S&P Dow Jones Indices

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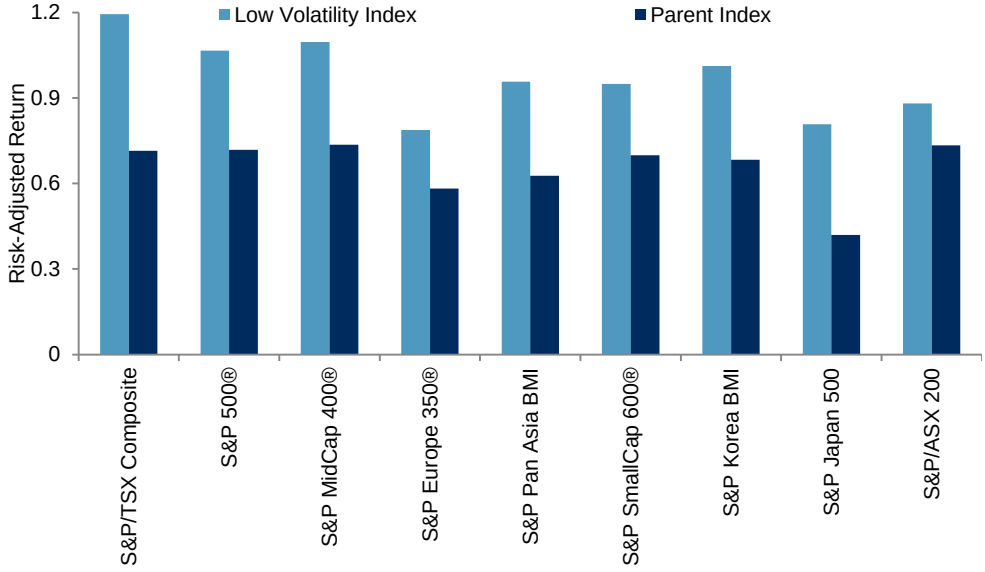
Low Volatility: A Practitioner's Guide

S&P Dow Jones Indices (S&P DJI) produces a range of low volatility indices, covering various single-country and international markets. These indices offer a perspective on the returns of lower volatility equities and provide a basis for index-linked products and benchmarks globally. This practitioner's guide:

- Explains the construction of low volatility indices;
- Identifies the role of broader market trends, valuations, interest rates, and sector exposures in determining their performance;
- Highlights the potential applications of low volatility strategies; and
- Summarizes the evidence for the existence and potential persistence of the so-called "low volatility anomaly."

Exhibit 1 illustrates an important aspect of low volatility indices: their potential to offer higher risk-adjusted returns than the market benchmark from which they were derived.

Exhibit 1: Risk-Adjusted Return Improvement From Low Volatility Indices



Source: S&P Dow Jones Indices LLC. Data from April 2003 to April 2018. Index performance based on annualized monthly total return in local currency, except for the S&P Pan Asia BMI, which uses USD. Past performance is no guarantee of future results. Chart is provided for illustrative purposes and reflects hypothetical historical performance. Please see the Performance Disclosure at the back of this document regarding the inherent limitations associated with back-tested performance.

INTRODUCTION

Basic financial theory is predicated on the idea that higher-risk investments should be priced to offer commensurately higher returns. Unfortunately for the theory, a growing body of empirical evidence—accumulated since the 1970s[1]—suggests that, across a wide range of time horizons, geographies, and market segments,[2] **stocks with lower volatility have displayed higher risk-adjusted returns.**

S&P Dow Jones Indices' Low Volatility Indices track the performance of a portfolio of the least volatile stocks selected from a given benchmark universe.

Meeting the need for low volatility benchmarks, S&P DJI's low volatility indices **track the performance of a portfolio of the least volatile stocks selected from a given benchmark universe**, such as the S&P 500. Indeed, the first-ever low volatility index was the S&P 500 Low Volatility Index, launched in April 2011. Many more have been produced since.[3]

The performance and risk/return characteristics of these indices, both over hypothetical back tests and subsequent to their launch dates, **provide further confirmation that lower-risk stocks can offer superior performance characteristics**. Exhibit 1 provides a summary for a selection of low volatility indices based on various benchmarks over the last 15 years, displaying the improved risk/return ratios of each low volatility index in comparison to its corresponding parent benchmark.

In light of the growing popularity of products (such as ETFs) offering access to low volatility strategies, **a growing body of research identifying and quantifying the drivers of low volatility performance has emerged**. These include the role of sectoral allocations, interest rate sensitivities, and equity valuations. In what follows, **we shall briefly summarize the salient points that emerge from this research**.

The S&P 500 Low Volatility Index rebalances quarterly to the 100 least volatile constituents.

More directly to practitioners' interests, we shall also examine the **portfolio applications** of low volatility strategies, in either a multi-factor or multi-asset context. We conclude by addressing the question of whether or not the so-called "low volatility anomaly" of higher risk-adjusted returns might continue.

Note that while our results extend in spirit to many similar equity strategies, our focus will be restricted to the indices produced by S&P DJI. Accordingly, we begin with a summary of the methodology used to construct our low volatility indices, and a brief examination of the practical consequences of using historical volatility rankings to form equity portfolios.

[1] Jensen, Michael C., Fischer Black, and Myron S. Scholes, "The Capital Asset Pricing Model: Some Empirical Tests," Studies in the Theory of Capital Markets, Praeger Publishers Inc., 1972.

[2] Chan, Fei Mei and Craig J. Lazzara, "Is the Low Volatility Anomaly Universal?," S&P Dow Jones Indices, April 2015.

[3] Please see Exhibit 19 in the Appendix for a full list of the low volatility indices offered by S&P DJI as of April 2018.

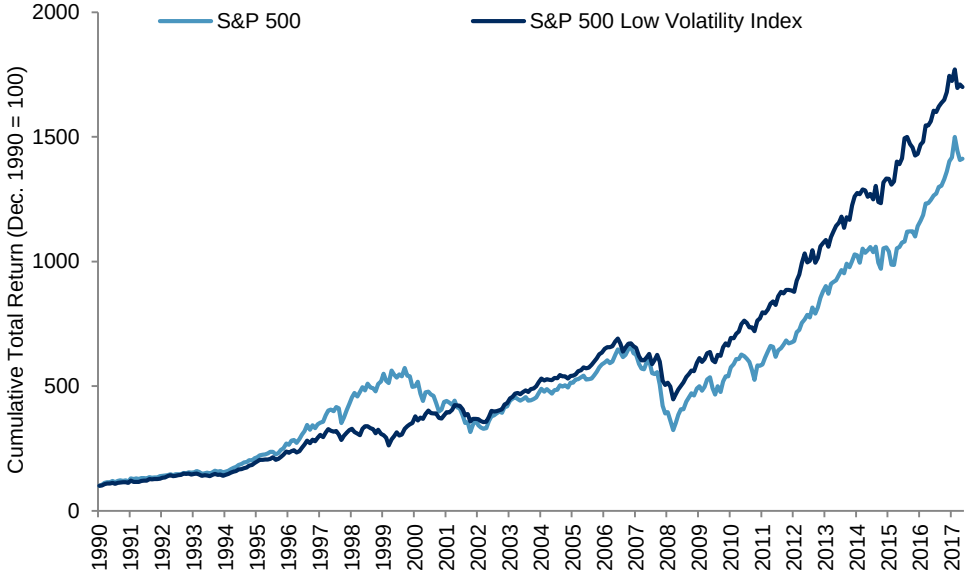
THE CONSTRUCTION OF S&P DJI LOW VOLATILITY INDICES

Broadly speaking, S&P DJI's low volatility indices select a subset of lower volatility stocks from the available universe (typically the lowest 20% by rank) and form portfolios from such selections by weighting each constituent in inverse proportion to its volatility. The selections are made, and the index is rebalanced, on a regular schedule—typically once per quarter.[4]

Constituents are weighted in inverse proportion to their trailing price volatilities.

For example, at each quarterly rebalance of the S&P 500 Low Volatility Index, the price volatility of each S&P 500 constituent over the past 252 trading days is calculated. Once ranked, the 100 least volatile constituents are selected for inclusion in the index, with index weights determined in inverse proportion to volatility (and summing to 100%). Exhibit 2a shows the cumulative total return of the S&P 500 Low Volatility Index, and Exhibit 2b gives the summary performance statistics in comparison with the benchmark.

Exhibit 2a: Comparison of Historical Cumulative Total Return



Source: S&P Dow Jones Indices LLC. Data from December 1990 to April 2018. Index performance based on rebased monthly total return in USD. Past performance is no guarantee of future results. Chart is provided for illustrative purposes and reflects hypothetical historical performance. Please see the Performance Disclosure at the back of this document regarding the inherent limitations associated with back-tested performance.

[4] Practical considerations mean that the methodologies applied to produce low volatility indices can differ from one market to another. For example, buffers to limit turnover at rebalancing may be applied to low volatility indices operating in less liquid markets. Full details of each index's construction may be found in its methodology. For example, see the S&P Low Volatility Indices Methodology.

Exhibit 2b: Summary Statistics

INDEX	RETURN (%)	VOLATILITY (%)	RETURN/RISK	TRACKING ERROR (%)	INFORMATION RATIO
S&P 500	10.14	14.04	0.72	-	-
S&P 500 Low Volatility Index	10.89	10.81	1.01	9.31	0.08

Source: S&P Dow Jones Indices LLC. Data from December 1990 to April 2018. Index performance based on annualized monthly total return in USD. Past performance is no guarantee of future results. Table is provided for illustrative purposes and reflects hypothetical historical performance. Please see the Performance Disclosure at the back of this document regarding the inherent limitations associated with back-tested performance.

Low volatility indices select stocks based on their *historical* volatilities.

PERSISTENCE IN VOLATILITY RANKINGS

Since our low volatility indices select stocks based on their *historical* volatilities, it is natural to ask whether such a selection process is successful in identifying those stocks that will be less volatile *in the future*. In essence, the question relates to the persistence of volatility rankings among stocks over time.[5]

This has been an effective way of identifying those stocks that will be less volatile in the *future*.

Exhibit 3 illustrates the persistence of volatility rankings by quintile among S&P 500 constituents over a one-year time horizon. To construct Exhibit 3, we ranked year-end S&P 500 constituents between 1990 and 2017 according to their trailing one-year volatility, and sorted the results into quintiles (the lowest 20% by volatility that year, the next 20%, and so on). For those constituents that remained in the benchmark for two or more consecutive year-ends, **Exhibit 3 shows the resulting transition matrix**—the total percentages from each quintile that were ranked in the first, second, third, fourth, or fifth quintile at the subsequent annual ranking.

Exhibit 3: S&P 500 Constituent Volatility Quintile Transition Matrix

		QUINTILE IN SUBSEQUENT RANKING				
		1	2	3	4	5
INITIAL QUINTILE	1	67%	22%	8%	2%	1%
	2	25%	39%	23%	10%	2%
	3	7%	28%	36%	23%	6%
	4	1%	10%	28%	40%	21%
	5	0%	1%	6%	24%	69%

Source: S&P Dow Jones Indices LLC. Data from December 1990 to December 2017. Past performance is no guarantee of future results. Table is provided for illustrative purposes.

For example, the top left figure of 67% in Exhibit 3 represents the percentage of stocks in the lowest volatility quintile each year that remained in the lowest volatility quintile the next year. The figures along the leading diagonal—which represents those constituents that remained in the same quintile—are the largest in each row and column, and it is particularly clear

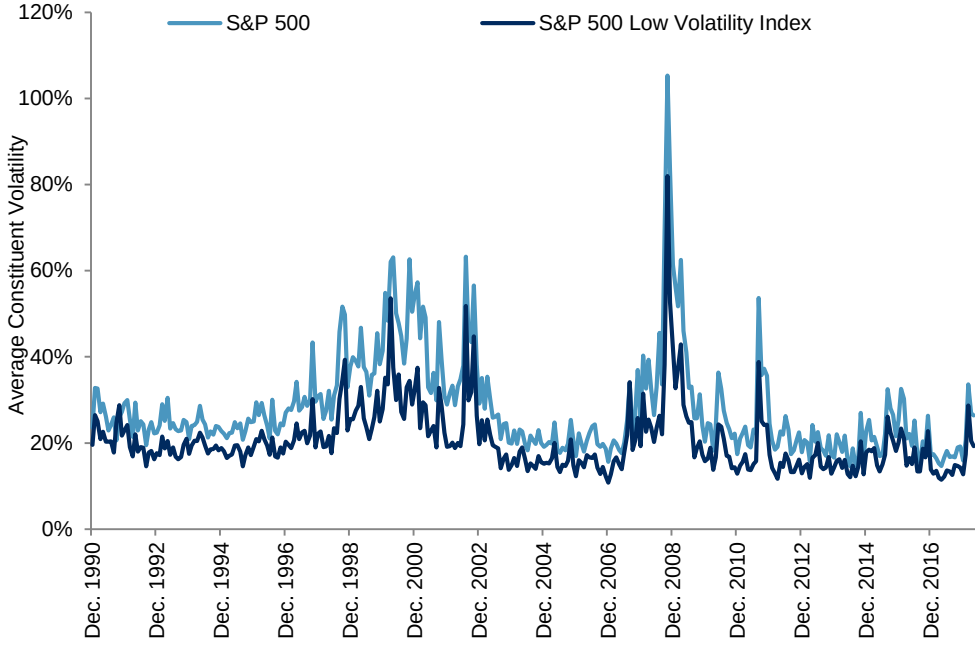
[5] Persistence in volatility levels in both absolute and relative terms over short- and medium-term time horizons is a well-known stylized fact. For more information, see Engle, Robert F. and Andrew J. Patton, "What Good is a Volatility Model?," *Quantitative Finance* Vol. 1, pp. 237-245 Jan. 29, 2001.

that **persistence in volatility ranks was highest for the most, and the least, volatile constituents**. Accordingly, Exhibit 3 provides a heuristic justification for selecting less volatile stocks based on trailing volatilities.

Less heuristically, Exhibit 4 provides explicit confirmation that **the index methodology was effective in selecting stocks that *subsequently* displayed lower volatility**. Exhibit 4 displays the lower historical (index-weighted) average volatility among S&P 500 Low Volatility Index constituents each month, compared with the equivalent average for the broader S&P 500. This reduction in average *constituent* volatility is a primary source for the lower *index* volatility shown in Exhibit 2b. In fact, over most time horizons, low volatility indices have nearly always proved less volatile than their benchmarks. Exhibit 20 in the Appendix provides a survey in the specific case of the S&P 500 Low Volatility Index.

Over most time horizons, low volatility indices were less volatile than their benchmarks.

Exhibit 4: Average Constituent Volatilities Were Lower in the Low Vol Index



Source: S&P Dow Jones Indices LLC. Data from December 1990 to April 2018. Past performance is no guarantee of future results. Chart is provided for illustrative purposes and reflects hypothetical historical performance. Please see the Performance Disclosure at the back of this document regarding the inherent limitations associated with back-tested performance.

Less volatile single-period returns create the *potential* for higher multi-period returns, simply due to the non-linear impact that changes in volatility have on *compounded* return series.[6] In fact, **the historical performance of low volatility indices cannot be explained fully by such simple "geometric" effects**.[7] Instead, the key to their performance lies in the

[6] For example, an asset that rises 40% or falls 30% in alternative periods will eventually tend to zero value, while an asset that rises or falls by half as much in each period will grow indefinitely, despite the lower average return of the latter. This is essentially a consequence of the difference between arithmetic and geometric averages.

[7] See Chan, Fei Mei, and Craig J. Lazzara, "In Search of the Low Volatility Anomaly: A Case Study," S&P Dow Jones Indices, April 2016.

difference between the volatility reductions achieved during rising markets, compared with the volatility reductions achieved during declining markets. This aspect of low volatility indices is perhaps best approached via the concepts of "upside capture" and "downside capture" ratios—to which we now turn.

UPSIDE AND DOWNSIDE CAPTURE RATIOS

Since they are composed of equities, low volatility indices typically rise when equity markets rise, and fall when equity markets fall.

Since they are composed of equities, low volatility indices typically rise when equity markets rise, and fall when equity markets fall, even if the lower volatility of their constituents means that their movements tend to be attenuated in both directions. However, **the extent to which low volatility indices *participate* in positive benchmark returns varies significantly from their typical participation in negative benchmark returns**. This lack of symmetry plays a significant role in the long-term performance of low volatility indices, and might also be said to provide a significant component of the investor interest in low volatility strategies more generally.

Exhibit 5 demonstrates the asymmetric nature of the relationship between the returns of the S&P 500 Low Volatility Index and the returns of the benchmark S&P 500 over various time horizons. Specifically, for each collection of non-overlapping intervals (days, weeks, months, etc.) in the period from December 1990 to April 2018, Exhibit 5 displays the average performance of the S&P 500, the average performance of the S&P 500 Low Volatility Index, and the ratio of the two, calculated on all the intervals where the S&P 500's returns were positive (upside capture) and, separately, on all the intervals where the S&P 500's returns were negative (downside capture).

Whether measured over days, weeks, months, quarters, or years, the S&P 500 Low Volatility Index displayed a higher upside capture ratio than downside capture ratio.

Exhibit 5: Low Volatility Capture Ratios Across Various Time Horizons

PERIOD	DURING WHICH S&P 500 RISES			DURING WHICH S&P 500 DECLINES		
	S&P 500	S&P 500 LOW VOLATILITY INDEX	UPSIDE CAPTURE	S&P 500	S&P 500 LOW VOLATILITY INDEX	DOWNSIDE CAPTURE
Trading Days (Total = 6,915)	0.73%	0.49%	**0.67**	-0.76%	-0.48%	**0.63**
Weeks (Total = 1,382)	1.60%	1.08%	**0.67**	-1.79%	-1.02%	**0.53**
Calendar Months (Total = 329)	3.10%	2.23%	**0.72**	-3.49%	-1.69%	**0.48**
Calendar Quarters (Total = 109)	6.14%	5.75%	**0.94**	-6.64%	-1.29%	**0.19**
Calendar Years (Total = 27)	17.38%	16.43%	**0.95**	-20.02%	2.32%	**-0.12**

Source: S&P Dow Jones Indices LLC. Data from December 1990 to December 2017. Past performance is no guarantee of future results. Table is provided for illustrative purposes and reflects hypothetical historical performance. Please see the Performance Disclosure at the back of this document regarding the inherent limitations associated with back-tested performance.

For example, the third row of Exhibit 5 shows that the S&P 500 rose by an average of 3.10% in the months in which it gained, while the S&P 500 Low Volatility Index rose by an average of 2.23% in those months. The ratio of

these two figures provides the monthly upside capture ratio of 0.72, which compares favorably with the monthly downside capture ratio, which was 0.48.

Higher dispersion in market declines may account for differences in capture ratios.

In fact, whether measured over days, weeks, months, quarters, or years, the S&P 500 Low Volatility Index displayed a **higher upside capture ratio than downside capture ratio.** Strikingly, **the difference increased with the length of the interval used for analysis**. In fact, over the four calendar years during which the S&P 500's total return was negative—an admittedly limited sample—the average total return of the S&P 500 Low Volatility Index was actually *positive*.

Rather than being specific to U.S. equities, **these characteristics extend universally to the global range of S&P Low Volatility Indices**. Exhibit 6 extends the analysis of Exhibit 5, focusing on the monthly capture ratios, to the collection of low volatility indices introduced earlier in Exhibit 1. For each index examined in Exhibit 6, the monthly upside capture ratio materially exceeded the downside capture ratio.

Part of what may be driving this result is the historical observation that **dispersion**[8]—interpreted as the difference, in magnitude, between relative winners and losers—**has generally been higher in months when the market fell**, compared with when it rose.[9] Since lower volatility stocks would naturally be expected to outperform during market declines, and to underperform during market gains, the difference in capture ratios may simply be a reflection of the proportionally larger relative rewards to outperforming in higher-dispersion markets.

[8] Edwards, Tim and Craig J. Lazzara, "Dispersion: Measuring Market Opportunity," S&P Dow Jones Indices, December 2013.

[9] Chan, Fei Mei and Craig J. Lazzara, "The Best Offense: When Defensive Strategies Win," S&P Dow Jones Indices, March 2015.

Other S&P Low Volatility Indices displayed a similar pattern of higher monthly upside capture ratios than downside capture ratios.

Exhibit 6: Monthly Capture Ratios of Various S&P Low Volatility Indices

INDEX	UPSIDE CAPTURE (MONTHLY)	DOWNSIDE CAPTURE (MONTHLY)
S&P Europe 350 Low Volatility Index	0.93	0.61
S&P Korea Low Volatility Index	0.87	0.58
S&P Pan Asia Low Volatility Index	0.74	0.51
S&P South Africa Low Volatility Index	0.84	0.46
S&P/ASX 200 Low Volatility Index	0.84	0.63
S&P/TSX Composite Low Volatility Index	0.71	0.31
S&P MidCap 400 Low Volatility Index	0.74	0.51
S&P SmallCap 600 Low Volatility Index	0.81	0.61
S&P Japan 500 Low Volatility Index	0.69	0.52
S&P BMI Emerging Markets Low Volatility Index	0.73	0.56

Source: S&P Dow Jones Indices LLC. Data based on monthly data from January 2001 to April 2018. Past performance is no guarantee of future results. Table is provided for illustrative purposes and reflects hypothetical historical performance. Please see the Performance Disclosure at the back of this document regarding the inherent limitations associated with back-tested performance.

Exhibit 6 offers a global perspective on the properties of low volatility indices; the broad similarity in their capture ratios may help to explain much of their long-term performance. However, not *all* practical aspects of low volatility index performance may be entirely explained through their capture ratios. Further insights may be gained through alternative perspectives; such as their sectoral exposures, their connections to macro factors like the interest rate environment, and their relationships to fundamental data, such as equity valuations. We begin with sectors.

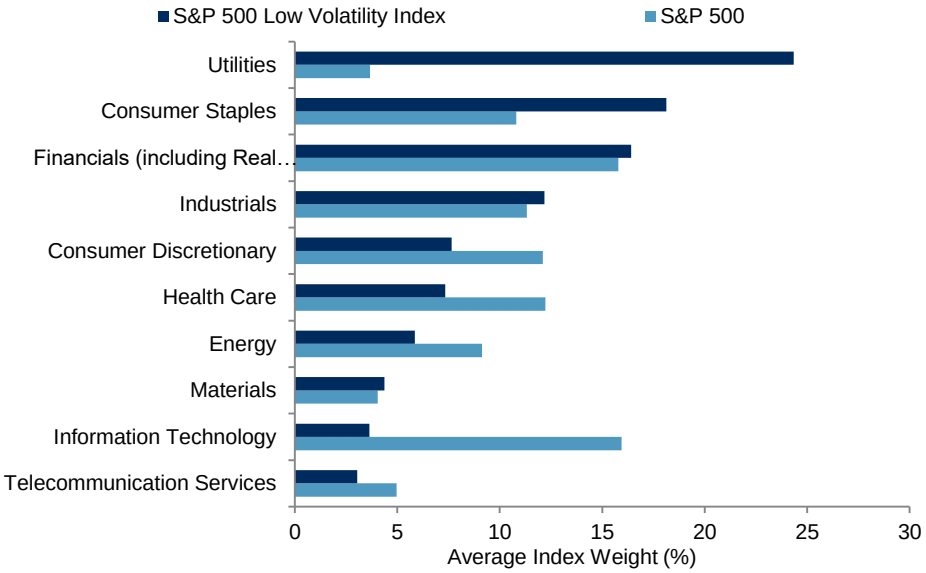
LOW VOLATILITY AND SECTORS

S&P Low Volatility Indices can maintain significant sector tilts.

The constituent selections made at each rebalance of the S&P Low Volatility Indices are **unconstrained by sector**; the index allocates as much (or as little) to each sector as is determined by the overall ranks of the volatilities of the stocks in that sector. Since sectoral peers often display similar volatilities, and since **some sectors are typically less volatile than others**, the selection process is likely to result in **significant sector bets**, relative to a capitalization-weighted benchmark.

Exhibit 7 shows the average sector breakdown of the S&P 500 in comparison to that of the S&P 500 Low Volatility Index, averaged over calendar months in the period from December 1990 to April 2018. As might be expected, on average, the S&P 500 Low Volatility Index showed significant tilts toward utilities and consumer staples, and away from information technology.

Exhibit 7: Comparing Average Sector Weights

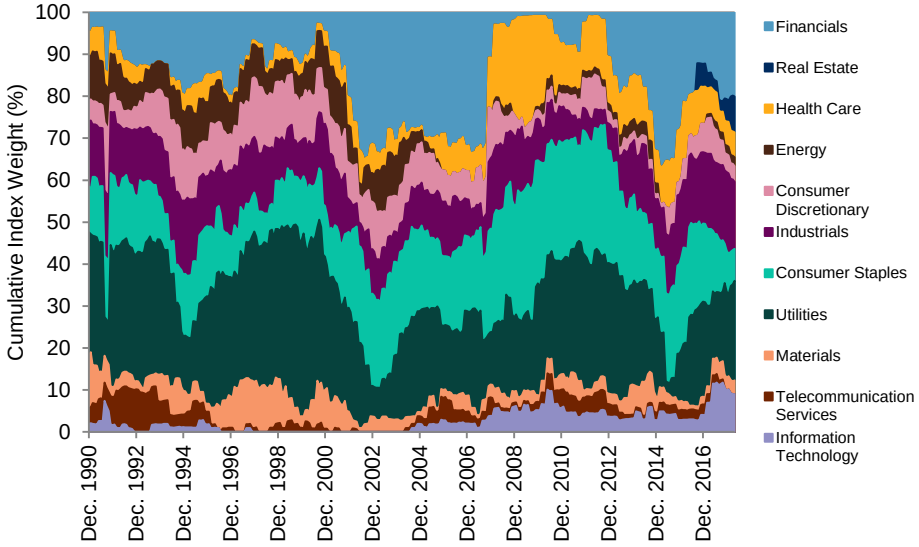


Source: S&P Dow Jones Indices LLC. Data based on monthly index weights from December 1990 to April 2018. Chart is provided for illustrative purposes and reflects hypothetical historical performance. Please see the Performance Disclosure at the back of this document regarding the inherent limitations associated with back-tested performance.

The sector tilts of low volatility indices can vary significantly over time.

However, **the sector compositions (and tilts) of low volatility indices can vary significantly over time**. Exhibit 8 shows the sectoral breakdown of the S&P 500 Low Volatility Index for each month in the period from December 1990 to April 2018. Note the near-total reduction in the financials weight (top series) in the lead-up to the 2008 financial crisis, and the lack of any significant allocation to information technology (bottom series) in the lead-up to the "dotcom bubble", and its aftermath.

Exhibit 8: S&P 500 Low Volatility Index Sector Weights



Source: S&P Dow Jones Indices LLC. Data based on monthly index weights from December 1990 to April 2018. Chart is provided for illustrative purposes and reflects hypothetical historical performance. Real Estate became a GICS® sector in September 2016; it was included in Financials prior to this date. Please see the Performance Disclosure at the back of this document regarding the inherent limitations associated with back-tested performance.

The high degree of variation in sector weights in the S&P 500 Low Volatility Index raises the question as to how much of the improvement in risk-adjusted returns comes from sectoral allocations. In order to answer this question, we apply the monthly returns of the (cap-weighted) S&P 500 sector indices to the respective historical sector weights in the S&P 500 Low Volatility Index to produce a hypothetical return series—referred to here as the **"Sector-Based Low Vol"** portfolio.[10] Comparing the returns and volatility of this hypothetical portfolio to the S&P 500 and S&P 500 Low Volatility Index provides an indication of **how much of the differential in their risk and return was generated through sectoral differences *alone***. Exhibit 9 provides a summary.

Exhibit 9: Constituent-Level Versus Sector-Level Effects

INDEX	TOTAL RETURN (%)	VOLATILITY (%)	RETURN/RISK
S&P 500	15.27	17.64	0.87
Sector-Based Low Vol	15.01	14.87	1.01
S&P 500 Low Volatility Index	16.41	13.00	1.26
Sector Contribution	**-0.26**	**-2.77**	**0.14**
Stock Contribution	**1.39**	**-1.86**	**0.25**

The Sector-Based Low Vol portfolio is a hypothetical portfolio.
Source: S&P Dow Jones Indices LLC. Data based on monthly index weights from December 1990 to April 2018. All figures are annualized. Past performance is no guarantee of future results. Table is provided for illustrative purposes and reflects hypothetical historical performance. Please see the Performance Disclosure at the back of this document regarding the inherent limitations associated with back-tested performance.

Over the full history, sector tilts accounted for most of the risk-reduction in the S&P 500 Low Volatility Index.

Between December 1990 and April 2018, the hypothetical portfolio representing the sector tilts of the S&P 500 Low Volatility Index displayed an annualized total return that was 0.26% *lower* than that of the S&P 500. However, its annualized volatility was 2.77% lower than that of the S&P 500; a proportionally greater reduction, resulting in an improved risk/return ratio.

Stock selection was more helpful for the low volatility index's returns.

Accordingly, we may conclude that both sector tilts and stock selection helped to improve the risk/return profile of the S&P 500 Low Volatility Index. Sector allocations contributed more significantly through risk reduction, while stock selection effects were responsible for the improvement in absolute returns. In fact, *all* of the historical return outperformance of the S&P 500 Low Volatility Index was generated by stock picks *within* each sector, rather than by sector selection itself.

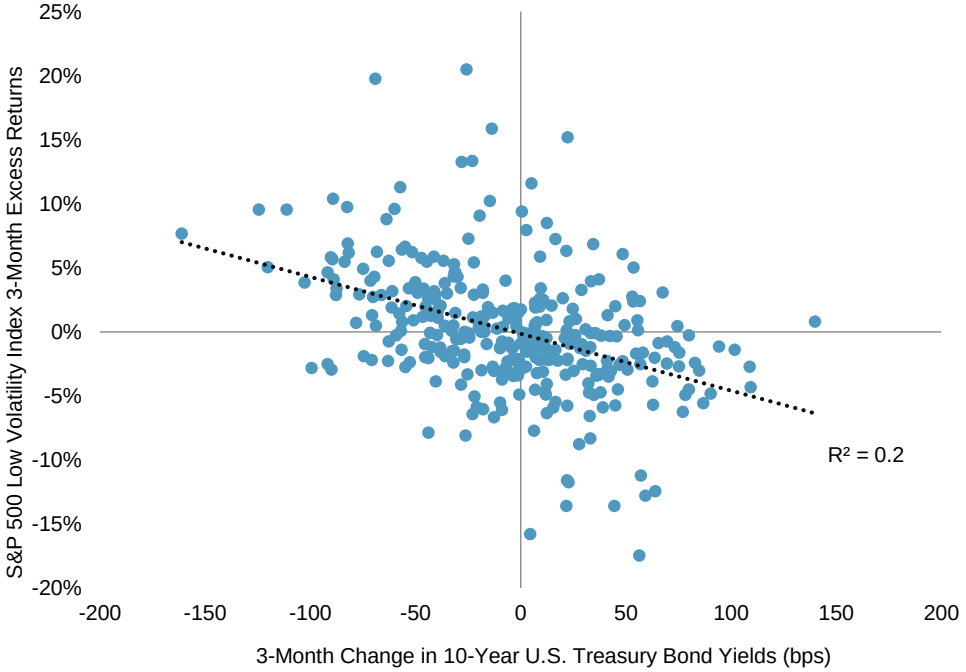
[10] The process applied here is essentially equivalent to a so-called "Brinson" attribution; Brinson, Gary P., L. Randolph Hood, and Gilbert L. Beebower, "Determinants of Portfolio Performance," *Financial Analysts Journal*, 42(4), 39-44, July 1986. The idea is that the difference in performance between a portfolio and its benchmark can be separated into "timing" (in this case, sector allocation) and "security selection" (in this case, stock selection within each sector).

LOW VOLATILITY AND INTEREST RATES

The relationship between low volatility indices and interest rates (or longer-dated bond yields) is of importance for two reasons. The first is that **the two are empirically, and naturally, related**. The second is that, during the period in which the performance of low volatility indices can be examined, there has been a global, multi-decade decline in interest rates. Accordingly, **the practitioner may ask whether the historically attractive performance of low volatility strategies might be attributed to multi-decade (and perhaps once-in-a-lifetime) changes in the fixed income environment**.

Exhibit 10 plots the historical relationship between the rolling three-month relative performance of the S&P 500 Low Volatility Index, compared with the contemporaneous change in the benchmark 10-year U.S. Treasury Bond yields. A negative association is clearly visible.

Exhibit 10: S&P 500 Low Volatility Index Relative Returns and 10-Year U.S. Treasury Bond Yields



When the equity market crashes, U.S. Treasury Bond yields tend to fall amid a "flight to safety".

Source: S&P Dow Jones Indices LLC. Data based on monthly total return index levels and yield to maturities from November 1990 to April 2018. Past performance is no guarantee of future results. Chart is provided for illustrative purposes and reflects hypothetical historical performance. Please see the Performance Disclosure at the back of this document regarding the inherent limitations associated with back-tested performance.

The relationship highlighted by Exhibit 10 depends on a further variable: the S&P 500's returns in the period. When the equity market crashes, U.S. Treasury Bond yields—especially the yields of highly rated bonds—tend to fall amid a "flight to safety". Conversely, U.S. Treasury Bond yields tend to rise in strong equity bull markets. Since low volatility indices tend to lag in bull markets and outperform in bear markets, it's entirely possible that the

relationship shown in Exhibit 10 is **simply a manifestation of their shared association to the overall equity market's direction**. In fact, this appears to be the case.

To demonstrate this, we first computed a "capture-adjusted" excess return for the S&P 500 Low Volatility Index equal to *the return in excess of what might be expected*, *given the benchmark's returns and the expected capture ratio.* The capture-adjusted excess return is calculated as the difference between (i) the S&P 500 Low Volatility Index's returns, and (ii) the product of S&P 500's returns and the appropriate upside or downside capture ratio for a three-month period (see Exhibit 5). **If the only relationship between bond yields and S&P 500 Low Volatility Index performance came from the equity market environment, we should expect to find no correlation between bond yields and the capture-adjusted excess returns**. Exhibit 11 confirms that this is the case; the trend line changes sign, while **the correlation effectively falls to zero**.

Exhibit 11: Capture-Adjusted S&P 500 Low Volatility Index Relative Returns and 10-Year U.S. Treasury Bond Yields

The performance of low volatility equity strategies is far more dependent on the direction of the equity market than on that of the bond market.

Source: S&P Dow Jones Indices LLC. Data based on monthly total return index levels and yield to maturities from November 1990 to April 2018. Past performance is no guarantee of future results. Chart is provided for illustrative purposes and reflects hypothetical historical performance. Please see the Performance Disclosure at the back of this document regarding the inherent limitations associated with back-tested performance.

Accordingly, taken together, Exhibits 10 and 11 demonstrate that the performance of low volatility equity strategies is far more dependent on the direction of the equity market than on that of the bond market.[11]

[11] This point has been raised before. See Chan, Fei Mei, "Rising Rates Arrive", March 23, 2017.

LOW VOLATILITY AND VALUATIONS

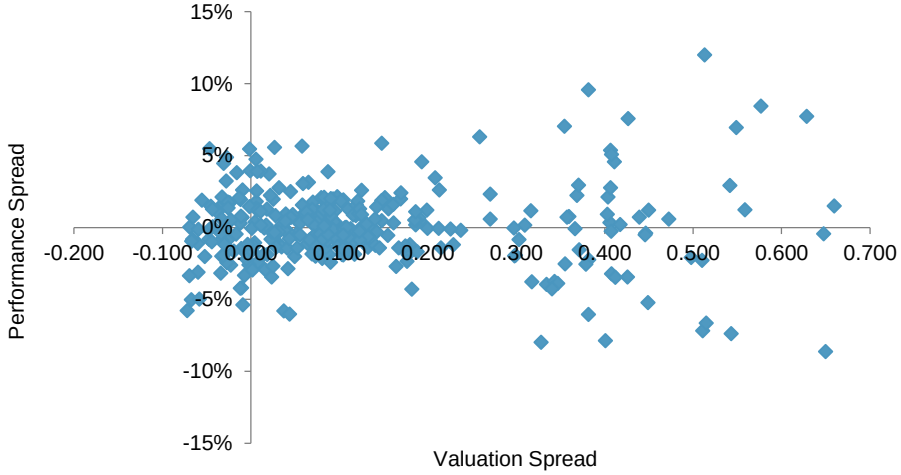
While so-called "quant" hedge funds and related institutions have been offering and implementing low volatility equity strategies for several decades, low-cost index funds and ETFs tracking low volatility indices are a more recent phenomena. The increasing popularity of such index-linked products has led some to query whether the more recent performance of low volatility indices may be explained *precisely by their growing popularity.*

So, is low volatility suffering from a form of "crowding"? The question has clear merit when examining *any* non-capitalization-weighted strategy, the continued attractiveness of which necessarily relies on the inability or disinclination of a sufficiently large base of investment capital to diminish future returns by adopting those strategies themselves. In other words, investment flows into low volatility strategies—if they are to be informative—must be compared with the magnitude and motivations of investors "taking the other side" and underweighting low volatility stocks.

We shall consider this question again in the context of the causes, and putative persistence, of the low volatility "anomaly". Returning to present concerns, we consider the related question: whether the performance of low volatility strategies in fact arose because lower volatility equities were once "cheap", and are now "expensive". In other words, **the practitioner may ask whether low volatility is essentially a disguised form of "value" investing**. Exhibit 12 highlights the results of an earlier study examining the relationship between relative valuations and the performance of low volatility strategies.[12]

Valuations cannot "explain away" the historical returns of low volatility.

Exhibit 12: Relative Valuations and Subsequent Relative Performance



Source: S&P Dow Jones Indices LLC, "The Valuation of Low Volatility," November 2016. Data from Dec. 31, 1990, to June 30, 2016. Past performance is no guarantee of future results. Chart is provided for illustrative purposes and reflects hypothetical historical performance. Please see the Performance Disclosure at the back of this document regarding the inherent limitations associated with back-tested performance.

[12] Chan, Fei Mei and Craig J. Lazzara, "The Valuation of Low Volatility," S&P Dow Jones Indices, November 2016.

Exhibit 12 compares the relative valuation of the S&P 500 Low Volatility Index against its relative performance in the subsequent month (both measures are relative to the S&P 500).[13] **If a causal link exists between relative valuations and relative performance, it is very difficult to see**: there has been substantial variation in relative returns following similar relative valuations. Other researchers have found similar results.[14] Suffice to say, **valuations do not appear to "explain away" the historical returns of low volatility**.

Although we shall return to the topic of whether the performance characteristics of low volatility indices might persist, this completes our review of the key drivers and aspects of their historical performance. We turn now to portfolio applications.

LOW VOLATILITY IN MULTI-FACTOR PORTFOLIOS

A commitment to low volatility can be challenging to maintain in bull markets.

Although the downside protection associated with low volatility indices may be attractive for turbulent times, many managers (and asset owners) also wish to participate fully in market gains. In other words, a commitment to low volatility strategies can become challenging to maintain during extended bull markets.

One way to manage this is to combine low volatility with strategies that demonstrate complementary characteristics.

One way to manage the tracking error implicit in low volatility strategies is to combine them with other investments exhibiting complementary characteristics. An example is provided by momentum (or relative strength) strategies, which typically outperform in extended periods of strong market gains. For example, the upside capture ratio of the S&P 500 Momentum between September 1994 and April 2018 was 1.06.[15]

Exhibit 13 illustrates the cumulative excess returns of the S&P 500 Low Volatility Index and the S&P 500 Momentum,[16] the latter chosen to be representative of momentum strategies in large-cap U.S. equities. A rise in either line means the corresponding index outperformed the S&P 500 that month. Generally—although not always—if one outperformed, the other underperformed (more precisely, the correlation of their excess monthly returns was -0.24).

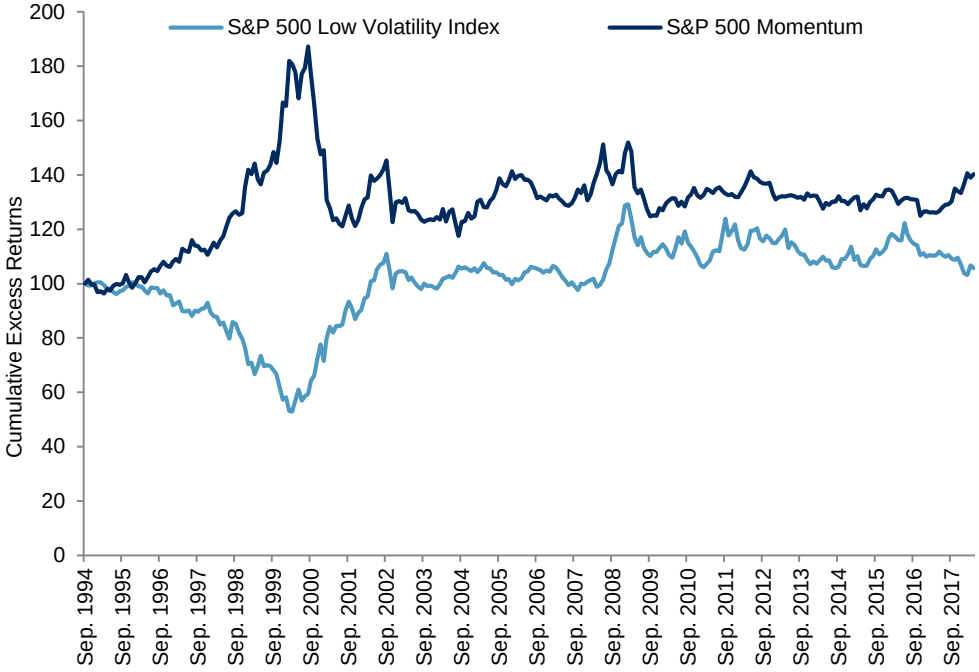
[13] Ibid.

[14] See Blitz, David, "The Value of Low Volatility," *The Journal of Portfolio Management*, Feb. 10, 2016.

[15] The upside capture ratio is based on monthly total return levels.

[16] For more information on momentum and S&P DJI's momentum methodology, see Preston, Hamish, "Momentum: A Practitioner's Guide," S&P Dow Jones Indices, January 2017.

Exhibit 13: Excess Returns to Low Volatility and Momentum Have Been Negatively Correlated, Historically



Source: S&P Dow Jones Indices LLC. Data based on monthly total return index levels from September 1994 to April 2018. Excess returns calculated by subtracting S&P 500 total returns. Past performance is no guarantee of future results. Chart is provided for illustrative purposes and reflects hypothetical historical performance. Please see the Performance Disclosure at the end of this document for more information regarding the inherent limitations associated with back-tested performance.

The hypothetical Blended portfolio displayed a greater participation in bull markets.

To illustrate the potential benefits of combining low volatility and momentum strategies, we constructed a hypothetical "Blended" portfolio containing both. Our hypothetical blend allocates 75% to the S&P 500 Low Volatility Index and 25% to the S&P 500 Momentum, assuming a quarterly rebalance. (The annualized volatility of this blend is approximately equal to that of the S&P 500 Low Volatility Index.) Exhibit 14 provides summary statistics for the period between September 1994 and April 2018.

Exhibit 14: Hypothetical Blend Versus the S&P 500 Low Volatility Index and S&P 500 Momentum

INDEX	RETURNS (%, ANN.)	VOLATILITY (%, ANN.)	RETURN/ RISK	UPSIDE CAPTURE (MONTHLY)	DOWNSIDE CAPTURE (MONTHLY)	TRACKING ERROR (%, ANN.)
Blended	11.36	11.00	1.03	0.80	0.58	7.19
S&P 500 Low Volatility Index	11.01	11.06	1.00	0.71	0.45	9.83
S&P 500 Momentum	11.36	16.67	0.68	1.06	0.98	8.82
S&P 500	9.74	14.50	0.67	-	-	-

The Blended portfolio is a hypothetical portfolio.
Source: S&P Dow Jones Indices LLC. Data from September 1994 to April 2018. Index performance based on total return in USD. Past performance is no guarantee of future results. Table is provided for illustrative purposes and reflects hypothetical historical performance. Please see the Performance Disclosure at the end of this document for more information regarding the inherent limitations associated with back-tested performance.

As we might have expected, the hypothetical Blended portfolio displayed a greater participation in bull markets than the S&P 500 Low Volatility Index;

the upside capture ratio was 0.80 compared with 0.71 for the S&P 500 Low Volatility Index. Naturally, the downside capture ratio also rose. However, a diversification benefit also arose from the combination, as evidenced by the higher return/risk ratio. The Blended portfolio's lower tracking error to the S&P 500, combined with its outperformance, also meant that the information ratio would have increased.

Of course, we have only scratched the surface of combining low volatility with other factors, or indeed combining factors more generally. We note in passing that in addition to momentum, **growth and equal-weight strategies may also offer attractive diversification characteristics** to low volatility, and highlight the growing literature on their combinations.[17]

LOW VOLATILITY IN MULTI-ASSET PORTFOLIOS

Equity allocations are frequently part of a broader multi-asset mix.

The previous section considered practical applications of low volatility within equity portfolios. Of course, equity allocations are frequently part of a broader multi-asset mix; **including other components that already offer a degree of downside protection**, such as fixed income. This section illustrates—somewhat stylistically—how **low volatility equity indices can provide practitioners with an expanded toolkit** for multi-asset portfolio construction.

We shall offer two examples of multi-asset applications: first, showing how a simple equity/bond mix might be improved with the addition of a low volatility sleeve; and second, illustrating how low volatility strategies may be used to gain access to more volatile markets without significant sacrifices to risk management.

To begin, we consider three highly simplified equity/bond portfolios, constructed to represent stylized "conservative", "moderate" and "growth" objectives. These "traditional" portfolios each comprise static, rebalanced combinations of the S&P 500 and the S&P U.S. Treasury Bond Index. The conservative portfolio allocates 50% to both the equity and fixed income index, the moderate portfolio represents a 60% equity/40% bond mix, while the growth portfolio reflects a 70% equity/30% bond combination.

We also form "alternative" hypothetical portfolios, also rebalanced monthly to fixed allocations, which employ the S&P 500 Low Volatility Index as an additional option, occupying the middle ground between the lower-risk fixed income and higher-risk equity allocations. Providing the allocations in the form S&P U.S. Treasury Bond Index/S&P 500/S&P 500 Low Volatility Index, the "conservative" version holds a 40%/30%/30% split; the

[17] See Chan, Fei Mei and Craig J. Lazzara, "The Sum of the Parts," May 2017 and also "Outperformance in Equal Weight Indices," January 2018, pp. 23.

"moderate" version holds 30%/40%/30% allocations; and the final "growth" portfolio holds a 20%/50%/30% mix.[18]

Exhibit 15 provides pro forma summary statistics of the various traditional and alternative combinations. In each case, the alternative portfolios experienced higher returns without a commensurate increase in risk. This is primarily because **the inclusion of the S&P 500 Low Volatility Index allowed the alternative portfolios to have less exposure to bonds (and more to equities) at the same level of portfolio risk**.

Incorporating low volatility within a traditional equity/bond allocation could have delivered higher returns without a commensurate increase in risk.

Exhibit 15: Summary Statistics

CATEGORY	CONSERVATIVE		MODERATE		GROWTH	
	TRAD	ALT	TRAD	ALT	TRAD	ALT
Return (%)	7.8	8.6	8.4	9.1	8.8	9.6
Excess Return (%, Ann.)	-	0.7	-	0.7	-	0.7
Return Volatility (%, Ann.)	7.0	7.1	8.4	8.3	9.7	9.7
Return/Risk (Ann.)	1.12	1.21	1.00	1.09	0.91	0.99

All portfolios are hypothetical. Trad represents the traditional portfolio. Alt represents the alternative portfolio.
Source: S&P Dow Jones Indices LLC. Data based on monthly total return index levels from December 1990 to April 2018. All volatility and return figures are annualized. Past performance is no guarantee of future results. Table is provided for illustrative purposes and reflects hypothetical historical performance. Please see the Performance Disclosure at the end of this document for more information regarding the inherent limitations associated with back-tested performance.

Thus, the option of incorporating low volatility equity strategies within a multi-asset portfolio may offer the potential for a more calibrated approach to risk management and can improve long-term, or risk-adjusted, returns.

Turning to our second illustrative example, consider the position of a hypothetical asset owner originally following the "traditional" and "moderate" 60/40 allocation described above. Suppose this asset owner wished to gain exposure to emerging market equities, yet was concerned about the potential volatility such an allocation may entail. How might low volatility help?

To illustrate the problem and one potential solution, we consider three simple portfolios. The "U.S." portfolio maintains 60% in the S&P 500 and 40% in the S&P U.S. Treasury Bond Index, and is recognizable as the moderate, traditional option above. The "U.S. + EM" portfolio holds 40% in each of the S&P 500 and the Treasury Bond Index, as well as 20% in the S&P Emerging BMI. Finally, the "U.S. + Low Vol EM" portfolio replaces the S&P Emerging BMI in the U.S. + EM portfolio with the S&P BMI Emerging Market Low Volatility Index.

[18] The allocations were set such that the volatility of each alternative portfolio was similar to that of its traditional counterpart over the entire period, provided that the low volatility allocation was set at 30%.

Exhibit 16 provides summary statistics for these hypothetical portfolios, assuming, as before, a monthly rebalance to static weights. (Note that the figures for the U.S. portfolio differ from those of Exhibit 15 due to the shorter history available for the emerging market indices.)

The addition of an emerging market-based low volatility strategy might have provided a way to access the higher returns of those markets, but without a significant increase in risk.

Exhibit 16: Summary Statistics

CATEGORY	U.S.	U.S. + EM	U.S. + LOW VOL EM
Return (%)	6.23	6.53	6.72
Risk (%)	8.53	9.54	8.20
Return/Risk	0.73	0.68	0.82

All portfolios are hypothetical.
Source: S&P Dow Jones Indices LLC. Data based on monthly total return index levels from January 2001 to April 2018. All figures are annualized. Past performance is no guarantee of future results. Table is provided for illustrative purposes and reflects hypothetical historical performance. Please see the Performance Disclosure at the end of this document for more information regarding the inherent limitations associated with back-tested performance.

As Exhibit 16 shows, replacing some U.S. equity exposure with a capitalization-weighted emerging market exposure might have delivered higher returns, but at a substantially higher level of overall risk. In contrast, the addition of an emerging market-based low volatility strategy might have provided a way to access the higher returns of those developing markets, but without a significant increase in risk. In fact, diversification effects might have allowed for an overall risk reduction.

These examples of potential applications of low volatility indices in a portfolio context are predicated on the assumption that the historical performance of low volatility will persist. **It is critical, therefore, to ask whether low volatility indices might display similarly higher risk-adjusted returns in the next few decades, as they displayed in the past**. While we cannot hope to answer this question definitively, the next section aims to provide the grounds on which optimism—or pessimism—might be founded.

It is critical to ask whether low volatility indices will offer improved risk-adjusted returns in the future.

PERSISTENCE OF THE LOW VOLATILITY ANOMALY

Explanations for the low volatility "anomaly" typically approach the problem from the opposite angle: offering behavioral or structural theories as to **why *higher* volatility stocks might *underperform***. From this perspective, the low volatility anomaly arises because investors "overpay" for riskier stocks compared to more pedestrian alternatives.

On the behavioral side, the "**preference for lotteries**" theory argues that the price of higher volatility stocks is elevated by a phenomenon analogous to the demand for—and purchase of—lottery tickets. Buyers of volatile stocks may well appreciate that, *on average,* they are likely to be disappointed but **they are willing to make a purchase, simply because of the *possibility* of extreme gains**. To the extent that some (or many)

investors continue to value extreme gains more highly than would be strictly proportional, the low volatility anomaly has the potential to persist.[19]

On the structural side, one can question the very premise that expected returns (in excess over a risk-free rate) should be commensurate with risk. This premise arises from the belief that market participants will arbitrage away any discrepancies—for example, by selling higher volatility stocks in favor of leveraged positions in less volatile stocks. In practice however, for many investors, the use of leverage is restricted by policy or incurs significant additional costs beyond a risk-free rate. In other words, **there may simply not be enough "arbitrageurs"** who are willing and able to exploit such tactics. **This creates the *potential* for lower-risk stocks to offer higher risk-adjusted returns**.[20]

Behavioral and structural reasons may be important in explaining the performance of low volatility indices.

This argument continues by noting that many institutional portfolios and funds maintain a non-zero allocation to cash equivalents in their equity portfolios, in order, for example, to meet operational needs or as a consequence of trading activity.[21] Of course, **unless it is biased towards stocks with a higher-than-average participation in market movements (or employs leverage) *any* equity portfolio with a significant cash allocation will likely lag the market when it rises**. Since many equity managers target one-to-one participation in the market's gains, they are obliged to bias their portfolios towards higher-risk stocks. Thus—the argument concludes—the disproportionate demand from institutional investors for higher-risk stocks provides the initial source of the low volatility anomaly, while the limited availability of low-cost leverage explains the inability of arbitrageurs to diminish it.[22]

In practice, a combination of structural and behavioral effects may be important in determining the performance of low volatility strategies.[23] While we cannot say whether they will continue, Exhibit 17 illustrates that the S&P 500 Low Volatility Index—one of the most widely followed of its kind—typically offered an improvement in risk-adjusted returns, and this has not visibly diminished since its launch in 2011. Historically, only around the "dotcom bubble" did the S&P 500 Low Volatility Index endure an extended period of underperformance—unsurprisingly, given the roaring

[19] Bali, Turan G., Stephen Brown, Scott Murray, and Yi Tang, "A Lottery Demand-Based Explanation of the Beta Anomaly," *Journal of Financial and Quantitative Analysis*, 52(6), 2369-2397, Dec. 1, 2016.

[20] Baker, Malcom, Brendan Bradley, and Jeffrey Wurgler, "Benchmarks as Limits to Arbitrage: Understanding the Low-Volatility Anomaly," *Financial Analysts Journal,* Vol. 67, No. 1, pp. 40-54, Jan. 21, 2011.

[21] See Edwards, Tim, Craig J. Lazzara, and Luca Ramotti, "The Volatility of Active Management," S&P Dow Jones Indices, August 2016, for empirical evidence that actively managed U.S. equity mutual funds appear to display a structural preference for higher-beta stocks in generating higher-risk portfolios, but prefer cash allocations in de-risking.

[22] See also Frazzini, Andrea and Lasse Heje Pedersen, "Betting Against Beta," *Journal of Financial Economics*, Vol. 111, Issue 1, January 2014. For an examination of the persistence of the low volatility anomaly, see Edwards, Tim, Craig J. Lazzara, and Hamish Preston, "The Persistence of Smart Beta," S&P Dow Jones Indices, pp. 13-15, October 2015.

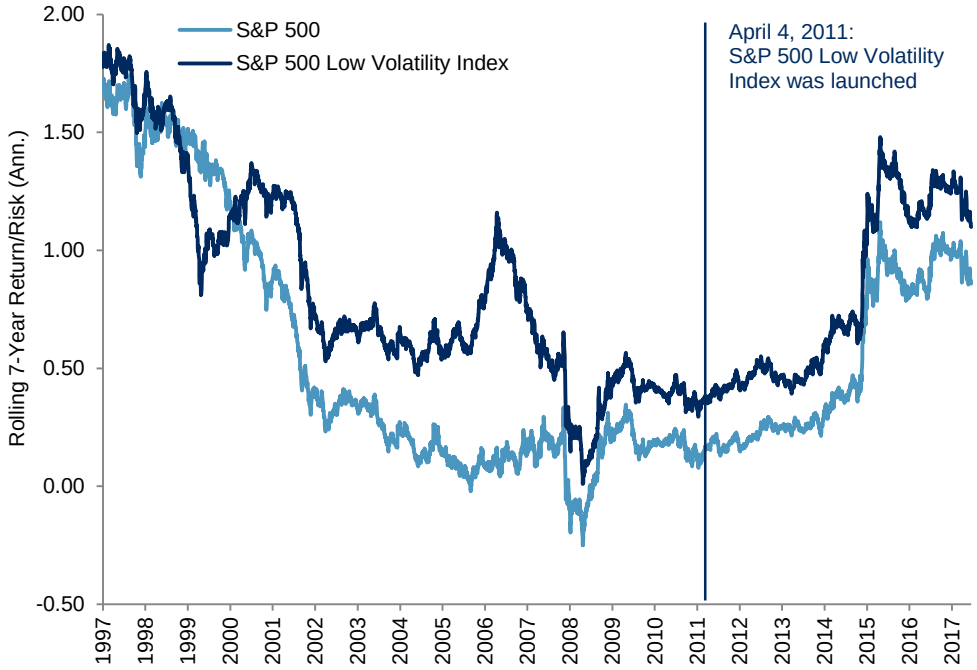
[23] For an overview of academic literature on the low volatility anomaly, see Soe, Aye, "The Low-Volatility Effect: A Comprehensive Look," S&P Dow Jones Indices, August 2012.

bull market of the time and low volatility's propensity to underperform during market gains.

The S&P Low Volatility Index was launched on April 4, 2011.

The improvement in risk-adjusted returns has not visibly diminished since then.

Exhibit 17: Return/Risk Ratio Has Not Diminished Since 2011



Source: S&P Dow Jones Indices LLC. Data based on daily total return index levels from Nov. 16, 1990, to April 30, 2018. All figures are annualized. Past performance is no guarantee of future results. Chart is provided for illustrative purposes and reflects hypothetical historical performance. Please see the Performance Disclosure at the end of this document for more information regarding the inherent limitations associated with back-tested performance.

LOW VOLATILITY OR MINIMUM VOLATILITY INDICES?

We conclude by offering a summary of the differences between low volatility indices (as discussed so far) and the similar, yet importantly different, concept of *minimum* volatility indices.[24]

At a basic level, low volatility indices form portfolios from the *least volatile stocks* out of a given universe. In contrast, minimum volatility indices aim to select *the least volatile portfolio* of stocks from all possible portfolios of stocks. Consequently, **a minimum volatility index might well contain some stocks with relatively high volatilities, if their correlation with the rest of the portfolio is low enough to provide a diversification benefit**.

In part because the universe of all possible portfolios is a *lot* bigger than the universe of possible portfolio constituents, minimum volatility indices require greater sophistication in both selection and weighting. Typically, an optimization procedure is applied to find the particular combination of

[24] For a full comparison of low and minimum volatility indices, please see Brzenk, Phillip and Aye Soe, "Inside Low Volatility Indices," S&P Dow Jones Indices, January 2017.

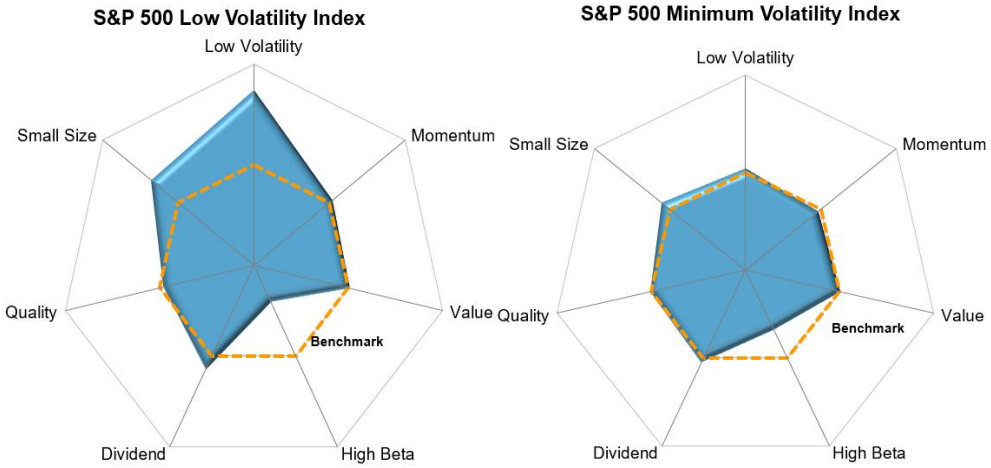
stocks that results in the least volatile portfolio. Minimum volatility indices also employ constraints at a sector and factor level, limiting the extent to which the final combination deviates from its benchmark and limiting the potential turnover at each rebalance.[25]

One way to demonstrate the impact of these differences in methodology is to consider the factor exposure of the two indices, as summarized in S&P DJI's quarterly S&P 500 Factor Dashboard.[26] Exhibit 18 shows the factor exposures of the S&P 500 Low Volatility Index and the S&P 500 Minimum Volatility Index as of Q1 2018. The central dotted line represents the (neutral by definition) factor exposures of the benchmark S&P 500, the outer line (inner line) represents the factor exposure for a portfolio owning the single S&P 500 stock with the highest (lowest) factor score. A point halfway from the benchmark to the outer edge would indicate a portfolio with the same average exposure to low volatility stocks as a cap-weighted portfolio containing half the capitalization of the S&P 500, selected from the lowest-ranked stocks by volatility (or momentum, or value, and so on).[27]

Exhibit 18: Low Volatility and Minimum Volatility Indices Can Have Different Factor Exposures

Minimum volatility indices are different to low volatility indices.

Their factor exposures illustrate differences in their construction.



Source: S&P Dow Jones Indices LLC. S&P 500 Factor Dashboard Q1 2018. Data as of March 29, 2018. Past performance is no guarantee of future results. Charts are provided for illustrative purposes.

As Exhibit 18 illustrates, **minimum volatility indices do not necessarily maintain a significant bias towards lower volatility stocks**. This may help to explain why the S&P 500 Minimum Volatility Index has typically provided more volatile returns than the S&P 500 Low Volatility Index. For example, computing rolling 12-month trailing volatilities in each index between December 1991 and April 2018 shows that the S&P 500 Low Volatility Index offered less volatile returns in 67% of the 317 months. On the other hand, due to their unconstrained design, low volatility indices can

[25] See the S&P 500 Minimum Volatility Index Methodology.

[26] For more information, please see the S&P 500 Factor Dashboard as of Q1 2018.

[27] A more detailed explanation of factor diagrams is offered in Lazzara, Craig, "Visualizing Factor Exposures," Jan. 3, 2017.

maintain a higher tracking error to their benchmark, and may also require higher levels of turnover to replicate.

CONCLUSIONS

S&P Dow Jones Indices publishes a range of low volatility equity indices, offered in various markets as the basis for benchmarks or investment products. These indices operate by selecting stocks that have historically displayed lower volatility than their peers, a process that has resulted in the indices typically selecting stocks that were less volatile in the future.

Over extended time periods, many of these indices have displayed relatively attractive investment characteristics in comparison with their parent benchmarks—nearly always displaying less risk, often displaying an improved risk/return ratio and, in several cases, even offering an improvement in total returns.

Low volatility indices can provide tools suitable to a more calibrated approach to risk management and return generation.

The performance of low volatility indices may be understood through their different upside and downside capture ratios, a feature that helps to explain how these indices relate to, and may outperform, their benchmarks over the market cycle. Further perspectives may be offered by their sectoral allocations, which typically differ significantly from those of their benchmark.

When combined with other factor-based equity indices, or when used within a multi-asset context, low volatility indices can provide tools suitable to a more calibrated approach to risk management and return generation.

APPENDIX

Exhibit 19: SPDJI Low Volatility Indices

LOW VOLATILITY INDEX	PARENT INDEX	LAUNCH DATE
S&P 500 Low Volatility Index	S&P 500	April 4, 2011
S&P BMI International Developed Low Volatility Index	S&P Developed BMI Ex-U.S. & Korea LargeMidCap	December 5, 2011
S&P BMI Emerging Markets Low Volatility Index	S&P Emerging Plus LargeMidCap	December 5, 2011
S&P 500 Low Volatility Index CAD Hedged	S&P 500	January 24, 2012
S&P Europe 350 Low Volatility Index	S&P Europe 350	July 9, 2012
S&P MidCap 400 Low Volatility Index	S&P MidCap 400	September 24, 2012
S&P SmallCap 600 Low Volatility Index	S&P SmallCap 600	September 24, 2012
S&P Pan Asia Low Volatility Index	S&P Pan Asia Ex-NZ LargeMidCap	November 19, 2012
S&P Korea Low Volatility Index	S&P Korea BMI	May 8, 2013
S&P Nordic Low Volatility Index	S&P Nordic BMI	May 17, 2013
S&P South Africa Low Volatility Index	S&P South Africa Composite	January 29, 2014
S&P Southern Europe Low Volatility Index	S&P Italy BMI, S&P Portugal BMI, S&P Spain BMI	February 28, 2014
S&P Emerging Markets Low Volatility Select Index	S&P Emerging Plus LargeMidCap	November 13, 2014
S&P Eurozone Low Volatility Index	S&P Eurozone BMI	March 30, 2015
S&P Eurozone Low Volatility USD Hedged Index	S&P Eurozone BMI	March 30, 2015
S&P Developed Asia Low Volatility	S&P Asia Pacific LargeMidCap	August 5, 2015
S&P EPAC Ex-Korea Low Volatility	S&P EPAC Ex-Korea LargeMidCap	May 25, 2015
S&P EPAC Ex-Korea Low Volatility USD Hedged Index	S&P EPAC Ex-Korea LargeMidCap	May 25, 2015
S&P Japan 500 Low Volatility Index	S&P Japan 500	June 8, 2015
S&P Japan 500 Low Volatility USD Hedged Index	S&P Japan 500	June 8, 2015
S&P Europe 350 Carbon Efficient Select Low Volatility Index	S&P Europe 350 Carbon Efficient Select Index	January 18, 2016
S&P Global Low Volatility Index	S&P Global LargeMidCap	April 11, 2016
S&P Developed Low Volatility Index	S&P Developed LargeMidCap	April 11, 2016
S&P/ASX 200 Low Volatility Index	S&P/ASX 200	October 17, 2017

Source: S&P Dow Jones Indices LLC. Data as of April 2018. Table is provided for illustrative purposes.

APPENDIX B

Exhibit 20: S&P 500 and the S&P 500 Low Volatility Index

PERIOD		ANNUALIZED RETURN (%)		ANNUALIZED VOLATILITY (%)		RETURN/RISK		12-MONTH MAXIMUM DRAWDOWNS (%)	
		S&P 500	S&P 500 LOW VOLATILITY INDEX	S&P 500	S&P 500 LOW VOLATILITY INDEX	S&P 500	S&P 500 LOW VOLATILITY INDEX	S&P 500	S&P 500 LOW VOLATILITY INDEX
Years	1	13.27	8.81	8.50	7.39	1.56	1.19	6.13	4.24
	3	10.57	10.52	10.26	9.04	1.03	1.16	8.36	5.29
	5	12.96	10.49	9.86	9.08	1.31	1.16	8.36	5.29
	7	12.30	12.44	10.98	8.82	1.12	1.41	16.26	5.50
	10	9.02	10.69	14.99	11.00	0.60	0.97	46.41	28.96
	15	9.55	10.57	13.22	9.86	0.72	1.07	46.41	28.96
	20	6.42	8.69	14.86	11.15	0.43	0.78	46.41	28.96
	25	9.59	10.52	14.24	10.93	0.67	0.96	46.41	28.96

Source: S&P Dow Jones Indices LLC. Figures based on monthly data as of April 2018. Past performance is no guarantee of future results. Table is provided for illustrative purposes and reflects hypothetical historical performance. Please see the Performance Disclosure at the end of this document for more information regarding the inherent limitations associated with back-tested performance.

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PERFORMANCE DISCLOSURE

The S&P 500 Low Volatility Index was launched on April 4, 2011. The S&P Europe 350 Low Volatility Index was launched on July 9, 2012. The S&P Korea Low Volatility Index was launched on May 8, 2013. The S&P Pan Asia Low Volatility Index was launched on November 19, 2012. The S&P South Africa Low Volatility Index was launched on January 29, 2014. The S&P/ASX 200 Low Volatility Index was launched on October 17, 2017. The S&P/TSX Composite Low Volatility Index was launched on April 10, 2012. The S&P MidCap 400 Low Volatility Index was launched on September 24, 2012. The S&P SmallCap 600 Low Volatility Index was launched on September 4, 2012. The S&P Japan 500 Low Volatility Index was launched on June 8, 2015. The S&P BMI Emerging Markets Low Volatility Index was launched on December 5, 2011. The S&P 500 Momentum was launched on November 18, 2014. The S&P 500 Minimum Volatility Index was launched on November 9, 2012. All information presented prior to an index's Launch Date is hypothetical (back-tested), not actual performance. The back-test calculations are based on the same methodology that was in effect on the index Launch Date. Complete index methodology details are available at www.spdji.com.

S&P Dow Jones Indices defines various dates to assist our clients in providing transparency. The First Value Date is the first day for which there is a calculated value (either live or back-tested) for a given index. The Base Date is the date at which the Index is set at a fixed value for calculation purposes. The Launch Date designates the date upon which the values of an index are first considered live: index values provided for any date or time period prior to the index's Launch Date are considered back-tested. S&P Dow Jones Indices defines the Launch Date as the date by which the values of an index are known to have been released to the public, for example via the company's public website or its datafeed to external parties. For Dow Jones-branded indices introduced prior to May 31, 2013, the Launch Date (which prior to May 31, 2013, was termed "Date of introduction") is set at a date upon which no further changes were permitted to be made to the index methodology, but that may have been prior to the Index's public release date.

Past performance of the Index is not an indication of future results. Prospective application of the methodology used to construct the Index may not result in performance commensurate with the back-test returns shown. The back-test period does not necessarily correspond to the entire available history of the Index. Please refer to the methodology paper for the Index, available at www.spdji.com for more details about the index, including the manner in which it is rebalanced, the timing of such rebalancing, criteria for additions and deletions, as well as all index calculations.

Another limitation of using back-tested information is that the back-tested calculation is generally prepared with the benefit of hindsight. Back-tested information reflects the application of the index methodology and selection of index constituents in hindsight. No hypothetical record can completely account for the impact of financial risk in actual trading. For example, there are numerous factors related to the equities, fixed income, or commodities markets in general which cannot be, and have not been accounted for in the preparation of the index information set forth, all of which can affect actual performance.

The Index returns shown do not represent the results of actual trading of investable assets/securities. S&P Dow Jones Indices LLC maintains the Index and calculates the Index levels and performance shown or discussed, but does not manage actual assets. Index returns do not reflect payment of any sales charges or fees an investor may pay to purchase the securities underlying the Index or investment funds that are intended to track the performance of the Index. The imposition of these fees and charges would cause actual and back-tested performance of the securities/fund to be lower than the Index performance shown. As a simple example, if an index returned 10% on a US $100,000 investment for a 12-month period (or US $10,000) and an actual asset-based fee of 1.5% was imposed at the end of the period on the investment plus accrued interest (or US $1,650), the net return would be 8.35% (or US $8,350) for the year. Over a three year period, an annual 1.5% fee taken at year end with an assumed 10% return per year would result in a cumulative gross return of 33.10%, a total fee of US $5,375, and a cumulative net return of 27.2% (or US $27,200).

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