX beta is 1.21, meaning VSMAX is 21% more volatile than the S&P 500 Index.

## Smart Beta

You may have heard the term "smart beta". Smart beta combines the principle of active and passive investing approach based on certain rules. One of the rules is to use an equal-weighted approach instead of a market-cap-weighted approach.

S&P 500 is a market-cap-weighted index meaning the weight of each stock in the S&P 500 index is solely based on its market cap. Hence, a company with a larger market cap will have the larger weight in the index. Since technology stocks have performed better in recent years, it represents 25% in S&P 500. An equal-weight approach would reduce technology exposure and increase weight to the undervalued stocks potentially resulting in over performance.

## Caution with Alpha and Beta

Firstly, alpha and beta are based on past performance. As you know past performance is not a guarantee for future results.

Secondly, alpha and beta are appropriate statistical measures when it is calculated against relevant benchmarks. For example, the "S&P 500 TR (Total Return)" is the calculation benchmark for most US stock funds. While "MSCI ACWI ex USA" is the calculation benchmark for international stock Funds. And "Bloomberg Barclays US Aggregate Bond" is the calculation benchmark for the US bond funds.

Thirdly, in general, beta is not a reliable measure of an investment when it is far off from the base value of 1.0.

Fourth, alpha is a performance of an investment on a risk adjusted basis (dependent on beta). So

if the value of beta is not reliable, then the value of alpha is not reliable either.

## Making Sense of $\alpha$ and $\beta$

How do we use alpha and beta in analyzing our investments?

Let's look at a hypothetical portfolio of the following funds.

- US Total Market Index Fund – Fund 1
- Small Cap Index Fund – Fund 2
- Total International Market Fund – Fund 3
- Total Bond Market Index Fund – Fund 4

The following table lists funds' alpha and beta over the last 10-year period. You can get the fund specific values from Morningstar.com under "risk" tab.

Fund	Alpha	Beta
Fund 1	-0.87	1.04
Fund 2	-4.63	1.21
Fund 3	0.22	1.00
Fund 4	-0.14	1.03

Keep in mind that the base value of alpha and beta for the benchmark index is 0 and 1.0, respectively.

What does alpha and beta of each fund mean to us as an investor?

### Observation 1:

- Fund 1 is the Total US Stock Market Index Fund with a negative alpha, indicating underperformance compared to its relevant benchmark, S&P 500. You would expect the fund's alpha to be close to zero, matching the return of S&P 500.
- What could be the reasons for the fund's underperformance if it closely follows the S&P 500 Index?
  - Is the underperformance due to higher fund fees?
  - Is the fund risk level higher relative to its benchmark?

**Consideration 1:** Should you swap fund 1 with another total stock market index fund with alpha 0 and beta 1.0?

### Observation 2:

- In comparison to Fund 1 (beta = 1.04), fund 2 is a much more volatile fund (beta = 1.21).
- So fund 2 needs to generate higher than the benchmark return to produce positive alpha. However it is not the case here as Fund 2 alpha is negative.
- Fund 2 (alpha = -4.63) has been underperforming the market over the last 10 years.

**Consideration 2:** Should you abandon a small cap index fund? This is a discussion for another post.

### Observation 3:

Fund 3 Total International Market Fund closely follows its relevant benchmark index; marginal over performance (alpha +0.22) and the same volatility (beta 1.00).

### Observation 4:

Fund 4 Total Bond Market Index Fund closely follows its relevant benchmark index; marginal underperformance (alpha -0.14) and the slightly higher volatility (beta 1.03).

## Summary

Investors can enhance the return of the portfolio by "seeking" alpha. However per CNBC.com article, a very few (less than 8%) of active managers outperform the market over the last 15 years. If you decide to "seek" alpha, pay attention to the fees, review the active manager's track record, and check your **appetite for taking risk**.

Besides alpha and beta other three common indicators of investment risk are R-Squared, Sharpe ratio and standard deviation.

## Standard Deviation

Standard deviation (SD) is one of the most common measures to gauge volatility of a mutual fund or an Exchange Traded Fund (ETF). You may be familiar with a “bell curve” from your statistics class, which is a graphical representation of a normal distribution of the data. Assuming the data follows a normal distribution pattern, 50% of the data would be less than mean and the other 50% greater than the mean. Then Standard deviation is a statistical measure of how spread out the data is from its mean. In general,

- 68% of values falls within + / - 1 SD of the mean
- 95% of values falls within + / - 2 SD of the mean
- 99.7% of values falls within + / - 3 SD of mean

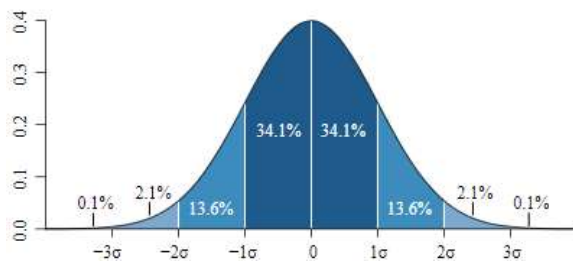


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In terms of a mutual fund or an ETF's return, Standard Deviation measures how widely fund's or ETF's return are spread out from its average return over a period of time. So it is an indicator of volatility based on past performance. Although past performance is not a guarantee of future result, the historical data on volatility at least gives you a sense of volatility to be expected in the future.

The higher SD value indicates more volatility and lower SD value indicates lower volatility. In other words, the fund with widely varied returns would have higher standard deviation than the fund with narrow return range.

## Standard Deviation Stock Fund

Let's look at a couple of examples.

The standard deviation of Vanguard Total Stock Market Index Fund (VTSAX) is 18.43 based on 3-year data per morningstar.com. The average return (mean) of VTSAX is 11.74 (3-year). So now let's calculate the range based on the mean (average return) and standard deviation.

-/+ **1** Standard Deviation (SD) from Mean

- -1 SD =  $(11.74) - 1*(18.74) = -6.69$
- +1 SD =  $(11.74) + 1*(18.74) = 30.17$

-/+ **2** Standard Deviation (SD) from Mean

- -2 SD =  $(11.74) - 2*(18.74) = -25.12$
- +2 SD =  $(11.74) + 2*(18.74) = 48.60$

-/+ **3** Standard Deviation (SD) from Mean

- -3 SD =  $(11.74) - 3*(18.74) = -43.55$
- +3 SD =  $(11.74) + 3*(18.74) = 67.03$

What does this tell you about the fund's future returns?

- 68% of the time return is expected between -6.69 and 30.17, within +/- 1 SD of the mean
- 95% of the time return is expected between -25.12 and 48.60, within +/- 2 SD of the mean
- 99.7% of the time return is expected between -43.55 and 67.03; within +/- 3 SD of the mean

So you would expect Vanguard Total Stock Market Index Fund to return between -25.12% to 48.60% almost all the time (95% of the time). If you compare VTSAX annual return from 2001 to 2019, 18 out of 19 times the return is between -25.12% and 48.60%. That is 94.7% of the time VTSAX annual return is within +/- 2-standard deviation of the mean!

## Standard Deviation Bond Fund

Now let's look at one of the bond funds. The standard deviation of Vanguard Total Bond Market Index Fund (VBTLX) is 3.44 based on 3-year data per morningstar.com. The average return of VBTLX is 5.34 (3-year). So what does this tell you about the fund's future returns?

- 68% of the time return is expected between 1.9 and 8.78, within +/- 1 SD of the mean
- 95% of the time return is expected between -1.54 and 12.22, within +/- 2 SD of the mean
- 99.7% of the time return is expected between -4.98 and 15.66; within +/- 3 SD of the mean

In comparison with Vanguard Total Stock Market Index Fund (VTSAX), the bond fund VBTLX is a lot less volatile with SD of 3.44 vs. VTSAX with SD of 18.43. At the same time, as expected, the upside and downside for the stock fund (VTSAX) is significantly higher than that of the bond fund (VBTLX).

## Caution with Standard Deviation

Standard deviation is not a measure of risk, rather it is the measure of volatility. For example, Fund A with following return over the past five years -12%, -5%, -10%, -15%, and -1% has the same SD (5.0) as Fund B with +12%, +5%, +1%, +15%, and +1% return. The fund or ETF's SD would increase with both above average return and below average return. In other words, the fund with consistent positive performance appears to be as volatile as the fund with consistent negative performance.

The other drawback of standard deviation measure is that it is not a relative measure. Meaning fund's SD is not compared to its relative benchmark or a similar fund in the same category. So the Fund's SD is more meaningful when comparing it with a benchmark or a similar fund in the same category.

Again, let's use Vanguard Total Stock Market Index Fund (VTSAX) as an example. Based on 3-years data, VTSAX standard deviation is 18.43 while the standard deviation of the fund's relative benchmark is 18.19. This indicates that the fund's volatility is similar to that of its benchmark.

## Sharpe Ratio

The Sharpe Ratio was developed by William Sharpe, Noble Laureate Professor of Finance at Stanford University.

Here is the mathematical formula for Sharpe Ratio.

$$\frac{\text{Return of Investment} - \text{Risk Free Return}^*}{\text{Standard Deviation of the Investment}}$$

\*Risk-Free Return: i.e., 90-days US Treasury

Mathematically, higher investment return (in numerator) and/or less volatility (standard deviation in denominator) would generate higher Sharpe Ratio.

In other words, Sharpe Ratio measures risk-adjusted return of an investment. The higher the Sharpe Ratio, the better the investment's risk-adjusted performance.

## Making Sense of Sharpe Ratio

Sharpe Ratio is useful when comparing two funds or ETFs. For example, if you are comparing two funds with similar return, which one is a better investment considering risk and return?

Following is the comparison of Sharpe Ratio between two large blend funds: Vanguard Dividend Appreciation Index Fund (VDADX) and Strategic Advisers Core Fund (FCSAX).

- Vanguard Dividend Appreciation Index Fund (VDADX): 0.76
- Strategic Advisers Core Fund (FCSAX): 0.61
- Category (Large Blend ): 0.52
- Benchmark Index: 0.65

Although the Sharpe Ratio for both funds, VDADX and FCSAX, are higher than the large blend category, VDADX has better risk-adjusted performance than FCSAX. Because VDADX Sharpe Ratio is higher than FCSAX.

## Caution with Sharpe Ratio

We know that higher Sharpe Ratio is better but Sharpe Ratio number by itself is meaningless. For example, Fund A with a Sharpe Ratio of 1.3 seems high but by itself does not tell you whether it is a good investment or bad investment. You have to compare the Sharpe Ratio with a similar

fund and/or benchmark to make sense of the fund's risk-adjusted return.

## R-Squared

R-Squared is another statistical measure of Modern Portfolio Theory (MPT). It indicates investment's similarity to its relevant benchmark. The value of R-Squared is between 1 and 100 where R-Squared of 100 indicates a fund or ETF moving in lockstep with the benchmark.

In general, the statistical measures such as alpha and beta are meaningless unless the R-Squared value of the investment is 75 or higher against the index.

## Risk and Return: Putting All Together

Let's use Vanguard Total Stock Market Index Fund (VTSAX) risk and volatility measures to make sense of risk and return of the fund. Following is the snapshot of the fund's risk and volatility measures over the last 10-years period from morningstar.com.

Trailing	Fund	Category	Index
<b>Alpha</b>	-0.63	-1.66	-0.22
<b>Beta</b>	1.04	1.01	1.02
<b>R-Squared</b>	99.35	95.12	99.77
<b>Sharpe Ratio</b>	0.95	0.86	0.98
<b>Standard Deviation</b>	13.76	13.74	13.54

**Alpha (-0.63):** The negative alpha indicates under performance compared to its benchmark index. However, the fund is performing better than the category as the category alpha is -1.66 compared with fund's alpha of -0.63.

**Beta (1.04):** Since the beta value is close to 1.0 it indicates that the fund moves in tandem with the benchmark index.

**R-Square (99.35):** Since R-Squared is close to 100, indicating the fund's movement is in lockstep

with its benchmark index. Hence, alpha and beta of this fund are meaningful measurements.

**Sharpe Ratio (0.95):** The higher Sharpe Ratio of the fund compared to its category (0.86) indicates that the fund's risk-adjusted performance is better than the category over the last ten-years period.

**Standard Deviation (13.76):** The fund's volatility is similar to that of the category with SD of 13.74 and the index with SD of 13.54.

In nutshell, you would expect VTSAX to generate above average risk-adjusted return compared to its category based on historical measures.

## Risk and Return: Fund vs. Fund Comparison

Following is the comparison of two funds in the large blend category: Vanguard Total Stock Market Index Fund (VTSAX) and Nuveen Large Cap Select A Fund (FLRAX).

Measures	VTSAX	FLRAX
<b>Alpha</b>	-0.63	-2.58
<b>Beta</b>	1.04	1.11
<b>R-Squared</b>	99.35	93.67
<b>Sharpe Ratio</b>	0.95	0.79
<b>Standard Deviation</b>	13.76	15.22

## Observations

Following is the comparison of two funds in the large blend category

- VTSAX has an advantage with less underperformance compared with FLRAX.
- FLRAX is more volatile compared with the benchmark index.
- VTSAX movement more closely resembles the movement of the benchmark index.
- VTSAX is less volatile compared with FLRAX.

- VTSAX has higher risk-adjusted return compared with FLRAX.

So between VTSAX and FLRAX, VTSAX is better performing fund with higher risk-adjusted return based on last 10-years data.

## Conclusion

In conclusion, all these statistical measures are based on the past performance. Nobody can predict funds volatility and its performance in the future with certainty. However, past performance at least provides some indication of what to expect in the future. So use the statistical measures as a rough guide in evaluating funds and ETFs.

Average investor like you and I cannot control the systematic risk (beta) but we can manage unsystematic risk (alpha) with diversification. Investing in a broadly diversified index fund is one of the ways to manage unsystematic risk.

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