Executive summary. Stock market volatility is the fluctuation in price of broad stock market indexes over a defined period. However, different measures of this volatility exist, each with important nuances. This brief is intended to serve as a primer to help in the understanding of these stock market volatility measures.
Introduction

As with other ways to measure risk, an accurate measurement of historical stock market volatility is critical for effective investing. Volatility is an important factor in the comparison of risk and reward between stocks and other asset classes. This comparison helps to determine the appropriate strategic asset allocation for an investor, given his objectives and risk tolerance. It is necessary to understand and measure volatility effectively, keeping in mind possible behavioral biases.

The popular measure of market volatility is what is reported by the evening news, the radio business report, or the Internet news headline: the absolute point change in an index such as the Dow Jones Industrial Average (DJIA), as in, “The Dow was down over 100 points today.” However, a direct comparison of volatility from one period to another should be made using percentage changes in the level of the index, not absolute changes. The absolute change in an index tends to make an event look more volatile than it actually is (Schwert, 1997). This is because round number milestones, like 100 points, tend to stick in people’s memories long after they have lost relevance as a percentage of the index level. Since the index generally rises over time, a similar point change becomes smaller and smaller as a percentage change, as shown in Figure 1.

Review of popular stock market volatility measures

When people associated with the investment industry talk about stock market volatility, often they are referring to the standard deviation of a stock market index’s returns. Figure 2 shows a chart of the annualized standard deviation of the S&P 500 Index and DJIA using rolling periods of 21 trading days (approximately one month).

A drawback to using the standard deviation of returns is that it assumes that stock market returns are normally distributed. As shown by the large spike in Figure 2, this is not the case. This large spike represents volatility data after the October 19, 1987, stock market crash, when both indexes fell by over 20% in one day. The drop would have been a 20+ standard deviation event, which would have had virtually zero probability of occurring in a normal distribution.

In addition, standard deviation can reflect only an index’s historical volatility. To gain any knowledge about future volatility, an investor has to make the assumption that future volatility is represented by the distribution of historical volatility results. One way to avoid this assumption is to allow investors to tell us what their expectations are for volatility in the future. The Chicago Board Options Exchange (CBOE) Volatility Index (VIX) does this.

Notes on risk: Past performance is not a guarantee of future returns. The performance of an index is not an exact representation of any particular investment, as you cannot invest directly in an index.

1 For a review of other types of risk measures, see Ambrosio (2007).
2 Index returns may or may not include dividends: When comparing price volatility, exclude dividends; when putting volatility into a total return or portfolio context, include dividends. For the purposes of this paper, all volatility references will be to price volatility. Standard deviation is a measure of return dispersion around the mean return.
The VIX, often referred to as the “investor fear gauge,” provides a 30-day forward look at expected stock market volatility using options on the S&P 500 Index. It uses a weighted average of the prices of out-of-the-money calls and puts. The VIX was introduced in 1993 and first used S&P 100 Index options, but on September 22, 2003, it was modified to use S&P 500 Index options. Figure 3 shows a chart of the VIX using daily data starting in January 1990.

On March 26, 2004, futures contracts were established for the VIX, which marked the first time that volatility could be traded directly on an exchange. Tradability is necessary to capitalize on investors’ perceptions of future volatility. Additionally, options were established on the VIX on February 24, 2006.

3 “Out-of-the-money” refers to options having no positive intrinsic value. For a call option, it is an option to buy the index at a price that is higher than the current index price. For a put option, it is an option to sell the index at a price that is lower than the current index price.

4 When the change to S&P 500 Index options was made in 2003, historical data under the “VIX” ticker symbol were calculated back to January 1990. The original volatility data based on the S&P 100 Index options are still available under the symbol “VXO.”
Another way to look at stock market volatility

While the VIX provides a look at market expectations for overall volatility, it does not specifically separate downside volatility out of its calculation. Neither does standard deviation, which, as mentioned above, does not consider investors’ expectations and assumes a normal distribution of returns. Although standard deviation and the VIX are calculated in different ways, there are some similarities between them. To show the similarities, Figure 4 charts the historical VIX Index against the standard deviation of the percentage changes of the S&P 500 Index. Over the period in which data were available for both measures (January 1990 through December 2008), the correlation of the VIX and standard deviation is 0.88.

In an effort to neutralize some of the disadvantages of using the VIX or standard deviation, investors can use another potential proxy for stock market volatility, the “percentage of days of volatility.” The percentage of days of volatility is a measurement of the percentage of days in a period when an index level goes up or down a certain percentage or more.

Figure 5 shows a comparison of the VIX Index and the percentage of days that the S&P 500 Index and DJIA dropped or rose 1% or more during 21-trading-day rolling periods. The percentage of days of volatility measure has a 0.81 correlation to the VIX and a 0.86 correlation to the standard deviation for the S&P 500 Index, as indicated in Figure 6, which shows that all three measures have similar directional movements. Figure 7, on page 6, shows a summary of the historical data for the percentage of days of volatility measure.

There are advantages to using the percentage of days of volatility measure over standard deviation or the VIX. First, although it uses historical information instead of expectations of volatility, it does not assume that the data are normally distributed. This measurement summarizes the actual percentage changes in an index, instead of providing an estimate of the distribution based on the mean and variance.
Second, downside and upside volatility can be shown separately by displaying the proportion of falling days in a period separately from the percentage of increasing days, as shown in Figure 7. This would be similar to a “risk of loss” calculation. More emphasis tends to be placed upon negative returns than positive returns because investors fear a loss more than they celebrate a gain. A volatility measure should be able to distinguish between positive and negative volatility in order to take risk aversion into account. For example, Figure 8, on page 6, shows only the percentage of days that the S&P 500 Index and DJIA dropped 1% or more from January 1970 through December 2008.

When comparing the charts, it appears that many high-volatility periods have a similar frequency of downside volatility (Figure 8) but a different frequency of total volatility (Figure 5). This means that many of the more memorably volatile periods (1974, 1987, 2000–2002) are set apart from other high-volatility periods by their additional upside volatility.

**Figure 5. Percentage of days of up and down volatility in the S&P 500 Index and DJIA, daily data from January 1970 through December 2008, and VIX Index level, daily data from January 1990 through December 2008**

![Graph showing percentage of days with up or down volatility for the S&P 500 and DJIA, with VIX index level as well.](image)

Sources: Vanguard, Standard and Poor’s, Dow Jones, and CBOE.

**Figure 6. Correlation table: S&P 500 volatility measures, from January 1990 through December 2008**

<table>
<thead>
<tr>
<th>Volatility measure</th>
<th>Percentage of days up or down 1% or more</th>
<th>Annualized standard deviation</th>
<th>Average VIX level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percentage of days up or down 1% or more</td>
<td>1.00</td>
<td>0.86</td>
<td>0.81</td>
</tr>
<tr>
<td>Annualized standard deviation</td>
<td>1.00</td>
<td></td>
<td>0.88</td>
</tr>
<tr>
<td>Average VIX level</td>
<td></td>
<td></td>
<td>1.00</td>
</tr>
</tbody>
</table>

Sources: Vanguard, Standard and Poor’s, and CBOE.
A third advantage to using the percentage of days of volatility measure is that different extremes of volatility can be tested separately. This cannot be done with VIX, since it is a single index that summarizes total volatility. Measuring extremes of standard deviation could result in the observation of “three-standard-deviation events,” which requires the assumption of a normal distribution. The percentage of days of volatility method does not assume that these extreme tails are uniform. For example, Figure 9 shows a chart of the percentage of days that the S&P 500 Index and DJIA dropped or rose 3% or more during the same time frame.

One disadvantage of the percentage of days of volatility measure is that it does not directly compare the differences in magnitude of the index’s percentage changes during different periods. In Figure 9, while the 1987 crash represents the tallest bar on the chart, it does not show up as an extremely different event from the 2002 bear market. In Figure 1, it is clear from the standard deviation that an extreme event occurred in 1987.

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**Figure 7. Percentage of days of volatility data for S&P 500 Index and DJIA, from January 1970 through December 2008**

<table>
<thead>
<tr>
<th>Percentage of days of volatility measures</th>
<th>S&amp;P 500 Index</th>
<th>DJIA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percentage of days up 3% or more</td>
<td>0.76%</td>
<td>0.84%</td>
</tr>
<tr>
<td>Percentage of days up 2% or more</td>
<td>2.65</td>
<td>2.92</td>
</tr>
<tr>
<td>Percentage of days up 1% or more</td>
<td>12.24</td>
<td>12.97</td>
</tr>
<tr>
<td>Percentage of days up</td>
<td>52.49</td>
<td>51.87</td>
</tr>
<tr>
<td>Percentage of days down 47.51%</td>
<td>48.13%</td>
<td></td>
</tr>
<tr>
<td>Percentage of days down 1% or more</td>
<td>11.46</td>
<td>11.67</td>
</tr>
<tr>
<td>Percentage of days down 2% or more</td>
<td>2.45</td>
<td>2.46</td>
</tr>
<tr>
<td>Percentage of days down 3% or more</td>
<td>0.66</td>
<td>0.66</td>
</tr>
<tr>
<td>Percentage of days up or down 3% or more</td>
<td>1.42%</td>
<td>1.50%</td>
</tr>
<tr>
<td>Percentage of days up or down 2% or more</td>
<td>5.10</td>
<td>5.37</td>
</tr>
<tr>
<td>Percentage of days up or down 1% or more</td>
<td>23.70</td>
<td>24.64</td>
</tr>
</tbody>
</table>

Sources: Vanguard, Standard and Poor’s, and Dow Jones.
Conclusion

Risk occurs to some degree in all investment markets, and volatility is one reflection of this risk. Contrary to popular opinion, volatility should not be feared; it should be recognized as a necessary part of the risk and reward relationship. A reasonable amount of volatility in an investment is the trade-off for higher long-term return expectations. Investors should not alter their asset allocation plan in response to short-term changes in volatility, but should review the reasonable long-term expectations for volatility when creating their strategic asset allocation.

References


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