Volatility Metrics for Mutual Funds

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INTRODUCTION

Many 401(k) participants face a sizeable number of funds from which to choose. The average plan offers 20 funds, and one in eight plans provides more than 25 funds.[1] With so many choices, investors may have difficulty allocating their plan assets.

Professional investors often explicitly or implicitly claim to understand the fundamentals of finance theory. They may, for example, base allocation decisions on historical returns, volatility, correlations of returns across funds or asset classes, investment fees, industry outlooks, or various other financial metrics. Most 401(k) participants do not have access to much of that information or are poorly equipped to benefit from it. They may be guided by recent historical returns, which are typically readily available and understood, even if incorrectly so. Funds with higher returns understandably appear more attractive to investors. However, the finance literature suggests that funds with higher returns also tend to exhibit more risk, or volatility, so that future returns may differ substantially from historical ones. It is typically assumed by economists that individual investors are risk-averse, so that a high-return, high-volatility fund is not necessarily preferred over a low-return, low-volatility fund. In fact, much financial theory is based on the idea that the efficient set of investments to hold should provide both the highest return for a given level of volatility and the lowest volatility for a given level of return. The average 401(k) participant could thus benefit from insights into both the returns of fund options and their volatility.

This report discusses a number of volatility metrics that are commonly used in the finance literature, in the financial press, on investment websites, or in fund disclosure materials. We identify a subset of metrics that are relatively easy to understand and that can help 401(k) participants gain insights into the volatility of funds in their plans' investment menus. We explore the extent to which alternative metrics convey consistent information by comparing the metrics across an illustrative set of funds. Finally, we conclude that the volatility rank order of funds is similar for multiple risk metrics of a particular type, so that 401(k) participants may benefit as much from an intuitive, easy-to-understand metric as from more complex metrics.

Definitions

The rate of return on an asset is the relative change in market value of that asset over a period of time. For example, the 2008 rate of return on a particular mutual fund is the percentage increase in the price per fund share from the beginning to the end of 2008.

Mutual fund prices tend to change daily. The greater the price fluctuations of a fund, the greater its volatility, or risk. (This report uses the terms "risk" and "volatility" interchangeably.) Volatility is the degree of fluctuation in returns, and volatility metrics are measures of dispersion of short-term returns. Volatility metrics are typically based on one-day returns, but one of the metrics discussed below is based on monthly returns.

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[1] *401(k) Benchmarking Survey, 2009 Edition*. Deloitte Consulting LLP, International Foundation of Employee Benefit Plans, and International Society of Certified Employee Benefit Specialists. http://www.deloitte.com/assets/Dcom-UnitedStates/Local%20Assets/Documents/us_consulting_401(k)AnnualBenchmarkingSurvey2009_081409.pdf

COMMONLY-USED VOLATILITY METRICS

Our review of fund prospectuses and other materials shows that mutual fund companies provide numerous volatility metrics. However, no one particular metric is used on a consistent basis. The metrics we encountered may be divided into absolute and relative metrics. Absolute metrics may be calculated directly from daily prices (or returns) of an asset; relative metrics involve a comparison to the volatility of an asset class or a market index. Table 1 provides examples of these metrics.

Table 1. Examples of Absolute and Relative Volatility Metrics

Absolute Metrics	Relative Metrics
• Best/Worst Historic Returns • Annualized Standard Deviation of Daily Returns (or of Monthly Returns) • Number of Trading Days with Price Change in Excess of 1 percent (or 2, 3 percent) • Financial Engines Fund Risk • Vanguard Risk Level • Sharpe Ratio	• Bear Market Decile Rank • Lipper Preservation Rating • Lipper Consistent Return Rating • Morningstar Risk Rating • Beta • R-squared

Absolute Volatility Metrics

Absolute risk metrics are directly based on daily (or other short-term) price changes of the fund or asset. Some are quite intuitive. For example, over the past 10 years, a fund may have gained as much as 40 percent during a single quarter and lost as much as 55 percent during a single quarter. Its best/worst historic returns, +40/-55 percent, indicate that it was more volatile than a fund with best/worst historic returns of, say, +10/-8 percent. Similarly, the price of a fund may have increased or decreased by more than 1 percent on 60 trading days last year, which indicates greater volatility than that of a fund with 20 days of price fluctuations in excess of 1 percent. Other metrics, such as the annualized standard deviation of daily returns, are perhaps less intuitive, and yet others, such as the Vanguard Risk Level, are proprietary and more difficult to interpret in a precise manner.

Below, we will discuss the absolute risk metrics of Table 1 in more detail.

Relative Volatility Metrics

The second set of metrics measure an asset's volatility relative to that of an asset class or index. For example, the Bear Market Decile Rank ranks a fund according to its relative performance during months in which the market generally moved downward among a large number of funds, and converts that ranking into a decile.[2]

[2] More precisely, from the Morningstar website at http://quicktake.morningstar.com/DataDefs/ETFRatingsAndRisk.html: The Bear Market Decile Rank "enables investors to gauge a fund's performance during a bear market. For stock funds, a bear market is defined as all months in the past five years that the S&P 500 lost more than 3%; for bond funds, it's all months in the past five years in which the Lehman Brothers Aggregate Bond index lost more than 1%. We add together a fund's performance during each bear market month over the past five years to reach a cumulative bear-

The comparison group differs for equity and bond funds. Similarly, the Lipper Preservation Rating, the Lipper Consistent Return Rating, and the Morningstar Risk Rating measure a fund's volatility relative to a peer group. These metrics thus segregate funds into specific categories and compare risk relative to funds in the same category. This approach could assign a low-risk ranking to a fund that is not so volatile as its peer funds, but still quite volatile when compared to, say, stable-value funds. While such metrics may be useful to sophisticated investors, they have the potential to misinform investors with a limited understanding of the volatility associated with specific asset categories.

A similar issue arises with metrics such as R-Square and Beta that involve a comparison to a specific index. For example, R-Square measures how closely the price of a fund tracks an index such as the S&P 500 index. It may be a useful gauge to evaluate how well the fund's manager accomplishes his goal of tracking a certain index. However, a high R-Square in itself conveys no information on the volatility of a fund. The Beta of a stock represents the idiosyncratic risk of the stock compared to the reference group. An interpretation of the Beta is the additional risk above the reference group that a given investment exposes the investor to.[3] Index-based volatility metrics thus have the potential to misinform investors who do not understand their context.

In conclusion, while relative volatility metrics may hold valuable information for sophisticated investors, they may be misinterpreted by the average 401(k) participant. Moreover, the method behind the metrics is often complex and proprietary, which makes the interpretation less tractable. We therefore restrict the remainder of this report to absolute volatility metrics.

ABSOLUTE VOLATILITY METRICS: AN ANALYSIS

This section defines several absolute volatility metrics and compares them across a set of funds and other securities.

Fund Basket

To illustrate risk metrics, we selected a basket of mutual funds and other assets. Our selection is not meant to be representative of all funds in 401(k) plans. With a few exceptions, we selected funds with at least 10 years of historical information from among a variety of asset categories. See Table 2 for a list of the funds and other assets.

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market return. Based on these returns, equity funds are compared against other equity funds and bond funds are compared against other bond funds. They are then assigned a decile ranking where the 10% of funds with the worst performance receive a ranking of 10, and the 10% of funds with the best performance receive a ranking of 1. Because Morningstar employs the trailing five-year time period for this statistic, only funds with five years of history are given a bear market decile ranking."

[3] E.g., Edwin Elton, Martin Gruber, Stephen Brown, and William Goetzmann. 2007. *Modern Portfolio Theory and Investment Analysis.* John Wiley & Sons, Inc.

Table 2. Illustrative Funds and Assets

Asset Category	Ticker	Style	Fund/Company Name
Large Cap	VTSMX	Large Blend	Vanguard Total Stock Mkt Idx
	AIVSX	Large Blend	American Funds Invmt Co of Amer A
	VFINX	Large Blend	Vanguard 500 Index Investor
	AGTHX	Large Growth	American Funds Growth Fund of Amer A
	FDGRX	Large Growth	Fidelity Growth Company
Mid Cap	RPMGX	Mid-Cap Growth	T. Rowe Price Mid-Cap Growth
	VIMSX	Mid-Cap Blend	Vanguard Mid Capitalization Index
Small Cap	NAESX	Small Blend	Vanguard Small Cap Index
	OTCFX	Small Blend	T. Rowe Price Small-Cap Stock
	DFSVX	Small Value	DFA US Small Cap Value I
International	CWGIX	World Stock	American Funds Capital World G/I A
	ANWPX	World Stock	American Funds New Perspective A
	FDIVX	Large Growth	Fidelity Diversified International
	AEPGX	Large Blend	American Funds EuroPacific Gr A
Bond	PTTRX	Interm Bond	PIMCO Total Return Instl
	VFIIX	Interm Gov't	Vanguard GNMA
	FKTIX	Muni Nat'l Long	Franklin Federal Tax-Free Income A
	VFSTX	Short Bond	Vanguard Short-Term Investment-Grade
	ABNDX	Interm Bond	American Funds Bond Fund of Amer A
	AHITX	High Yield Bond	American Funds American Hi Inc Tr A
	VWITX	Muni Interm	Vanguard Interm-Term Tx-Ex
	TPINX	World Bond	Templeton Global Bond A
Lifestyle, Lifecycle	VGSTX	Moderate	Vanguard STAR
	FFFCX	Target 2010	Fidelity Freedom 2010
	VTXVX	Target 2015	Vanguard Target Retirement 2015
	FFFDX	Target 2020	Fidelity Freedom 2020
	VTTVX	Target 2025	Vanguard Target Retirement 2025
	FFFEX	Target 2030	Fidelity Freedom 2030
Real Estate	DFREX	Real Estate	DFA Real Estate Securities I
	VGSIX	Real Estate	Vanguard REIT Index
Companies	GE		General Electric Co
	KO		Coca-Cola Co
	PG		Procter & Gamble Co
	DD		E I du Pont de Nemours and Co
	IBM		International Business Machines Corp

Best/Worst Historic Quarterly Returns

Figure 1 shows the best and worst quarterly returns during the past 10 years (Quarter 1 of 2000 through Quarter 3 of 2009) of the assets in our illustrative selection. As may be expected, small cap funds exhibit larger gains and larger losses than large cap funds. Bonds, especially short- and intermediate-term bonds, were generally less volatile than stocks, except for the high-yield bonds ("junk bonds") fund in our selection (AHITX), which exhibited volatility that was comparable to that of large cap equity funds. Lifecycle funds with target dates farther into the future (VTTVX and FFFEX) were more volatile than those with nearer horizons (FFFCX and VTXVX). Real estate funds and individual companies' stocks were more volatile than other assets in our selection.

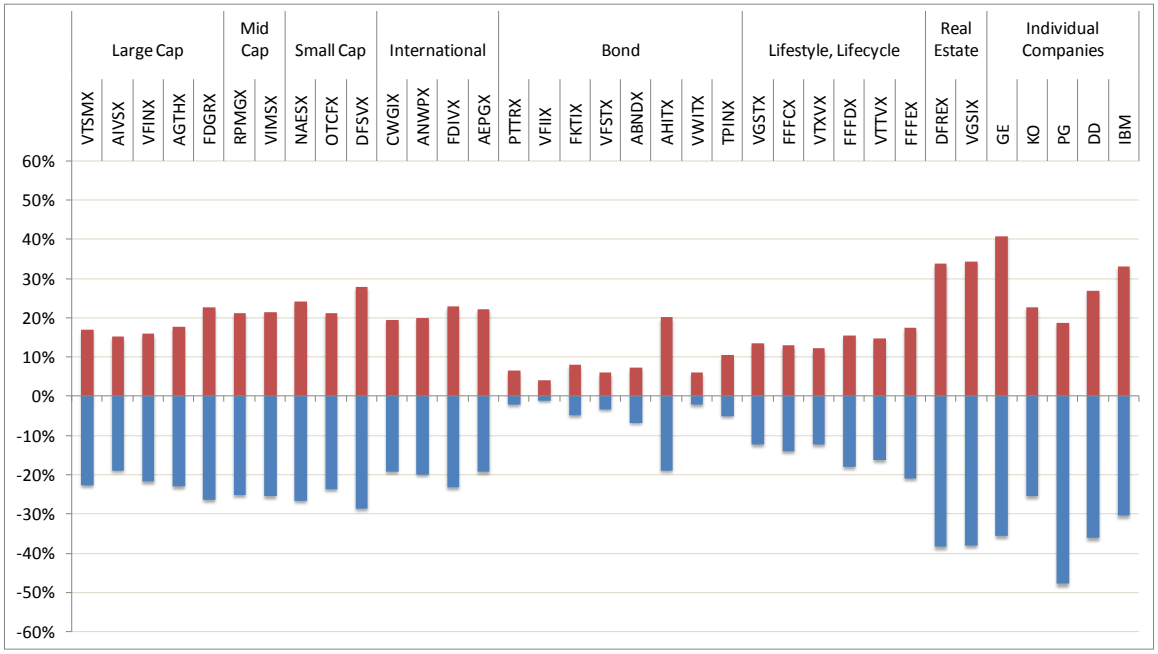

Figure 1. Best/Worst Historical Quarterly Returns (2000.Q1-2009.Q3)

Standard Deviation of Daily Returns

The academic finance literature widely refers to the annualized standard deviation of daily returns, defined as:[4]

$$s = \sqrt{N \sum_{t=1}^{T} \frac{(r_t - \bar{r})^2}{T-1}},$$

where r_t is the rate of return on trading day *t*, *T* is the number of trading days in the period over which the metric is calculated, $\bar{r}$ is the average daily return over that period, and *N* is the number of trading days in a year. If the standard deviation is calculated over a one-year period, *T* and *N* are about 252 and equal to one another.

While the annualized standard deviation of daily returns is widely used in the academic literature, it may not be intuitive to many 401(k) investors. Perhaps for that reason, it is not commonly found in fund prospectuses. One of its advantages is that it may be calculated over relatively short durations, so that it is available even for funds with a short history. In contrast, the best/worst historical return metric defined above is less informative for funds with few historical quarters.

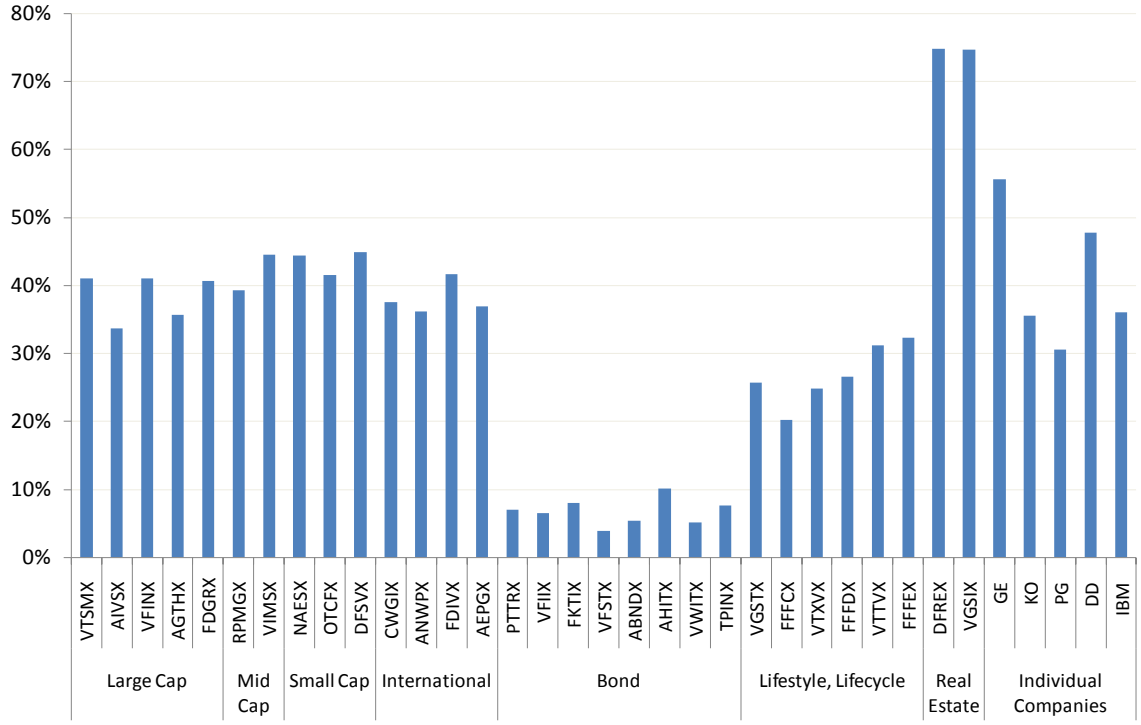

Figure 2. Annualized Standard Deviation of Daily Returns in 2008

Figure 2 shows the annualized standard deviations of daily returns for 2008. The year 2008 was a particularly volatile year, especially for real estate funds. In cross-section, however, the qualitative pattern of relative volatility across asset categories shown in Figure 2 generally holds

Below we compare various volatility metrics discussed here.

[4] E.g., Edwin Elton, Martin Gruber, Stephen Brown, and William Goetzmann. 2007. *Modern Portfolio Theory and Investment Analysis.* John Wiley & Sons, Inc.

Standard Deviation of Monthly Returns

An alternative volatility metric is the annualized standard deviation of monthly returns. See Figure 3.

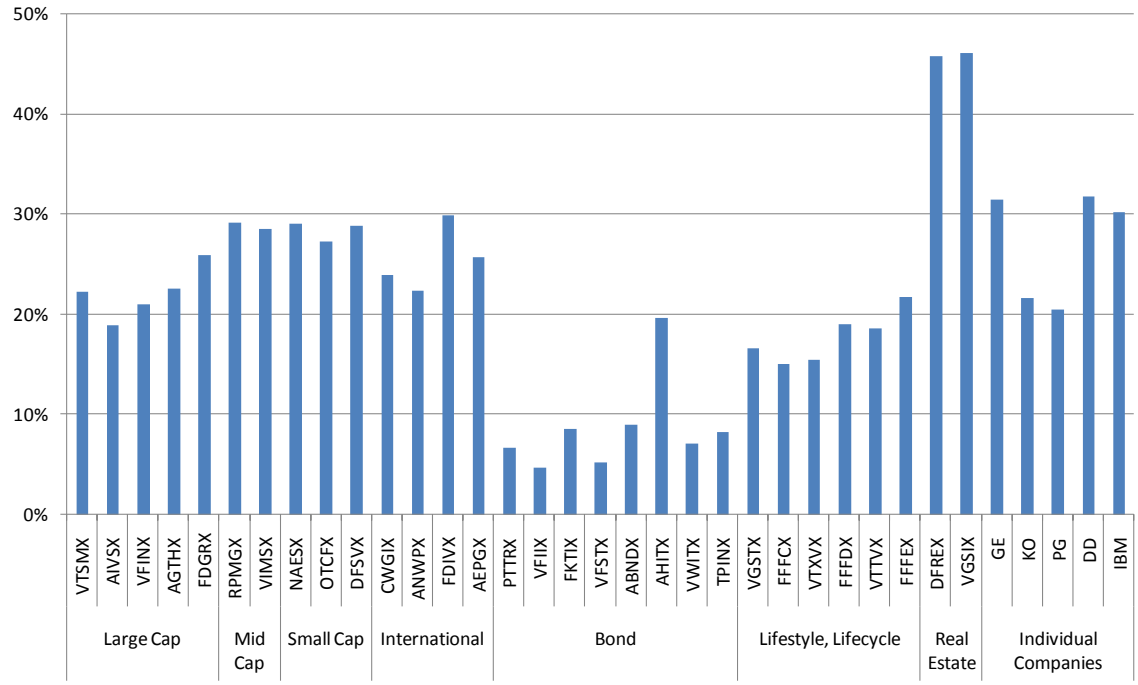

Figure 3. Annualized Standard Deviation of Monthly Returns in 2008

With the exception of AHITX, a high-yield bond fund, the cross-sectional pattern of standard deviations based on daily and monthly returns are qualitatively similar. The magnitude of the monthly metric is lower because intra-month price fluctuations do not enter the calculations.

Number of Trading Days with Price Changes in Excess of 1 Percent

A fourth volatility metric is the number of trading days during a year on which the price of an asset increased or decreased by more than 1 percent; see Figure 4 for the number of days during 2008. Similar metrics are sometimes calculated based on price changes in excess of 2 or 3 percent. An advantage of these metrics over standard deviations is that they be readily understood.

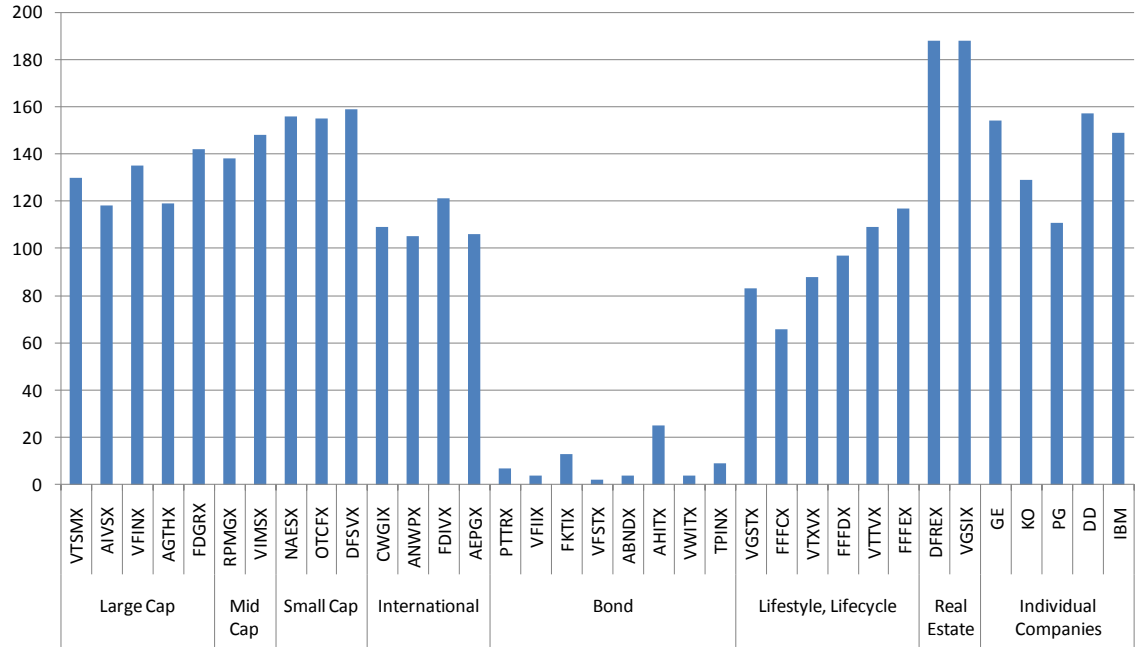

Figure 4. Number of Trading Days during 2008 with Price Changes in Excess of 1 Percent

Other Absolute Volatility Metrics

Institutions such as Vanguard and Financial Engines, Inc. also publish metrics that measure risk levels for funds. Such proprietary metrics often use simple 5-point scales that facilitate comparisons across funds. The table below, taken from Vanguard's website, shows a description of how Vanguard assigns funds into classes of conservative, moderate, or aggressive.

Table 3. Category Descriptions of Vanguard Risk Levels

Vanguard funds can be categorized in risk levels from 1 to 5. Knowing the risk level you're comfortable with, and the length of time you expect to invest, can help you select an appropriate fund for your investing needs.

Conservative funds—Risk level 1	Vanguard funds are classified as conservative if their share prices are expected to remain stable or to fluctuate only slightly. Such funds may be appropriate for the short-term reserves portion of a long-term investment portfolio, or for investors with short-term investment horizons (three years or less).
Conservative to moderate funds—Risk level 2	Vanguard funds classified as conservative to moderate are subject to low-to-moderate fluctuations in share prices. In general, such funds may be appropriate for investors with medium-term investment horizons (four to ten years).
Moderate funds—Risk level 3	Vanguard funds classified as moderate are subject to a moderate degree of fluctuation in share prices. In general, such funds may be appropriate for investors who have a relatively long investment horizon (more than five years).
Moderate to aggressive funds—Risk level 4	Vanguard funds of this type are broadly diversified but are subject to wide fluctuations in share price because they hold virtually all of their assets in common stocks. These funds may be appropriate for investors who have a long-term investment horizon (ten years or longer).
Aggressive funds—Risk level 5	Vanguard funds classified as aggressive are subject to extremely wide fluctuations in share price. These funds may be appropriate for investors who have a long-term investment horizon (ten years or longer). The unusually high volatility associated with these funds may stem from a number of strategies.

Source: The Vanguard Group, Inc.

Financial Engines, Inc. publishes a volatility metric scaled such that 1.0 corresponds to overall market risk. Market risk is defined as the amount of volatility in a hypothetical portfolio that includes all the cash, bonds, and stocks in the same proportion as held by U.S. investors. The table below, taken from Financial Engines' website, shows examples of risk numbers for common asset types.

Table 4. Definitions of Financial Engines Risk Metric Values

Money market risk (0.2)	The risk of an investment in short term U.S. Government securities such as Treasury bills
Long-term bond risk (0.7)	The risk of an investment which tracks the Lehman Brothers Long-term Government Bond Index
Market risk (1.0)	The risk of an investment which tracks the return of a hypothetical portfolio that includes all the cash, bonds, and stocks in the same proportion as held by U.S. investors
S&P 500 risk (1.5)	The risk of an investment which tracks the S&P 500 Index
Small cap index risk (1.8)	The risk of an investment which tracks the S&P SmallCap 600/Citigroup Index (an index of smaller stocks)
Typical large cap stock risk (3.0)	The risk of an investment in a typical single large cap stock
Typical small cap stock risk (4.0)	The risk of an investment in a typical single small cap stock

Risk-Adjusted Returns: The Sharpe ratio

We argued in the introduction above that investors could benefit from insights into both the returns of fund options and their volatility. This invites the question whether a single, combined return/risk metric could provide a similar level of information as two separate return and risk metrics. The literature offers several risk-adjusted return metrics. William Sharpe proposed a widely-used ratio, the "reward-to-variability ratio", now better known as the Sharpe ratio.[5] The ratio is defined as $(R - R_f)/\sigma$, where *R* is the rate of return of the asset, R_f is the rate of return on a risk-free asset, and σ is the standard deviation of daily returns.

We calculated annual 2000-2008 Sharpe ratios for several funds. Across funds, bond funds exhibit high Sharpe ratios,because of their relatively low volatility. We also found that for many funds the Sharpe ratios vary substantially more from year to year than the volatility metrics discussed above. Much of the variation of Sharpe ratios stems from variation in unadjusted returns, rather than from variation in the risk-free rate or in the standard deviation of daily returns.

[5] Sharpe, W. F. (1966). "Mutual Fund Performance." *Journal of Business* 39 (S1): 119–138. For a revised version see Sharpe, W. F. (1994). "The Sharpe Ratio." *Journal of Portfolio Management* 21 (1): 49–58.

We tentatively conclude that the risk-adjusted return, at least as measured by the Sharpe ratio, conveys useful information, but that it may be more difficult to interpret than returns and volatility separately.

Absolute Volatility Metrics Compared

In Table 5 we compare the absolute risk metrics discussed above. Since the scale of the various metrics differs, we applied a color-coding scheme that mathematically assigns green to the lowest values within a metric, yellow to the median, and red to the highest values, with mixed shades in between. The resulting "heat map" indicates that the various metrics are generally consistent in their relative rankings, except for the Vanguard Risk Levels. (Vanguard publishes Vanguard Risk Levels for its own funds only.) In other words, if one were to use volatility metrics discussed here to rank-order funds by volatility, approximately similar rankings would result from any of the metrics, except for the Vanguard Risk Levels.

Table 5. A Heat Map of Absolute Volatility Metrics

		Quarterly Best + Worst Return	Standard Deviation (daily)	Standard Deviation (monthly)	Trading Days with change >1%	Vanguard Risk Levels	Financial Engines Investment Risk
Large Cap	VTSMX	39.7%	41.0%	22.3%	130	4	1.83
	AIVSX	34.3%	33.7%	18.9%	118		1.51
	VFINX	37.9%	41.0%	21.0%	135	4	1.80
	AGTHX	40.8%	35.7%	22.6%	119		1.93
	FDGRX	49.1%	40.6%	25.9%	142		2.27
Mid Cap	RPMGX	46.6%	39.2%	29.2%	138		2.05
	VIMSX	47.2%	44.5%	28.6%	148	5	1.99
Small Cap	NAESX	50.8%	44.4%	29.1%	156	5	2.18
	OTCFX	44.9%	41.6%	27.3%	155		1.95
	DFSVX	56.7%	44.9%	28.9%	159		2.11
International	CWGIX	38.8%	37.5%	23.9%	109		1.58
	ANWPX	40.0%	36.2%	22.4%	105		1.66
	FDIVX	46.2%	41.6%	29.9%	121		1.82
	AEPGX	41.7%	36.9%	25.7%	106		1.70
Bond	PTTRX	8.7%	7.1%	6.7%	7		0.63
	VFIIX	5.1%	6.5%	4.7%	4	2	0.64
	FKTIX	13.0%	8.0%	8.5%	13		0.76
	VFSTX	9.3%	4.0%	5.3%	2	1	0.43
	ABNDX	14.2%	5.4%	9.0%	4		0.64
	AHITX	39.1%	10.1%	19.7%	25		1.18
	VWITX	8.4%	5.1%	7.2%	4	2	0.73
	TPINX	15.5%	7.6%	8.2%	9		0.92
Lifestyle, Lifecycle	VGSTX	26.0%	25.7%	16.6%	83	3	1.19
	FFFCX	27.1%	20.2%	15.1%	66		1.14
	VTXVX	24.7%	24.8%	15.4%	88	3	1.22
	FFFDX	33.7%	26.6%	19.0%	97		1.35
	VTTVX	31.3%	31.3%	18.6%	109	3	1.43
	FFFEX	38.5%	32.4%	21.8%	117		1.50
Real Estate	DFREX	72.4%	74.7%	45.8%	188		2.62
	VGSIX	72.6%	74.7%	46.1%	188	4	2.65
Individual Companies	GE	76.7%	55.6%	31.5%	154		2.71
	KO	48.4%	35.6%	21.6%	129		2.47
	PG	66.8%	30.6%	20.5%	111		2.81
	DD	63.3%	47.8%	31.8%	157		3.07
	IBM	63.8%	36.1%	30.3%	149		3.94

Low Volatility High Volatility

SUMMARY AND CONCLUSION

This paper presents various risk or volatility metrics that are commonly reported in fund prospectuses, on investor websites, in the financial press, or in the finance literature. We distinguish absolute and relative volatility metrics and conclude that relative metrics can be misleading to investors who lack sufficient understanding of the comparison that is implicit in relative metrics. We then quantify absolute metrics for an illustrative selection of funds and individual company stocks.

We conclude that the rank order of funds is similar for most, but not all, absolute risk metrics. In particular, a casual investor is likely to draw similar conclusions about the volatility rank order of funds in his investment menu whether he uses the best/worst historical return, the standard deviation of daily returns, the standard deviation of monthly returns, the number of trading days with price changes in excess of 1 percent, or the Financial Engines Fund Risk metric.

Given the absence of clear superiority of any single metric, relatively minor advantages and disadvantages may draw distinctions among them.

- An availability argument can be made against the best/worst historical return metric, because it may not be available for relatively new funds.
- A consistency argument can be made for the standard deviation of daily returns, since it would serve both casual investors and sophisticated investors, who may gravitate toward this measure because of its prominence in the finance literature.
- A simplicity argument can be made for the number of trading days with price changes in excess of 1 percent, because it is intuitive and easy to understand.

In short, we narrowed the field of commonly-used volatility metrics down to five, none of which being clearly superior to the others. All five metrics discussed here appear to hold merit for educating 401(k) participants about the volatility rank order of their fund options.

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