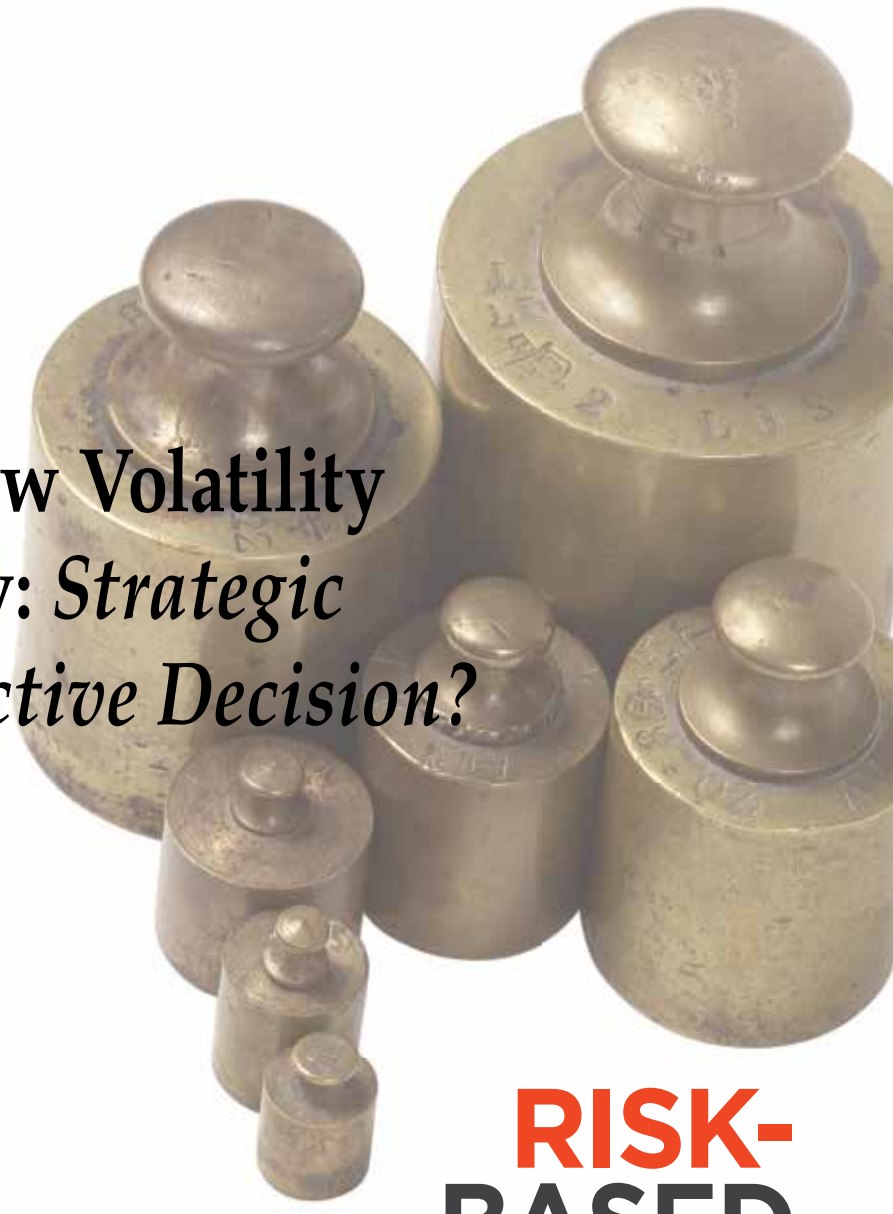
THE JOURNAL OF

INVESTING

THEORY & PRACTICE FOR FUND MANAGERS

FALL 2013 Volume 22 Number 3



Pursuing the Low Volatility Equity Anomaly: *Strategic Allocation or Active Decision?*

ERIK KNUTZEN

RISK-BASED PORTFOLIOS

special section

IIJ Institutional Investor Journals

The Voices *of* Influence | iijournals.com

Pursuing the Low Volatility Equity Anomaly: *Strategic Allocation or Active Decision?*

Erik Knutzen

Erik Knutzen
is the chief investment officer at NEPC LLC in Cambridge, MA.
eknutzen@nepc.com

In the past several years, asset managers have built investment strategies based on historical evidence that lower volatility stocks earn superior risk-adjusted returns. These approaches are being called low volatility, managed volatility, minimum variance, or similar names. They seek to exploit what has been identified in studies by academics and practitioners alike as an equity pricing anomaly. This anomaly joins previously identified persistent stock market inefficiencies associated with low price-to-book and smaller company shares.

This article evaluates the low volatility anomaly, its potential causes, whether it is likely to persist, and the role, if any, of low volatility equity investing in long-term investment programs.

Based on historical information, we conclude that the low volatility equity anomaly appears to exist and can be explained by certain behavioral and structural biases of investors. But its continued existence into the future is less certain. We also observe that even well-documented anomalies experience multi-year periods of outperformance and underperformance relative to broad market benchmarks such as the Standard & Poor's 500 Index. These episodes of relative under- and overvaluation appear to be driven by market fundamentals and investor behavior.

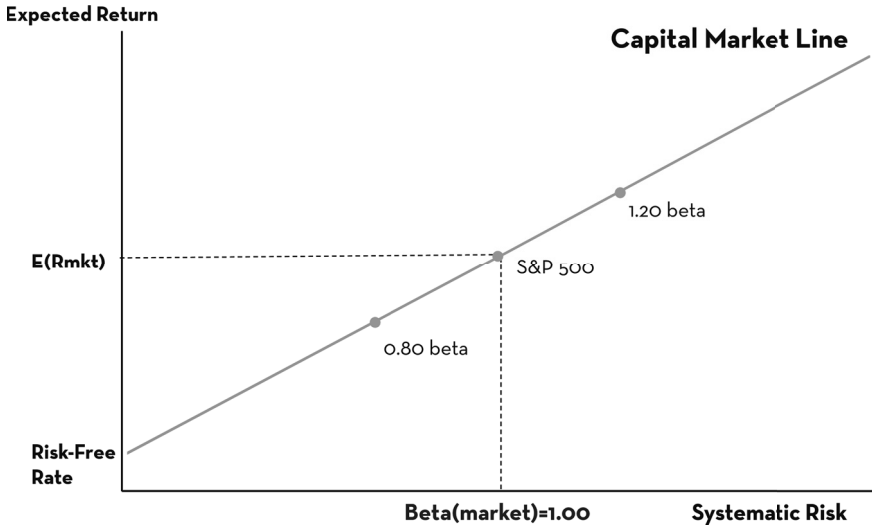
Therefore, we believe that any effort to capture a particular anomaly should be viewed as an active decision, requiring a valuation framework to assess entry and exit points. In fact, we do not recommend attempting to capture single anomalies through long-term strategic allocations. Furthermore, given the strong performance of low volatility stocks over recent time periods, now may be an inopportune time to make such an allocation to this new category.

LOW VOLATILITY STOCKS: PERFORMANCE

According to capital market theory, as investors move away from risk-free assets they expect to be compensated with higher returns in the long term. This relationship between risk and return is described by an upward sloping capital market line (Exhibit 1).

For a diversified equity portfolio, capital market theory indicates a relationship between the portfolio's sensitivity to the broad market benchmark and expected return. This sensitivity is quantified in the beta of the portfolio. A broad market benchmark, such as the S&P 500, which represents large-company U.S. stocks, has a beta of 1.00. A diversified portfolio constructed of aggressive growth stocks might have a beta of 1.20, while a similarly well-diversified

EXHIBIT 1
Theoretical Capital Market Line



Source: NEPC, LLC.

portfolio of more conservative stocks might have a beta of 0.80. While beta and volatility are not equivalent, they measure similar risk relationships. In general, it is expected that lower-beta stocks will exhibit lower volatility than the benchmark and, conversely, a portfolio of higher-volatility stocks will exhibit higher beta than the benchmark.

That said, the behavior of lower and higher volatility stocks has not always appeared consistent with the capital market line. To understand this, academic and practitioner researchers have sorted stocks into volatility groups and built hypothetical portfolios of low volatility and high volatility stocks. More recently, index providers have created benchmarks of lower volatility stocks and built historical performance records;[1] one such benchmark is Standard & Poor's Low Volatility Equity Index. Comparisons over a series of historical periods between this benchmark and the broader S&P 500 Index show lower volatility stocks outperforming over many time periods with lower risk as measured by standard deviation of returns (Exhibits 2 and 3).

These studies indicate that there is an inconsistency between the realized and predicted relationship between risk and return, pointing to the presence of a historic low volatility equity return anomaly. In order to evaluate whether this anomaly is here to stay, we examine its potential causes.

LOW VOLATILITY ANOMALY: POTENTIAL EXPLANATIONS

As we evaluate a possible anomaly, it is important to identify why security prices diverge from fair value, and also to identify why such mis-valuation is not arbitraged away. To explain the historically observed low volatility anomaly, a number of explanations related to investors' structural biases or behavioral preferences have been put forward. As we describe these potential causes of the anomaly (and there may be others), we note that they are in many ways connected. The picture that emerges is one of related potential behavioral and structural drivers of the anomaly. We also distinguish between potential causes of mispricing and why this mispricing is not arbitraged away.

Lottery Preference

Investment managers can choose higher risk–reward exposures relative to their benchmarks by buying higher beta stocks. High beta stocks are more volatile, so there are significant opportunities for excess returns, including the potential for extreme outperformance. Owning higher beta stocks relative to a benchmark, all things being equal, ought to lead to higher returns before taking risk into consideration. This can also be

EXHIBIT 2
Low Volatility Index Annual Performance

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
S&P Low Volatility Index	9.3%	10.9%	-2.6%	38.2%	17.5%	30.4%	8.1%	-7.8%	25.0%	4.4%	-7.2%	22.8%	17.7%	2.2%	19.7%	0.6%	-21.4%	19.2%	13.4%	14.8%	10.3%
S&P 500 Index	7.6%	10.1%	1.3%	37.6%	23.0%	33.4%	28.6%	21.0%	-9.1%	-11.9%	-22.1%	28.7%	10.9%	4.9%	15.8%	5.5%	-37.0%	26.5%	15.1%	2.1%	16.0%
Excess Return (+/-)	1.7%	0.8%	-3.9%	0.6%	-5.5%	-3.0%	-20.5%	-28.8%	34.1%	16.3%	14.9%	-5.9%	6.8%	-2.7%	3.9%	-4.9%	15.6%	-7.3%	-1.7%	12.7%	-5.7%

Source: eVestment Alliance.

EXHIBIT 3
Low Volatility Index Risk and Return (annualized returns, periods ending 12/31/2012)

	5 - Year				*10 - Year*				*1992-2012*			
	Return	Beta	Std. Dev.	Sharpe Ratio	Return	Beta	Std. Dev.	Sharpe Ratio	Return	Beta	Std. Dev.	Sharpe Ratio
S&P Low Volatility Index	6.1%	0.59	14.1%	0.40	9.1%	0.61	11.4%	0.65	9.9%	0.55	11.2%	0.61
S&P 500 Index	1.7%	1.00	21.8%	0.06	7.1%	1.00	16.9%	0.32	8.2%	1.00	14.8%	0.34

Source: eVestment Alliance.

viewed as a process of buying lottery tickets. Lacking other tools for enhancing returns—for instance, applying leverage to their portfolios—managers can crowd the trades for high growth and "story" stocks. Lottery preference appears to create mispricing by bidding up high beta stocks while leaving low beta stocks undervalued.

Benchmark Reference

A common practice for long-term investors is to perform an asset allocation analysis to establish a target exposure to an equity investment category. The investor then identifies a benchmark representative of the equity exposure (or beta) and hires portfolio managers to oversee assets whose performance is measured against that particular benchmark. For active investment managers, they are then evaluated based on whether they outperform that benchmark, while their risk is measured in terms of tracking error or active divergence from that benchmark. As a result, most active managers construct their portfolios with an eye to bets taken relative to the benchmark, seeking to maximize unit of excess return per unit of tracking error, also known as "information ratio."

In this framework, active managers are not encouraged to, or compensated for, taking sustained, high tracking error divergences from the benchmark, such as what would be required by a low volatility portfolio, even if that portfolio has a higher Sharpe ratio, or return per unit of total risk (as measured by volatility). Low volatility portfolios tend to have tracking errors of 5.0% or more from a typical capitalization-weighted benchmark, while most plan sponsors seek to manage their active risk within tighter ranges. This leads savvy investment managers—who are trying to keep their mandates—to stay within tracking error guard-rails, seeking to optimize the information ratio rather than the Sharpe ratio. This may be a reason that the low volatility anomaly may not be arbitraged away.

Leverage Aversion

In the case of the low volatility anomaly, investors seeking to match the return of a standard market-based benchmark would need to add leverage to their low volatility portfolio to create an expected return equal to the broad market. Most investors either are unable to

apply leverage to their portfolios due to specific policies, or choose not to, due to governance, operational, and/or risk limitations. Investors who do apply leverage in their portfolios often do so within pre-packaged vehicles, such as hedge funds or private equity, or through other strategies, such as risk parity. Most investors do not consider levering components of their traditional long-only investment strategies. This is another reason that the low volatility anomaly may not be susceptible to arbitrage by investors.

Other Documented Anomalies

The performance of low volatility stocks may also be explained by well-documented anomalies, such as those associated with low price-to-book and small-company stocks. Lower volatility portfolios—whether constructed hypothetically with back-tests or in real time—often comprise companies that have lower price-to-book ratios than the capitalization-weighted benchmarks. Although the current holdings of the low volatility indexes highlighted in the Appendix do not display these characteristics as of December 31, 2012, both lower volatility stocks and value-oriented stocks tend to exhibit similar characteristics in terms of beta relative to standard benchmarks.

Lower volatility portfolios also may have lower average market capitalizations than those of the capitalization-weighted market benchmarks. This is less because managers are specifically seeking to favor smaller companies and is a reflection of a more equal-weighted approach to portfolio construction than the standard capitalization-weighted indexes.

LOW VOLATILITY ANOMALY: HERE TO STAY?

The behavioral and structural factors cited in the previous section offer a meaningful explanation of the existence and potential continuation of anomalous returns. Of the four, we consider *Leverage Aversion* to be most compelling and least likely to be arbitraged away by future investor behavior. *Lottery Preference* and *Benchmark Reference* also appear well-embedded into investor behavior; however, overcoming them is not as structurally challenging. In fact, investors are beginning to move away from their strict focus on benchmark and tracking error in order to incorporate more absolute return–oriented strategies, such as flexible mandates and hedge funds, into their equity programs.

The *Other Documented Anomalies* have been well-articulated by academics and practitioners. As a result, many investment strategies—quantitative and fundamental—have been crafted to exploit these anomalies, including what are commonly called "fundamental indexing" strategies.

Although there appears to be historical evidence of the low volatility anomaly and some plausible reasons to believe that it can be explained by structural and behavioral biases of investors, it is critical to consider whether the anomaly will exist going forward and to establish appropriate expectations.

EXPECTATIONS FOR THE LOW VOLATILITY ANOMALY

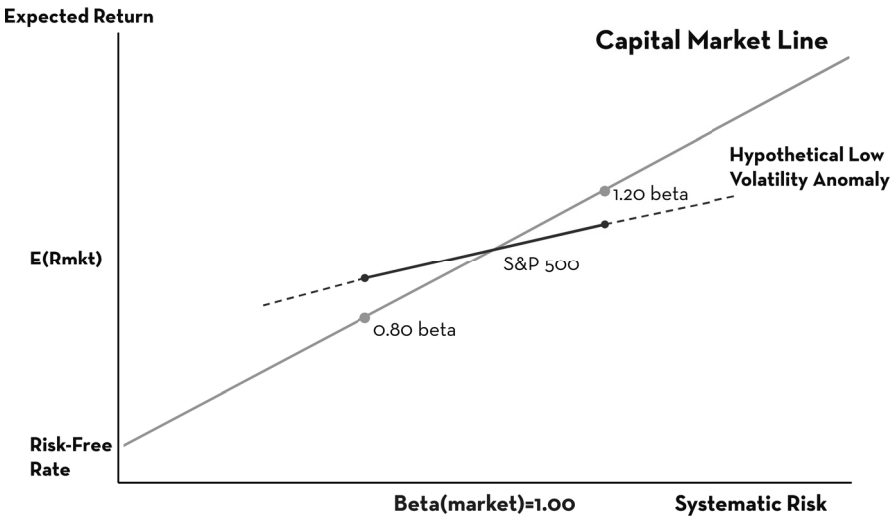
The behavioral and structural drivers of the anomaly indicate that, over the long term, investors can expect that a portfolio of low volatility stocks can provide a higher risk-adjusted return than a broad capitalization-weighted benchmark. To evaluate this, we use our example of two portfolios with betas of 1.20 and 0.80. For the sake of simplicity (and to reflect the challenging current environment) we assume a cash return of zero.

If, over a reasonably long investment cycle, the broad market provides a return of 10% (again, we're using round, and optimistic, numbers for easy math) with a volatility of 18%, then, absent the low volatility anomaly and other exogenous factors, the 1.20 beta portfolio would provide an expected return of 12.0% with an expected volatility of 21.6%, and the 0.80 beta portfolio would provide an expected return of 8.0% with a volatility of 14.4%. The portfolios would have identical Sharpe ratios (real return per unit of volatility) of 0.56. This outcome is consistent with expectations of the capital asset pricing model that we saw in Exhibit 1.

Now let's assume that, due to the low volatility anomaly, an investor can expect to earn more return per unit of risk taken with a portfolio of low volatility stocks than with a portfolio of high volatility stocks. Let's assume, for example, a return of 9% with only 80% of the volatility of the market benchmark, while the higher volatility portfolio returns only 11%, but with 20% more volatility than the benchmark. Now the low volatility portfolio has a superior Sharpe ratio than the

EXHIBIT 4

Theoretical Capital Market Line with Hypothetical Low Volatility Anomaly



Source: NEPC, LLC.

broad market and, of course, the higher volatility portfolio (Exhibit 4).

In this case, investors who apply a modest amount of leverage to their low volatility strategy can create a portfolio with the same expected return as the broad market benchmark with lower volatility and a higher Sharpe ratio.

This hypothetical example represents a potentially reasonable expectation of future outcomes over a full market cycle. Given the behavioral and structural drivers of the anomaly, however, it is not reasonable to expect a portfolio of low volatility stocks to outperform a standard market benchmark over a full market cycle on both an absolute and risk-adjusted basis. Nevertheless, this is what appears to have happened over the periods covered in Exhibits 2 and 3. Exhibit 5 shows the realized return and risk of low volatility stocks from 1992 to 2012, as measured by the S&P Low Volatility Index, compared to the S&P 500.

To expect a comparable return and risk profile for low volatility stocks going forward, investment program sponsors would not need to be averse to applying leverage or seeking lottery tickets. They would simply hold the low volatility portfolio and capture an above-benchmark return.

Such an outcome in the future would require an assumption of one or more of the following:

- Myopia by investors due to benchmark reference
- Outsized price-to-book and/or small company anomalies going forward
- A remarkable expansion of valuation for lower volatility stocks without mean reversion
- A complete failure of investors to arbitrage away an obvious and highly rewarding anomaly

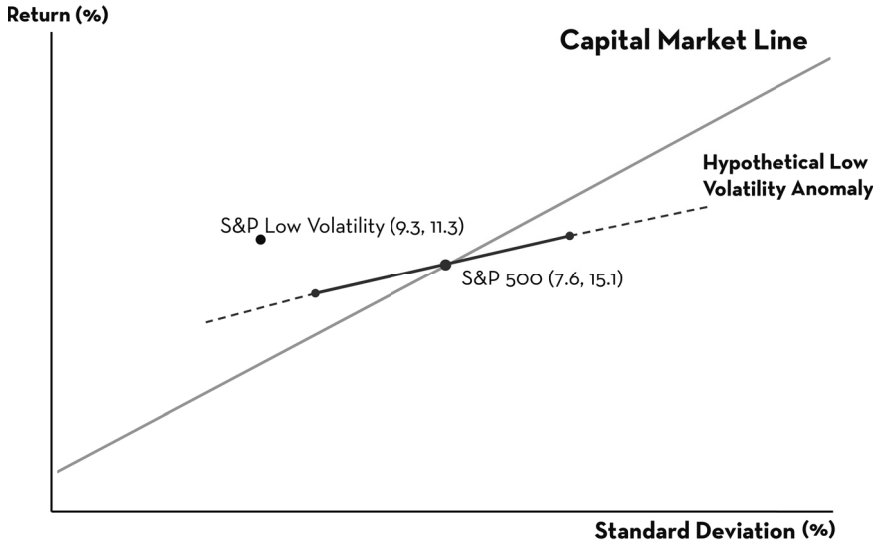
Although in the short term anything is possible, we do not believe these assumptions are reasonable over a complete investment cycle nor should underpin an allocation to a dedicated strategy.

LOW VOLATILITY ANOMALY: RISKS

When evaluating the low volatility anomaly, investors should consider both the potential for it to be arbitraged away and relative valuation levels.

The "quant meltdown" of August 2007 demonstrated the potential for both these risks when applied to the low price-to-book and small-company anomalies. That episode was fueled by too many investors—particularly leveraged hedge funds—crowding the same exposures based on the low price-to-book and small-company anomalies. This led to a period of sharp underperformance, which took years to recoup for many

EXHIBIT 5
S&P Low Volatility Index Risk and Return, 1992–2012



Source: NEPC, LLC.

strategies, fueling the question of whether these anomalies have been arbitraged away.

At the very least, they certainly do not appear to have the same information content that they did prior to 2007. Such experience highlights the challenges of seeking to capture anomalies: They are prone to be arbitraged by significant flows of investor capital, and they tend to experience multi-year cycles of outperformance and underperformance reflected in periods of undervaluation and overvaluation, respectively.

Many investors are familiar with the relative performance of value and growth stocks over time (Exhibit 6). Even if value stocks post superior performance on a risk-adjusted basis over the long term, they are subject to meaningful periods of underperformance relative to growth stocks, as from 1997 to 2000.

Low volatility stock portfolios are no exception to this phenomenon (Exhibit 7).

The rolling three-year performance of the S&P Low Volatility Equity Index compared to the S&P 500 shows periods, as from 1996 to 1999, when low volatility stocks underperformed by a wide margin. While this performance was recouped in the subsequent "tech wreck" and into the 2000s, such cycles raise the question of whether investors will have sufficient patience to bear the pain of underperformance in order to be around when it reverses. Even single year results, such as the 28.8% underperformance of the S&P Low Volatility Index in 1999, may be more than even the most sophisticated investor can stomach.

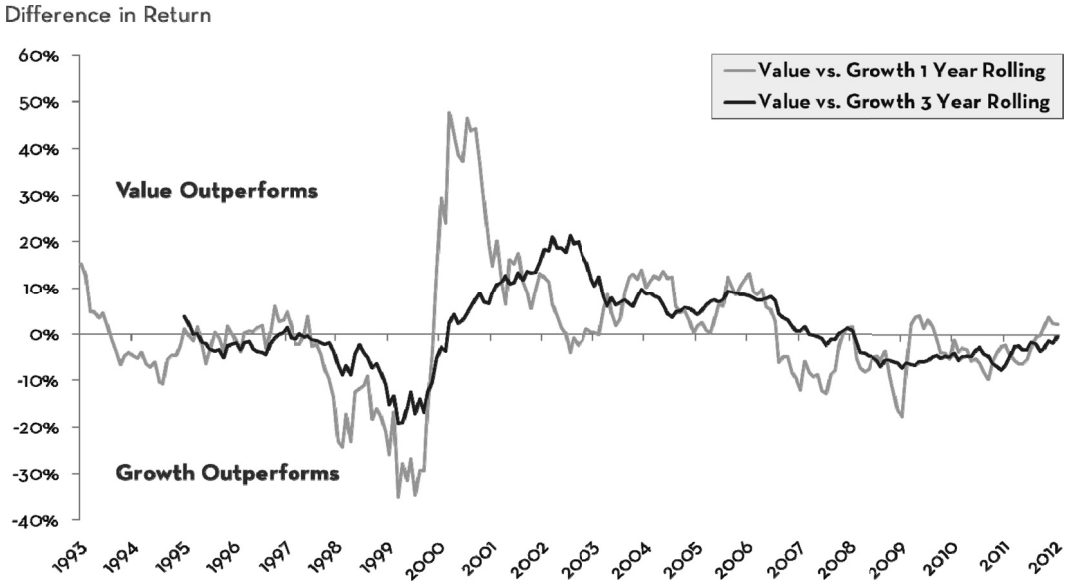
It is worth noting the similarity in the relative performance series of low volatility stocks and value stocks and the common episodes of sharp divergences from broad market benchmarks, both positive and negative. And some approaches to constructing low volatility portfolios also entail taking additional factor risks, including heavy sector or industry bets—such as the 38% exposure to the Utilities sector in the S&P Low Volatility Index, as shown in the Appendix—that may drive performance divergence.

The marked cyclicality of the performance of low volatility stocks also underscores that there are relatively attractive and unattractive entry points to capture factor-based anomalies such as low price-to-book or low volatility (or other factors reflected in fundamental indexing strategies). Investors can assess valuation measures for groups of stocks that benefit from such anomalies in order to determine their relative attractiveness at different points in time.

Exhibit 8 shows one valuation indicator for U.S. low beta stocks (a proxy for low volatility stocks) over the past 40 years. This demonstrates the linkage between

EXHIBIT 6

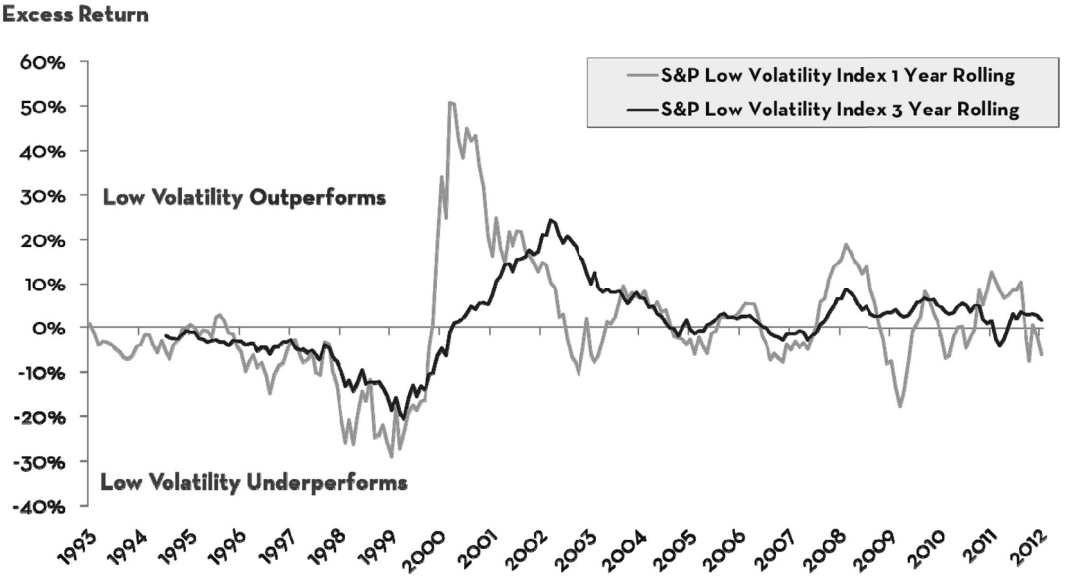
Russell 1000 Value vs. Growth Performance—Rolling 1- and 3-Year Returns



Source: eVestment Alliance.

EXHIBIT 7

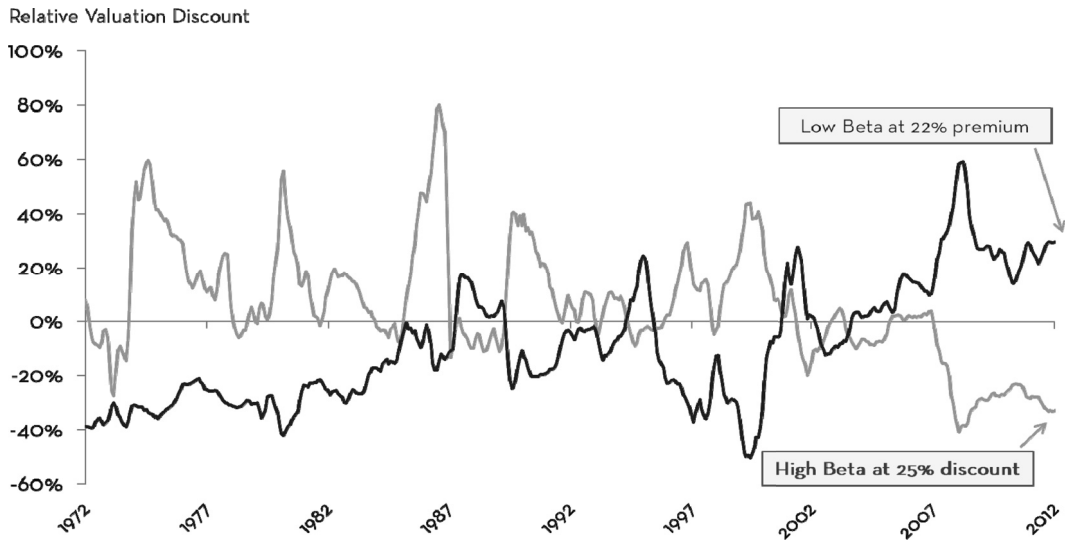
S&P Low Volatility Index Excess Return vs. S&P 500 Index—Rolling 1- and 3-Year Returns



Source: eVestment Alliance.

EXHIBIT 8

Relative Valuation of U.S. Low Beta and High Beta Stocks



Source: Alliance Bernstein L.P.

the performance of this category of stocks and their relative valuation. It also shows, at least according to this measure, that low volatility stocks may be trading amidst the high end of their valuation range.

Expensive valuation for low volatility stocks is consistent with their strong recent relative performance and may also indicate an impending period of sustained underperformance. In fact, in order for the track record of low volatility stocks to become consistent with the expectations we described earlier as reasonable, this category may have to experience a lengthy period of sub-par returns. As a result, investors seeking to profit from the anomaly may end up merely chasing historical returns while realizing a sustained period of disappointing results.

This may be the worst time to allocate assets to a low volatility equity strategy—akin to hiring an active manager just before mean reversion kicks in after a multi-year period of tremendous outperformance.

LOW VOLATILITY ANOMALY: MAKING IT WORK FOR YOU

Equity factors, even those representing persistent anomalies, go in and out of favor. These performance cycles, which can be deep and protracted, test the patience of even the most sophisticated investors. As a result, the pursuit of these anomalies requires active buy and sell decisions based on a variety of inputs, including valuation and market sentiment.

Most investment program sponsors (and consultants) do not have the resources, skills, and/or governance structure to make these decisions in an informed and consistent fashion. Specifically, we believe trying to capture the low volatility anomaly is an active investment management decision and should be implemented accordingly.

As noted earlier, it is possible for anomalies to be arbitraged away over time and for new anomalies to arise, given investor behavior and changes in the structure of markets. Therefore, investors should not attempt to capture single anomalies through long-term strategic allocations.

Instead, investment program sponsors should seek to exploit this and other anomalies through broader active management mandates that are not limited to one factor. Currently, many managers seek to capture these anomalies—the low price-to-book and small company anomalies being good examples—through established investment processes. Capable active managers constantly evaluate the relative attractiveness of these and

other factors and can adjust portfolio exposures accordingly over time.

An additional observation from this discussion is the limitation of strict benchmark orientation. Investors should reduce their reliance on pure tracking-error considerations when evaluating asset managers. This can lead to moving away from "style box" investing, reducing constraints, and assessing more flexible mandates, including long–short equity strategies.

CONCLUSION

Although the low volatility equity anomaly appears to exist based on historical information and can be explained by certain behavioral and structural biases of investors, its continuation into the future is less certain. Even sustained anomalies, however, experience multiyear periods of outperformance and underperformance relative to standard benchmarks, moving between episodes of relative under- and overvaluation based on market fundamentals and investor behavior.

The low volatility anomaly does not appear to be an exception. Therefore, we believe any attempt to capture a particular anomaly within a single asset category—such as equities—should be viewed as an active decision, requiring a valuation framework to assess entry and exit points. Furthermore, given recent valuations of low volatility stocks, and the associated strong performance over most trailing time periods, now may be a particularly inopportune time to make a strategic allocation to this particular investment strategy.

APPENDIX

LOW VOLATILITY INDEX CONSTRUCTION

Multiple index providers have created benchmarks to measure the performance and characteristics of low volatility stocks. Here is a brief description of index construction approaches from three common providers:

- The Standard & Poor's 500 Low Volatility Index measures the performance of the 100 least-volatile stocks in the Standard & Poor's 500 Index. Volatility is defined as the standard deviation of the security's daily price returns over the prior 252 trading days. The index construction methodology employs a volatility-driven weighting scheme, using the divisor methodology used in all of S&P Dow Jones' equity indexes. There are two steps in the creation of the indexes. The first is the selection of the companies; the second is the weighting of the index constituents. To be eligible for the S&P 500 Low Volatility Index, constituents must have traded on all 252 trading days in the 12 months leading up to the rebalancing reference date.
- The Russell Defensive Indexes are part of the Stability Index series. In this series, Russell segments each of its core market-cap-weighted indexes into defensive and dynamic sub-indexes based on quality and volatility factors. The indexes are market-cap-weighted and are broadly representative.
- The MSCI Minimum Volatility Indexes are calculated by optimizing a parent MSCI Index by using an estimated security co-variance matrix, to produce an index that has the lowest absolute volatility for a given set

EXHIBIT A1

Low Volatility Benchmark Characteristics (as of 12/31/2012)

Benchmark	Average Market Cap ($ Billions)	Median Mkt Cap ($ Billions)	P/E	P/B	Dividend Yield	5-Yr Earnings Growth
S&P 500	25.5	11.9	16.9	2.4	2.3	13.7 (3 Year)
S&P Low Volatility Index	41.1	39.6	17.2	2.4	3.4	4.1 (3 Year)
Russell 1000	15.9	5.8	16.8	2.3	2.1	9.4
Russell 1000 Defensive	23.6	8.4	16.1	2.9	2.5	8.9
MSCI US Minimum Volatility Index	137.4	19.7	16.4	2.6	3.0	7.1

Source: S&P Dow Jones Indices, Russell Investments, Acadian Asset Management.

EXHIBIT A2

Low Volatility Benchmark Sector Allocations (as of 12/31/2012)

Benchmark	Consumer Discr. (%)	Consumer Staples (%)	Energy (%)	Financials (%)	Health Care (%)	Industrials (%)	Info. Tech. (%)	Materials (%)	Telecom Services (%)	Utilities (%)	Other (%)
S&P 500	11.5	10.6	11.0	15.6	12.0	10.1	19.0	3.6	3.1	3.4	0.0
S&P Low Volatility Index	3.0	25.0	2.0	12.0	12.0	7.0	4.0	3.0	3.0	29.0	0.0
Russell 1000	12.5	9.8	10.5	16.5	12.0	10.9	17.7	3.9	2.8	3.4	0.0
Russell 1000 Defensive	9.4	17.7	10.1	6.6	18.7	8.9	18.6	1.6	3.5	4.9	0.0
MSCI US Minimum Volatility Index	8.6	15.5	6.1	14.4	17.2	5.9	14.1	2.9	6.7	8.5	0.0

Source: S&P Dow Jones Indices, Russell Investments, Acadian Asset Management.

EXHIBIT A3

Low Volatility Benchmark Market Capitalization Breakouts (as of 12/31/2012)

Benchmark	> $50 Billion (%)	$15-50 Billion (%)	$7.5-15 Billion (%)	$1.5-7.5 Billion (%)	$750-1.5 Billion (%)	$400-750 Million (%)	< $400 Million (%)
S&P 500	12.4	31.8	31.0	24.8	0.0	0.0	0.0
S&P Low Volatility Index	20.0	42.0	24.0	14.0	0.0	0.0	0.0
Russell 1000	6.3	18.3	19.2	54.9	0.0	0.0	0.0
Russell 1000 Defensive	10.7	22.9	22.1	44.0	0.0	0.0	0.0
MSCI US Minimum Volatility Index	31.4	38.4	22.0	8.1	0.0	0.0	0.0

Source: S&P Dow Jones Indices, Russell Investments, Acadian Asset Management.

of constraints. The starting universe to determine a Minimum Volatility Index is an MSCI Equity Index. The estimated security co-variance matrix is based on the relevant Barra multi-factor equity model. The index is rebalanced in May and November, coinciding with the semiannual index review of the parent indexes.

Exhibits A1–A3 provide comparative data on these low volatility benchmarks compared to traditional capitalization-weighted benchmarks.

ENDNOTES

The author thanks his colleagues Oliver Fadly, Jeff Markarian, Tim McCusker, and John Minahan for their extensive input into and review of this article.

[1]For the sake of brevity we have chosen not to describe in detail in the body of this paper the various approaches that academics, investment managers, and index providers have used to conduct their studies or to construct low volatility portfolios/benchmarks. However, we include some summary

information on index construction in the Appendix, and a Bibliography of papers, which provide further information on the topic. Studies also indicate that the anomaly has been in evidence in non-U.S. stock markets as well. Again, for the sake of brevity, we focus on U.S. stocks in this study. That said, our research indicates the discussion and conclusions are broadly applicable across global stock markets.

BIBLIOGRAPHY

Amenc, N., F. Goltz, A. Lodh, and L. Martellini. "Diversifying the Diversifiers and Tracking the Tracking Error: Outperforming Cap-Weighted Indices with Limited Risk of Underperformance." *The Journal of Portfolio Management*, Vol. 38, No. 3, Spring 2012.

Ang, A. "GM Asset Management and Martingale's Low Volatility Strategy." *Columbia CaseWorks*, February 21, 2012, pp. 1-6.

Asness, C.S., A. Frazzini, and L.H. Pedersen. "Leverage Aversion and Risk Parity." *Financial Analysts Journal*, Vol. 68, No. 1 (January/February 2012), pp. 47-59.

Baker, M., B. Bradley, and J. Wurgler. "Benchmarks as Limits to Arbitrage: Understanding the Low-Volatility Anomaly." *Financial Analysts Journal*, Vol. 67, No. 1 (January/February 2011), pp. 40-54.

Clarke, R., H.D. Silva, and S. Thorley. "Minimum Variance Portfolios in the U.S. Equity Market." *The Journal of Portfolio Management*, Vol. 33, No. 1 (Fall 2006), pp. 10-24.

Feuerman, J., and R. Zingone. "Low Volatility Equity Strategies: The 'Moneyball' of the Investment World." *Insights*, J.P. Morgan Asset Management, 2012.

Frazzini, A., and L.H. Pedersen. "Betting Against Beta." Working paper, AQR Capital Management and New York University, December 20, 2010.

Haugen, R., and N. Baker. "Case Closed." Working paper, Haugen Custom Financial Systems and Quantitative Equity Management, October 2008.

Hintz, D. "The Third Dimension of Style." Russell Research, Russell Investments, 2010.

Low Volatility Insights. Martingale Asset Management, Vol. 6, 8, and 9 (2011, 2012).

"Low Volatility Investment Survey." aiCIO, March/April 2012, pp. 55-61.

"Low Volatility Strategies: A Comparison." Research Affiliates, LLC, 2012.

"Managed Volatility Equity Strategies in Asset Allocation." Acadian Asset Management, LLC, 2010.

Meidan, D. "Does a Low Volatility Portfolio Need a 'Low Volatility Anomaly?'" INTECH Investment Management LLC, December 2012.

Melas, D., R. Briand, and R. Urwin. "Harvesting Risk Premia with Strategy Indices: From Today's Alpha to Tomorrow's Beta." *Research Insight*, MSCI Inc., September 2011.

Silva, H.D. "Exploiting the Volatility Anomaly in Financial Markets." *CFA Institute Conference Proceedings Quarterly*, Vol. 29, No. 1 (March 2012), pp. 47-56.

Viceira, L., and H. Tung. "Martingale Asset Management LP in 2008, 130/30 Funds, and a Low-Volatility Strategy." Harvard Business School, December 22, 2009, pp. 1-22.

Vliet, P.V. "Low-Volatility Investing: A Long-term Perspective." Research, Robeco Institutional Asset Management BV, January 16, 2012.

——. "Ten Things You Should Know About Low-Volatility Investing." *The Journal of Investing*, Vol. 20, No. 4 (Winter 2011).

To order reprints of this article, please contact Dewey Palmieri at dpalmieri@iijournals.com or 212-224-3675.

NEPC LLC Disclaimers and Disclosures

- Past performance is no guarantee of future results.
- All investments carry some level of risk. Diversification and other asset allocation techniques do not ensure profit or protect against losses.
- The information in this report has been obtained from sources NEPC believes to be reliable. While NEPC has exercised reasonable professional care in preparing this report, we cannot guarantee the accuracy of all source information contained within.
- This report contains summary information regarding the investment management approaches described herein but is not a complete description of the investment objectives, portfolio management and research that supports these approaches. This analysis does not constitute a recommendation to implement any of the aforementioned approaches.