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In Search of the Low Volatility Anomaly: A Case Study

"There is nothing more deceptive than an obvious fact."

- Sir Arthur Conan Doyle, "The Boscombe Valley Mystery"

EXECUTIVE SUMMARY

- We introduce a simple analytic toolkit to assess the performance of factor indices compared to their cap-weighted parents. The methodology attributes a factor index's excess returns to its incremental (or decremental) level of risk and to a changed tradeoff between risk and return.
- The low volatility "anomaly," as defined by an improved tradeoff between risk and return, not only exists, but has strengthened in the past six years.
- More broadly, this toolkit can be used to assess the existence and persistence of any factor-based effect.

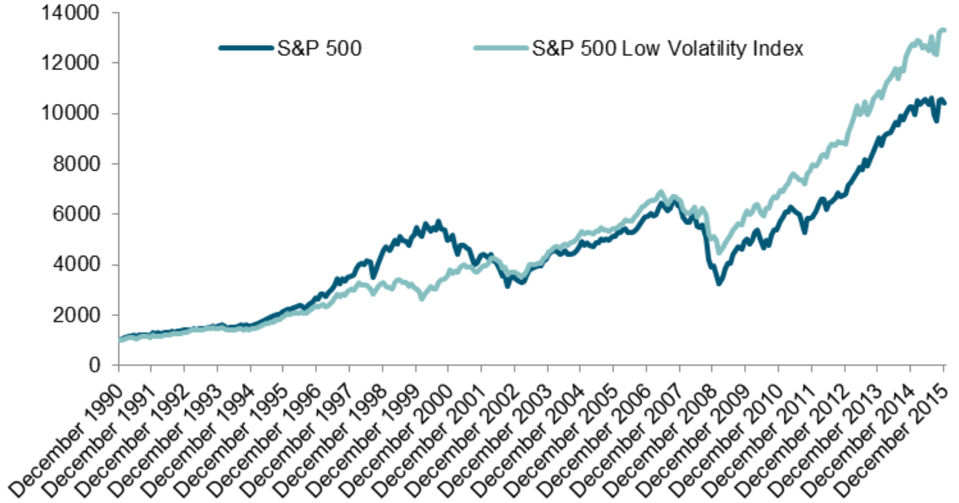
Classical economic theory tells us that risk and return are directly related—in general, in order to earn above-average returns an investor must be prepared to bear above-average risks. Empirically, however, this relationship does not hold; ample research and evidence point to the existence of a low volatility factor comparable to other factors such as beta, small size, or cheap valuation.[1] Because this seems to fly in the face of what we think we know about risk and return, the low volatility factor is often referred to as the low volatility anomaly.

Exhibit 1 shows that the S&P 500® Low Volatility Index[2] (including backtested history) outperformed its parent S&P 500 between 1991 and 2015, despite exhibiting lower risk.

[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; Haugen, Robert A. and A. James Heines, "Risk and the Rate of Return on Financial Assets: Some Old Wine in New Bottles," *Journal of Financial and Quantitative Analysis*, December 1975; Baker, Malcolm, Brendan Bradley, and Jeffrey Wurgler, "Benchmarks as Limits to Arbitrage: Understanding the Low-Volatility Anomaly,' *Financial Analysts Journal*, January/February 2011.

[2] The S&P 500 Low Volatility Index is designed to reflect the performance of the 100 stocks in the S&P 500 with the lowest historical standard deviation of returns.

Exhibit 1: Performance of the S&P 500 Low Volatility Index and the S&P 500



Source: S&P Dow Jones Indices LLC. Data from Dec. 31, 1990, through Dec. 31, 2015. The S&P 500 Low Volatility Index was launched on April 4, 2011. All data prior to that date are back-tested. Past performance is no guarantee of future results. Chart is provided for illustrative purposes and reflects hypothetical historical performance. Please see the Performance Disclosures at the end of this document for more information regarding the inherent limitations associated with back-tested performance.

The low volatility phenomenon not only applies to large-cap U.S. stocks, but rather it seems to extend across global equity markets.

Over the 25 years covered by Exhibit 1, the low volatility index had a compound annual return of 10.9%, with 11% annualized volatility. Comparable data for the benchmark S&P 500 are a compound return of 9.8% and volatility of 14%.[3] Importantly, the low volatility phenomenon not only applies to large-cap U.S. stocks, but rather it seems to extend across global equity markets.[4]

Theoretical explanations for the existence of the low volatility anomaly abound.[5] Baker, Bradley, and Taliaferro, for example, demonstrated that the low beta anomaly can be decomposed into stock- and industry-level effects.[6] Our immediate focus here, however, is on the *persistence* of the low volatility anomaly, rather than on explanations for its existence.[7] **More broadly, we offer a simple toolkit that can be used to assess the persistence of any factor-based effect.**

Exhibit 2 charts the rolling five-year return difference between the S&P 500 Low Volatility Index and the S&P 500. It is easy to look at the exhibit and conclude that the once-potent low volatility effect has faded away in the

[3] Volatility is computed as the annualized standard deviation of monthly returns.

[4] Chan, Fei Mei and Craig J. Lazzara, "Is the Low Volatility Anomaly Universal?" April 2015.

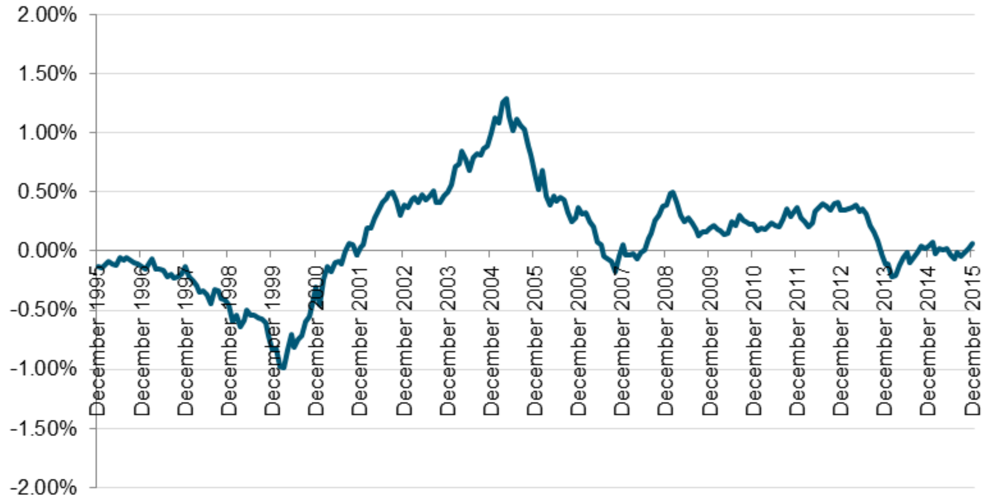
[5] Blitz, David, Eric G. Falkenstein, and Pim van Vliet, "Explanations for the Volatility Effect: An Overview Based on the CAPM Assumptions," May 28, 2013.

[6] Though beta and volatility are different, both are commonly used risk measures. Baker, Malcolm, Brendan Bradley, and Ryan Taliaferro, "The Low Beta Anomaly: A Decomposition into Micro and Macro Effects," September 2013.

[7] For a summary of research on the existence of the low volatility anomaly, see Soe, Aye M., "The Low-Volatility Effect: A Comprehensive Look," August 2012. For a more general treatment of issues surrounding the persistence of factor effects, see Preston, Hamish, Tim Edwards, and Craig J. Lazzara, "The Persistence of Smart Beta," October 2015.

past few years. Since early 2013, the performance spread has drifted around zero. Does this mean that the low volatility anomaly has disappeared?

Exhibit 2: 5-Year Rolling Geometric Mean Difference (S&P 500 Low Volatility Index Versus the S&P 500)



Source: S&P Dow Jones Indices LLC. Data from Dec. 31, 1990, through Dec. 31, 2015. The S&P 500 Low Volatility Index was launched on April 4, 2011. All data prior to that date are back-tested. Past performance is no guarantee of future results. It is not possible to invest directly in an index, and index returns do not reflect expenses an investor would pay. Chart is provided for illustrative purposes and reflects hypothetical historical performance. Please see the Performance Disclosures at the end of this document for more information regarding the inherent limitations associated with back-tested performance.

Risk adjustment is important generally nowhere more so than in considering strategies like low volatility.

PEELING THE ONION

Volatility Drag

One can, of course, attempt to address this question with a detailed factor analysis.[8] Here we will apply a simpler approach, based on the view that we can analyze the difference between any two indices in terms of two variables: the differences in the portfolios' *risk* levels and the differences in the *ratio of return to risk*. Risk adjustment is important generally[9], and nowhere more so than in considering strategies like low volatility, for which reduced risk exposure is an integral part of the index's definition.

An obvious first step in analyzing the impact of differential risk is to remember that the arithmetic of compounding favors less-volatile return patterns. Consider the hypothetical return patterns described in Exhibit 3.

[8] See, e.g., Kang, Xiaowei, "Evaluating Alternate Beta Strategies," February 2012.

[9] See Preston, Edwards, and Lazzara, *op. cit*., pp. 8-10.

Exhibit 3: Illustration of Volatility Drag

PERIOD 1 (%)	PERIOD 2 (%)	COMPOUND RETURN (%)	GEOMETRIC MEAN (%)
1	-1	-0.01	-0.003
5	-5	-0.25	-0.125
10	-10	-1.00	-0.501
15	-15	-2.25	-1.131
20	-20	-4.00	-2.020
25	-25	-6.25	-3.175
30	-30	-9.00	-4.606
35	-35	-12.25	-6.325
40	-40	-16.00	-8.348
45	-45	-20.25	-10.697
50	-50	-25.00	-13.397

Source: S&P Dow Jones Indices LLC. Table is provided for illustrative purposes and reflects hypothetical performance.

We can think about return along two dimensions: the amount of risk borne and the tradeoff between risk and return.

In each case, the *expected* return is 0%, since the results for period 1 and period 2 offset each other.[10] However, there is a notable difference between increasing, and then declining, 1%, relative to increasing, and then declining, 50%. The end result depends on the compounding of each period's return, and Exhibit 3 shows us that the compound return (and geometric mean return) decline as the pattern of returns becomes more volatile. Therefore *volatility drag*—i.e., the difference between the geometric and arithmetic average returns—grows as volatility increases. Since a low volatility index is, by design, less volatile than its parent, **its performance should be advantaged by lower volatility drag**.

We can express these concepts algebraically by defining the following terms.

Expected return = arithmetic mean = AM

Compound periodic return = geometric mean = GM

Volatility drag = VD = GM – AM

Using subscript $_p$ for a portfolio (e.g., a low volatility index) and subscript $_b$ for a benchmark (e.g., the cap-weighted index from which the low volatility index draws its constituents) lets us separate the volatility drag from the differences in expected returns.

$$\text{Compound return difference} = GM_p - GM_b$$

$$= (AM_p + VD_p) - (AM_b + VD_b)$$

$$= (AM_p - AM_b) + (VD_p - VD_b)$$

[10] We compute the expected return by taking the arithmetic mean of both periods' results.

So the difference in compound average returns (as shown in Exhibit 2) is accounted for by **the difference in expected returns plus the difference in volatility drag**.

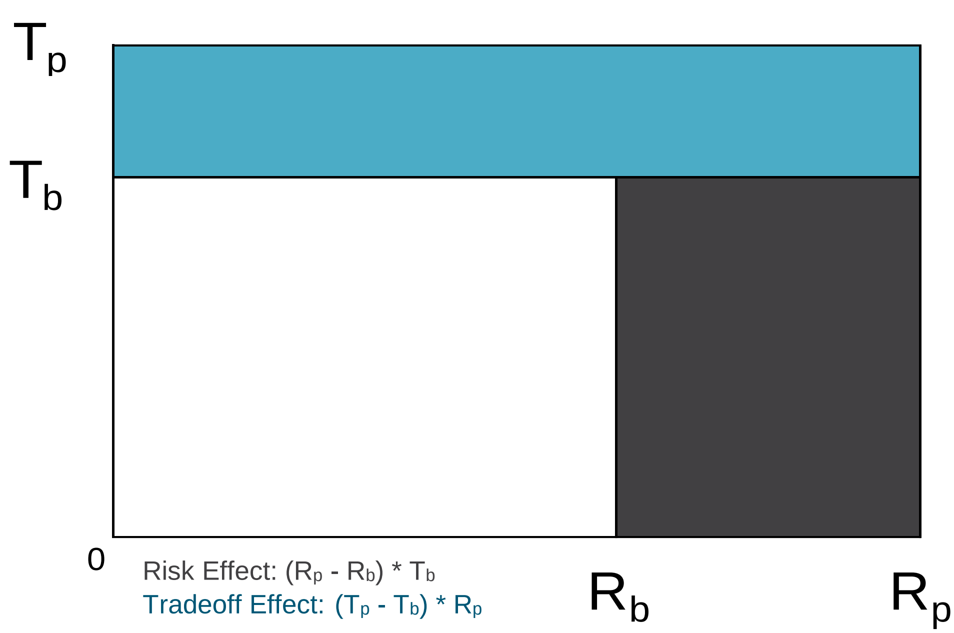
Expected Returns

Exhibit 4 gives us a framework within which to think about expected, or arithmetic, return differences. We can think about return along two dimensions: the *amount* of risk borne (denoted by R) and the *tradeoff* between risk and return (denoted by T). In fact, T is *defined* by dividing return by risk; T tells us how much return we receive in exchange for every unit of risk we bear. The product of R and T is exactly equal to return. In Exhibit 4, therefore, the benchmark's return is denoted by (T_b * R_b), while the portfolio's return is denoted by (T_p * R_p).

The better the portfolio's return/risk tradeoff, the higher its incremental return.

We divide the difference between portfolio and benchmark return into two components, shaded in gray and blue in Exhibit 4. We call the gray area the *risk effect*; algebraically it is defined as (R_p - R_b) * T_b. Think of the risk effect as the incremental (or decremental) return earned as a function of the portfolio bearing more (or less) risk than the benchmark. Since risk bearing theoretically pays off, the risk effect should be positive for a portfolio that takes more risk than its benchmark and negative for a portfolio that takes less risk than its benchmark.

Exhibit 4: Decomposition of Arithmetic Return Differences



Source: S&P Dow Jones Indices LLC. Chart is provided for illustrative purposes.

The tradeoff effect, on the other hand, tells us whether the portfolio was more or less efficient than the benchmark in producing performance. The better the portfolio's return/risk tradeoff, in other words, the higher its incremental return.[11]

The difference between portfolio and benchmark returns can thus be divided into three components.

1. The change in volatility drag, which should favor lower-risk strategies.
2. The change in return commensurate with changing risk. This should favor higher-risk strategies most of the time, since there is typically a positive reward for bearing risk. Combining this risk effect with the change in volatility drag lets us calculate a total risk effect.
3. The change in the return/risk tradeoff, which can be either positive or negative**. If there is an anomaly to be found, this is where it is likely to reside.**

It appears that about one-half of the performance advantage of the low volatility strategy came simply because it was less volatile, but that first impression may be misleading.

Cumulative Performance

Exhibit 5 illustrates the application of these principles over the entire period for which return data exist for the S&P 500 Low Volatility Index. Our observations include the following.

- The difference in *geometric* means between the S&P 500 Low Volatility Index and the S&P 500 is 0.083% per month. This seems like a small difference, but the cumulative return over 25 years for the S&P 500 Low Volatility Index amounts to 1331%, versus 1040% for the S&P 500.[12]
- The difference in *arithmetic* means (i.e., simple average monthly returns) between the two indices was 0.046% per month, while the difference in volatility drag was 0.037% per month. So at first blush, it appears that about one-half of the performance advantage of low volatility resulted simply because the low vol strategy was less volatile.
- But that first impression may be misleading. It is inaccurate to conclude that low volatility is mainly a risk reduction story, for the reasons shown in Exhibit 5. **The low volatility strategy's lower volatility may be a double-edged sword.** There was a positive return for bearing risk in the 1991-2015 interval. The S&P 500 Low Volatility Index's return was reduced by 0.205% per month since it bore less risk than the S&P 500. Adding this effect to the impact of volatility drag means that the low volatility strategy's reduced volatility *cost* the index an average of 0.168% per month.

[11] We acknowledge some ambiguity in constructing Exhibit 4, since the space at the upper right of the chart, which we assigned to the tradeoff effect, could arguably be a risk effect, or a separate interaction effect. Algebraically, the value of the ambiguity is $(R_p – R_b) * (T_p – T_b)$. For a low volatility index, the first of these terms is definitionally negative and the second is empirically positive, so the product of the two is usually negative. This means that treating the ambiguity as part of the tradeoff effect reduces the measured tradeoff effect below what it would otherwise be. We err, in other words, in the direction of conservatism.

[12] This example is for illustrative purpose only.

- Countering the risk effects was the S&P 500 Low Volatility Index's improved reward for bearing risk. The S&P 500 produced 0.209 units of return for every unit of risk, whereas the S&P 500 Low Volatility Index's return to risk ratio was an impressive 0.288. The impact of this improved return to risk tradeoff resulted in an incremental performance of 0.251% per month.

Arguably, this 0.251% per month is a measure of the low volatility anomaly. Its existence is not a reward for risk bearing, which is accounted for separately—and in any event, low volatility's lower risk should not require a return premium.

The S&P 500 Low Volatility Index's returns have (unsurprisingly) consistently benefited from reduced volatility drag.

Exhibit 5: Sources of Monthly Relative Performance

REFERENCE	FACTOR	S&P 500 LOW VOLATILITY INDEX (%)	S&P 500 (%)	DIFFERENCE (%)
A	Geometric Mean	0.867	0.784	0.083
B	Arithmetic Mean	0.918	0.871	0.046
C	Volatility Drag (A-B)	-0.051	-0.088	0.037
D	Standard Deviation	3.187	4.168	-
E	Reward for Risk (B/D)	0.288	0.209	-
F	Impact of Changed Risk Level ((Dp-Db)*Eb)	-	-	-0.205
G	Impact of Improved Tradeoff ((Ep-Eb)*Dp)	-	-	0.251
H	Difference in Arithmetic Means (F+G)	-	-	0.046
I	Sum of Risk Effects (C+F)	-	-	-0.168
J	Improved Tradeoff, Arguably an Anomaly (G)	-	-	0.251
K	Difference in Geometric Means (I+J)	-	-	0.083

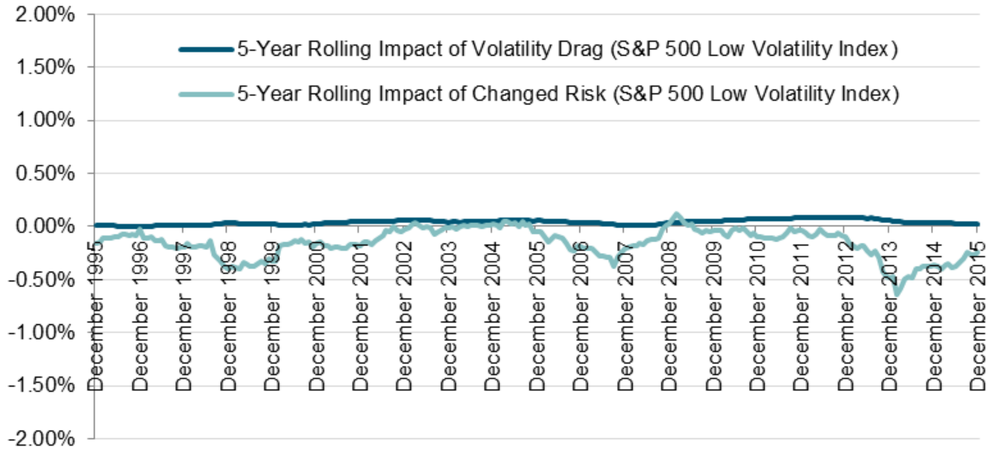
Source: S&P Dow Jones Indices LLC. Data from Dec. 31, 1990, through Dec. 31, 2015. The S&P 500 Low Volatility Index was launched on April 4, 2011. All data prior to that date are back-tested. Past performance is no guarantee of future results. Table is provided for illustrative purposes and reflects hypothetical historical performance. Please see the Performance Disclosures at the end of this document for more information regarding the inherent limitations associated with back-tested performance.

DECOMPOSITION OVER TIME

Exhibit 5 is an overview of 25 years of index history. To understand whether the putative low volatility anomaly is increasing or (as Exhibit 2 suggests) decreasing, we need to look at how the components of return have evolved through time. We will use a rolling five-year window, just as in Exhibit 2.

Exhibit 6 shows the evolution of volatility drag and the impact of changed risk (rows C and F in Exhibit 5). The S&P 500 Low Volatility Index's returns have (unsurprisingly) consistently benefited from reduced volatility drag, but they have typically been reduced because the portfolio assumes less risk than its benchmark. More often than not, the sum of these risk effects was negative—for most of the period measured in Exhibit 6, there was a positive reward for risk bearing, and the reduction in return from taking on less risk typically swamped the benefits of lower volatility drag.

Exhibit 6: Impact of Volatility Drag and Changed Risk

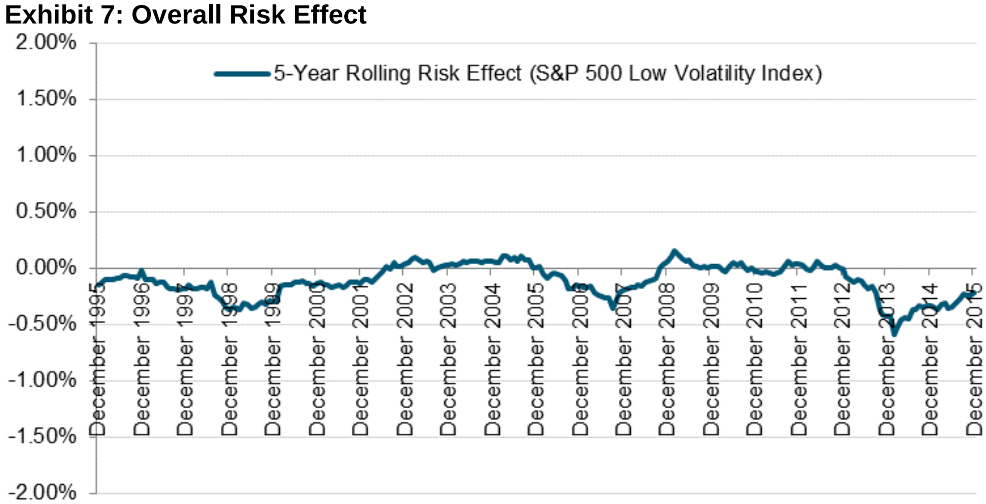


Source: S&P Dow Jones Indices LLC. Data from Dec. 31, 1990, to Dec. 31, 2015. The S&P 500 Low Volatility Index was launched on April 4, 2011. All data prior to that date are back-tested. Past performance is no guarantee of future results. Chart is provided for illustrative purposes and reflects hypothetical historical performance. Please see the Performance Disclosures at the end of this document for more information regarding the inherent limitations associated with back-tested performance.

The tradeoff effect contributed to the S&P 500 Low Volatility Index's underperformance during the inflation of the technology bubble in 1997-1999.

This is more clearly seen in Exhibit 7, which combines the two effects shown in Exhibit 6. If this were the extent of the low volatility story, there would be no challenge to market efficiency and no academic discussion of a possible anomaly, since **the S&P 500 Low Volatility Index's lower risk was a performance drag most of the time**.

Exhibit 7: Overall Risk Effect



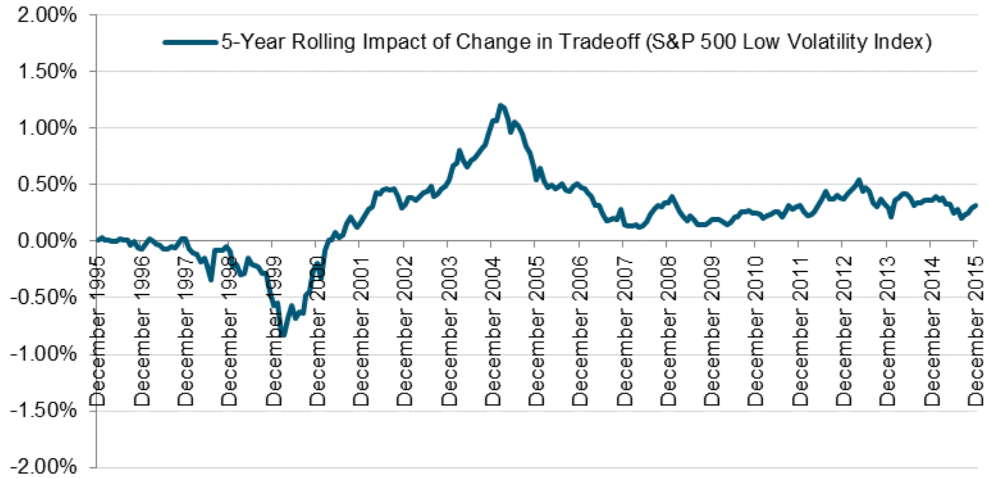
Source: S&P Dow Jones Indices LLC. Data from Dec. 31, 1990, to Dec. 31, 2015. The S&P 500 Low Volatility Index was launched on April 4, 2011. All data prior to that date are back-tested. Past performance is no guarantee of future results. Chart is provided for illustrative purposes and reflects hypothetical historical performance. Please see the Performance Disclosures at the end of this document for more information regarding the inherent limitations associated with back-tested performance.

THE TRADEOFF EFFECT

Of course, there *is* more to the story, since the S&P 500 Low Volatility Index typically produced more return per unit of risk than did the S&P 500 over the period observed. As Exhibit 8 shows, the tradeoff effect contributed to the S&P 500 Low Volatility Index's underperformance during the inflation of the technology bubble in 1997-1999. As the bubble deflated, the tradeoff effect turned positive, reaching a peak in 2005, and it has been consistently positive since then.

For the S&P 500 Low Volatility Index, risk reduction was a drag on performance, but the change in tradeoff more than compensated for the change in risk level.

Exhibit 8: Impact of Change in Tradeoff



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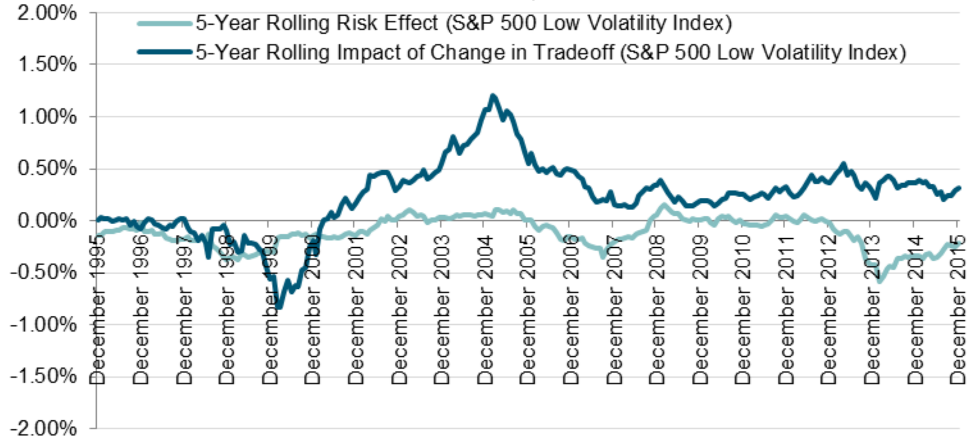
In Exhibit 9, we combine the risk effect and the tradeoff effect. More often than not, the risk that the S&P 500 Low Volatility Index shed was a drag on performance but, with the exception of the first five years, the change in tradeoff more than compensated for the change in risk level.

More importantly, the juxtaposition allows us to see that **the "anomalous" benefit of the low volatility strategy has not faded away** (as the performance differential chart in Exhibit 2 seems to suggest). Rather, the tradeoff effect has been eclipsed by the risk effect; the S&P 500 Low Volatility Index has been disadvantaged by reducing risk in a period (since the market bottom of March 2009) when risk-taking was richly rewarded.

Exhibit 9: Risk Effect and Impact of Change in Tradeoff

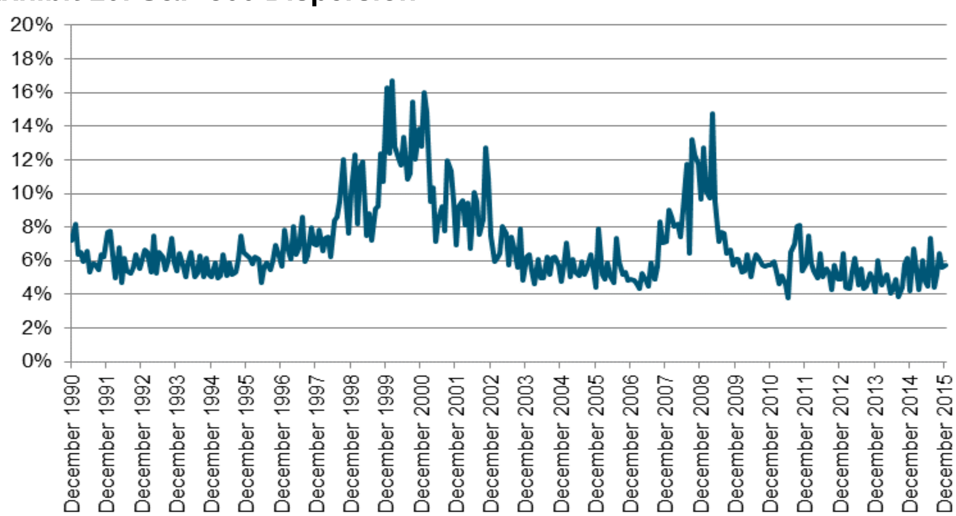


Source: S&P Dow Jones Indices LLC. Data from Dec. 31, 1990, to Dec. 31, 2015. The S&P 500 Low Volatility Index was launched on April 4, 2011. All data prior to that date are back-tested. Past performance is no guarantee of future results. Chart is provided for illustrative purposes and reflects hypothetical historical performance. Please see the Performance Disclosures at the end of this document for more information regarding the inherent limitations associated with back-tested performance.

When dispersion is relatively wide, the opportunities to profit from stock selection are relatively large; when dispersion is narrow, the opportunities diminish.

However, there is another element to consider when analyzing factor indices. The performance differential between any factor index and its parent is conditioned by market dispersion, which is a measure of the opportunity available to investors.[13] When dispersion is relatively wide, the opportunities to profit from stock selection are relatively large; when dispersion is narrow, the opportunities diminish. Historically, S&P 500 dispersion peaked during the deflation of the technology bubble and during the 2008 financial crisis (see Exhibit 10). Otherwise, dispersion has mostly hovered between 4% and 8%.

Exhibit 10: S&P 500 Dispersion



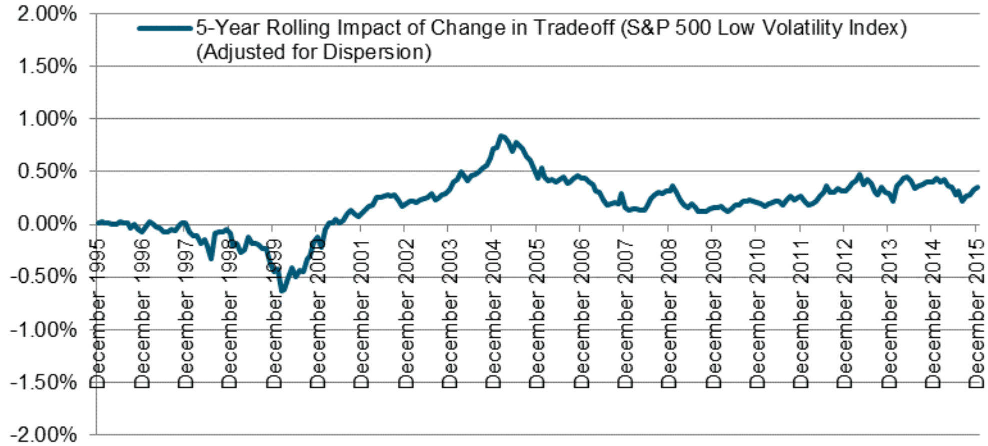
Source: S&P Dow Jones Indices LLC. Data from Dec. 31, 1990, to Dec. 31, 2015. Past performance is no guarantee of future results. Chart is provided for illustrative purposes.

[13] Chan, Fei Mei and Craig J. Lazzara, "Gauging Differential Returns," January 2014. See also Edwards, Tim and Craig J. Lazzara, "Dispersion: Measuring Market Opportunity," December 2013.

The negative tradeoff for the S&P 500 High Beta Index provides additional confirmation of the persistence of the low volatility effect.

Over the past few years, dispersion has lingered near record low levels; i.e., opportunity has been relatively limited. If we adjust the S&P 500 Low Volatility Index's tradeoff to account for the dispersion environment, the effect is even greater.[14] As Exhibit 11 shows, after adjusting for dispersion levels, the tradeoff effect has been generally higher over the past two years than during the 2008 peak. **To the degree that we can identify the low volatility anomaly with the low volatility strategy's improved tradeoff between risk and return, it is alive and well.**

Exhibit 11: Impact of Change in Tradeoff (Adjusted for Dispersion)



Source: S&P Dow Jones Indices LLC. Data from Dec. 31, 1990, to Dec. 31, 2015. The S&P 500 Low Volatility Index was launched on April 4, 2011. All data prior to that date are back-tested. Past performance is no guarantee of future results. Chart is provided for illustrative purposes and reflects hypothetical historical performance. Please see the Performance Disclosures at the end of this document for more information regarding the inherent limitations associated with back-tested performance.

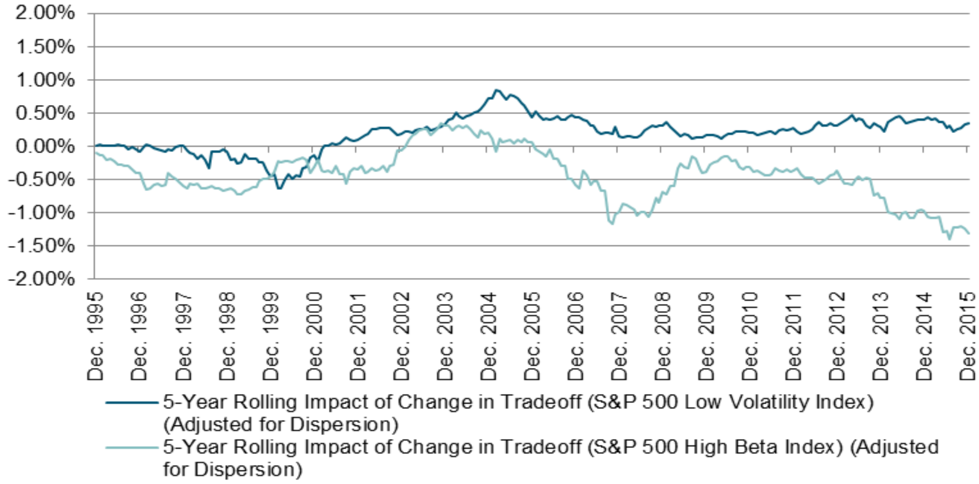
PEELING MORE ONIONS

There is nothing about this analytic process that is unique to low volatility indices. Exhibit 12, for example, shows the dispersion-adjusted tradeoff for both the S&P 500 Low Volatility Index and its disparate counterpart, the S&P 500 High Beta Index.[15] Generally speaking, the S&P 500 High Beta Index's tradeoff has been negative, and since the market bottom of 2009, the high beta strategy's tradeoff has become more negative even as the low volatility strategy's has improved. Given the close relationship between beta and total volatility, the negative values for the S&P 500 High Beta Index provide additional confirmation of the persistence of the low volatility effect.

[14] The adjustment is simple; we simply divide each month's tradeoff by a scaled measure of the S&P 500's dispersion.

[15] The S&P 500 High Beta Index is designed to reflect the performance of the 100 stocks in the S&P 500 with the highest systematic risk.

Exhibit 12: Change in Tradeoff Effect for Two Disparate Factor Indices

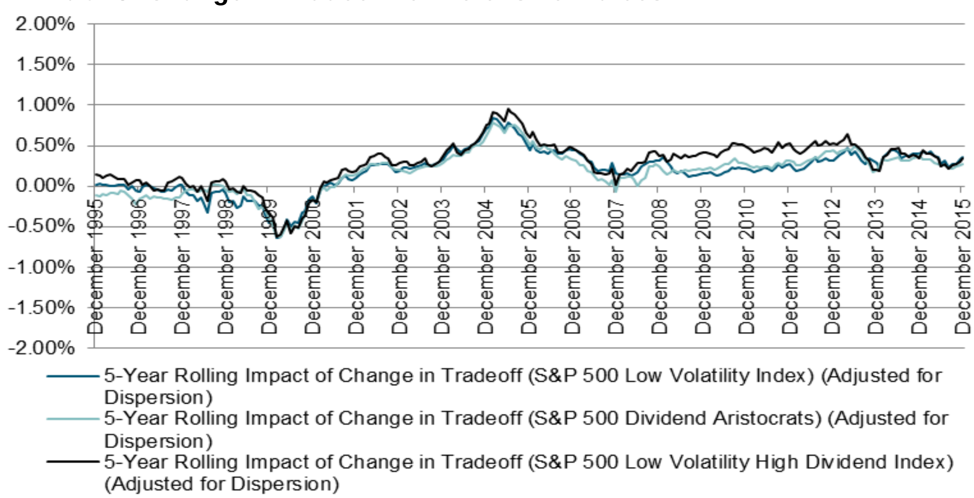


Source: S&P Dow Jones Indices LLC. Data from Dec. 31, 1990, to Dec. 31, 2015. The S&P 500 Low Volatility and the S&P 500 High Beta Indices were launched on April 4, 2011. All data prior to that date are back-tested. Past performance is no guarantee of future results. Chart is provided for illustrative purposes and reflects hypothetical historical performance. Please see the Performance Disclosures at the end of this document for more information regarding the inherent limitations associated with back-tested performance.

Despite major differences in their methodologies, the tradeoff patterns of the S&P 500 Low Volatility Index, S&P 500 Dividend Aristocrats, and S&P 500 Low Volatility High Dividend Index are so similar that they practically track one another.

Exhibit 13 shows the tradeoff for two other defensive strategy indices that are also subsets of the S&P 500, the S&P 500 Dividend Aristocrats and the S&P 500 Low Volatility High Dividend Index.[16] Remarkably, given the major differences in index methodologies, the tradeoff patterns in Exhibit 13 are so similar that they practically track one another.

Exhibit 13: Change in Tradeoff for Defensive Indices

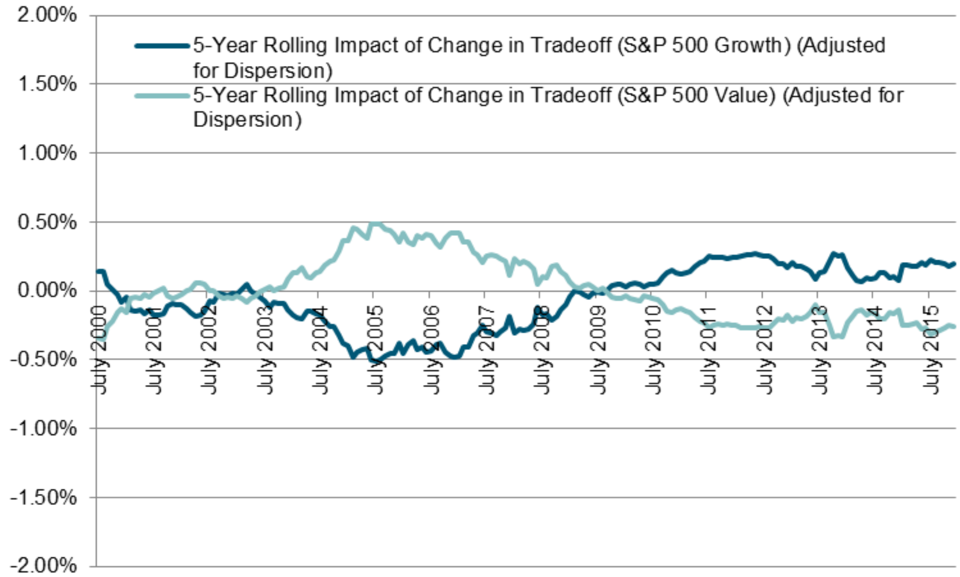


Source: S&P Dow Jones Indices LLC. Data from Dec. 31, 1990, to Dec. 31, 2015. The S&P 500 Low Volatility was launched on April 4, 2011. The S&P 500 Dividend Aristocrats was launched on May 2, 2005. The S&P 500 Low Volatility High Dividend Index was launched on September 17, 2012. All data prior to those dates are back-tested. Past performance is no guarantee of future results. Chart is provided for illustrative purposes and reflects hypothetical historical performance. Please see the Performance Disclosures at the end of this document for more information regarding the inherent limitations associated with back-tested performance.

[16] The S&P 500 Dividend Aristocrats Index is designed to measure the performance of S&P 500 members that have increased dividends for at least the last 25 consecutive years. The S&P 500 Low Volatility High Dividend Index is designed to measure the performance of the 50 least-volatile high dividend-yielding stocks in the S&P 500.

Visually, Exhibit 14's comparison of the S&P 500 Growth and the S&P 500 Value indices is quite striking, if unsurprising.[17] We partition the entire S&P 500 between growth and value so that the two indices are complementary and, collectively, compose the entire S&P 500. Given this context, it is not surprising that the growth and value tradeoffs are practically mirror images.

Exhibit 14: Change in Tradeoff for S&P 500 Growth and S&P 500 Value Indices



Source: S&P Dow Jones Indices LLC. Data from June 30, 1995, to Dec. 31, 2015. Past performance is no guarantee of future results. Chart is provided for illustrative purposes.

If we think of a positive tradeoff effect as an "alpha," there are no consistently positive sector alphas. Nor should there be.

The decomposition process can be applied to *any* subset of the S&P 500.[18] For example, we analyzed a number of other factor indices in the 1995-2015 period as well as all 10 sector indices of the S&P 500 from 1991 to 2015 (see Appendices B and C for details). If we think of a positive tradeoff effect as an "alpha," **there are no consistently positive sector alphas**. Nor should there be—if we had found any, it would have raised questions about our methodology. Instead, we see periodic improvements and decrements in each sector's tradeoff as market leadership rotates.

We highlight the information technology and financials sectors in Exhibits 15a and 15b—an interesting juxtaposition, since these sectors are associated with the two biggest bubbles and busts of the last 20 years. At first blush, Exhibit 15a shows what one might expect to find for these sectors. Information technology burgeoned in the second half of the 1990s only to deflate just as spectacularly in the early 2000s; financials outperformed the broader market in the buildup to the 2007-2008 crisis. Exhibit 15b compares "sector alphas" for information technology and

[17] We identify growth using three factors: sales growth, the ratio of earnings change to price, and momentum. See http://spindices.com/indices/equity/sp-500-growth for further details on methodology. We identify value using three factors: the ratios of book value, earnings, and sales to price. See http://spindices.com/indices/equity/sp-500-value for further details on methodology.

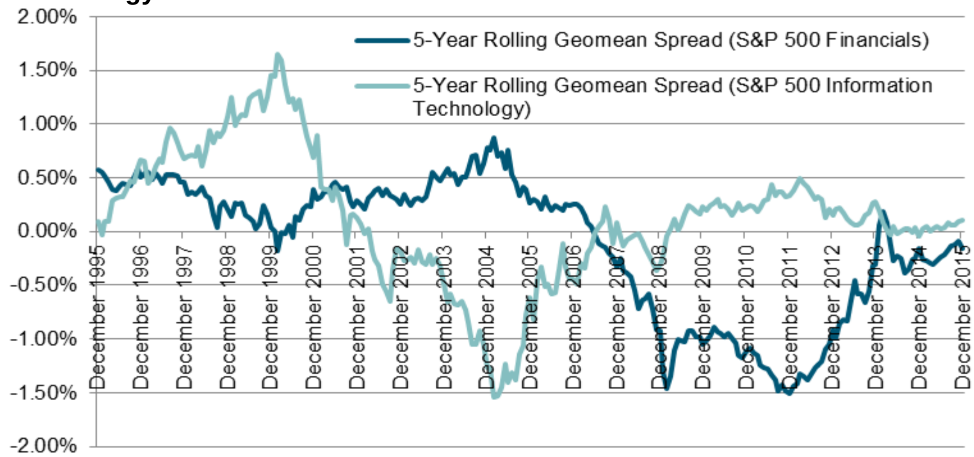
[18] Or, *mutatis mutandis*, to any factor index and its cap-weighted parent.

financials, which shows that their similarities may have been more superficial than real.

- Even in 2000, at the height of the tech bubble, information technology's "sector alpha" was negligible. This implies that **the exceptional returns of the information technology sector in its glory years were a function of the sector's exceptionally high volatility levels**.
- The financials sector, on the other hand, showed substantial positive "alpha" in the early 2000s (and has shown substantial negative "alpha" since 2007). **The sector's apparent idiosyncratic performance, in other words, appears to have been truly idiosyncratic.**

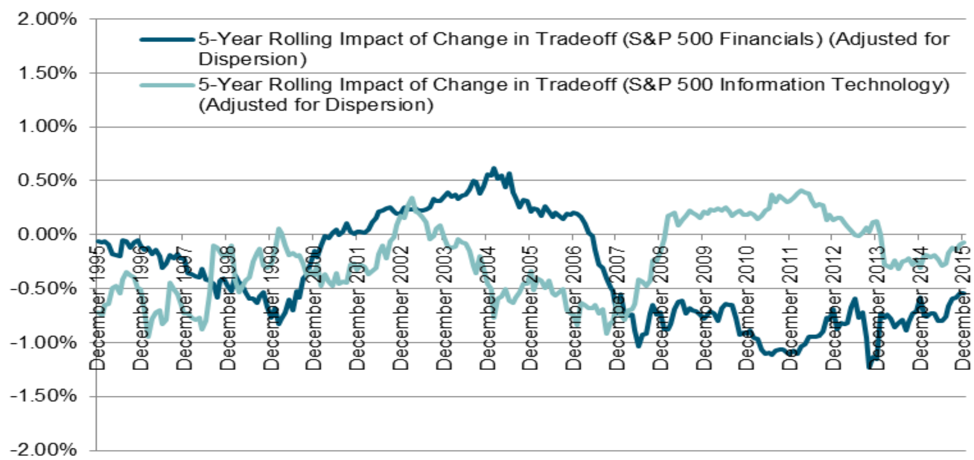
We found that the S&P 500 Low Volatility Index's recent performance challenges are attributable to its reduced level of risk in an environment that, until recently, has been favorable for risk-taking.

Exhibit 15a: Performance Differential for S&P 500 Financials and Information Technology Sectors



Source: S&P Dow Jones Indices LLC. Data from Dec. 30, 1990, to Dec. 31, 2015. Past performance is no guarantee of future results. Chart is provided for illustrative purposes.

Exhibit 15b: Tradeoff for S&P 500 Financials and Information Technology Sectors



Source: S&P Dow Jones Indices LLC. Data from Dec. 31, 1990, to Dec. 31, 2015. Past performance is no guarantee of future results. Chart is provided for illustrative purposes.

CONCLUSION

We have presented a simple methodology that can be used to assess the performance of factor (or other) indices compared to their cap-weighted parents. The methodology attributes a factor index's return differential both to its incremental (or decremental) **level of risk** and to a changed **tradeoff between risk and return**. In the particular case of the S&P 500 Low Volatility Index, our analysis indicates that its recent performance challenges are attributable to its reduced level of risk in an environment that, until recently, has been favorable for risk-taking. **The S&P 500 Low Volatility Index's improved tradeoff between risk and return, which is arguably the source of its anomalous performance, has remained intact.**

APPENDIX A: APPLES TO APPLES

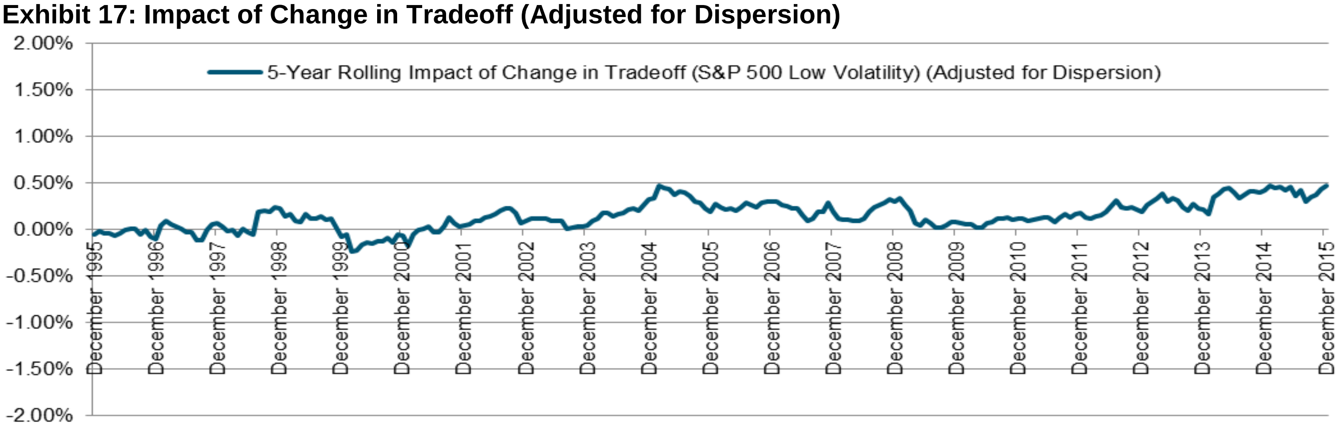
The S&P 500 Low Volatility Index is much closer to being equal-weighted than cap-weighted, which makes it arguable that the S&P 500 Equal Weight Index is a more appropriate benchmark for the low volatility strategy than is the cap-weighted S&P 500.[19] Rescaling Exhibit 5 using the S&P 500 Equal Weight Index as the benchmark is also worthwhile because in the period from 1991 to 2015, the S&P 500 Low Volatility Index **underperformed** the S&P 500 Equal Weight Index by a monthly average of 7.7 bps. Here, the tradeoff effect remains significant and positive, but the low volatility strategy's reduced risk was a burden for which the improved tradeoff could not compensate. **Detecting the low volatility anomaly, in other words, does not depend on using the cap-weighted S&P 500 as a benchmark.**

Exhibit 16: Sources of Relative Performance

REFERENCE	FACTOR	S&P 500 LOW VOLATILITY INDEX (%)	S&P 500 EQUAL WEIGHT INDEX (%)	DIFFERENCE (%)
A	Geometric Mean	0.867	0.994	-0.077
B	Arithmetic Mean	0.918	1.051	-0.134
C	Volatility Drag (A-B)	-0.051	-0.107	0.057
D	Standard Deviation	3.19	4.62	-
E	Reward for Risk (B/D)	0.288	0.227	-
F	Impact of Changed Risk Level ((Dp-Db)*Eb)	-	-	-0.326
G	Impact of Improved Tradeoff ((Ep-Eb)*Dp)	-	-	0.193
H	Difference in Arithmetic Means (F+G)	-	-	-0.134
I	Sum of Risk Effects (C+F)	-	-	-0.270
J	Improved Tradeoff, Arguably an Anomaly (G)	-	-	0.193
K	Difference in Geometric Means (I+J)	-	-	-0.077

Source: S&P Dow Jones Indices LLC. Data from Dec. 31, 1990, through Dec. 31, 2015. The S&P 500 Low Volatility Index was launched on April 4, 2011. The S&P 500 Equal Weight Index was launched on January 8, 2003. All data prior to those dates are back-tested. Past performance is no guarantee of future results. Table is provided for illustrative purposes and reflects hypothetical historical performance. Please see the Performance Disclosures at the end of this document for more information regarding the inherent limitations associated with back-tested performance.

Exhibit 17: Impact of Change in Tradeoff (Adjusted for Dispersion)

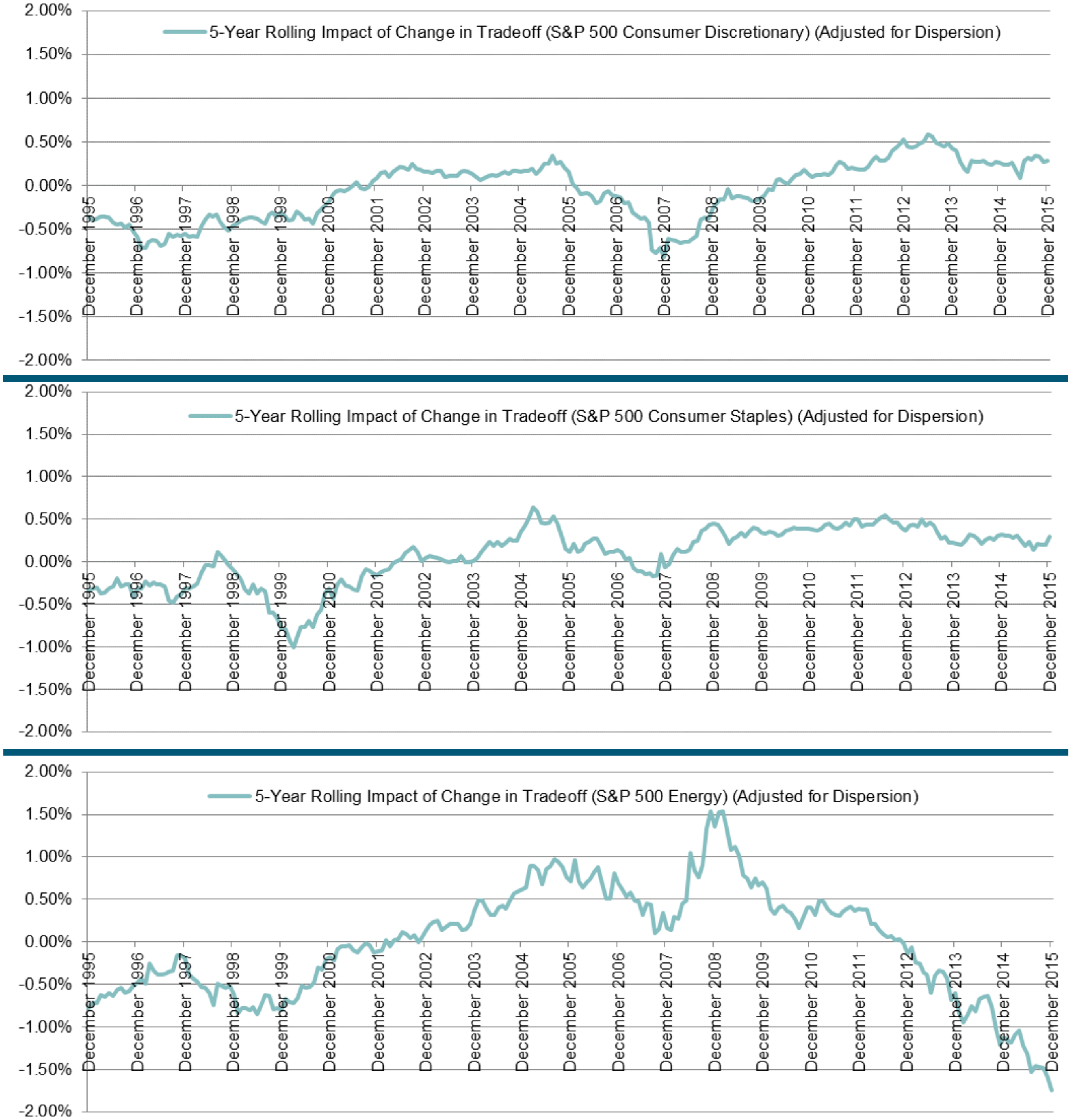


Source: S&P Dow Jones Indices LLC. Data from Dec. 31, 1990, to Dec. 31, 2015. The S&P 500 Low Volatility Index was launched on April 4, 2011. All data prior to that date are back-tested. Past performance is no guarantee of future results. Chart is provided for illustrative purposes.

[19] See Edwards, Tim and Craig J. Lazzara, "Equal-Weight Benchmarking: Raising the Monkey Bars," June 2014.

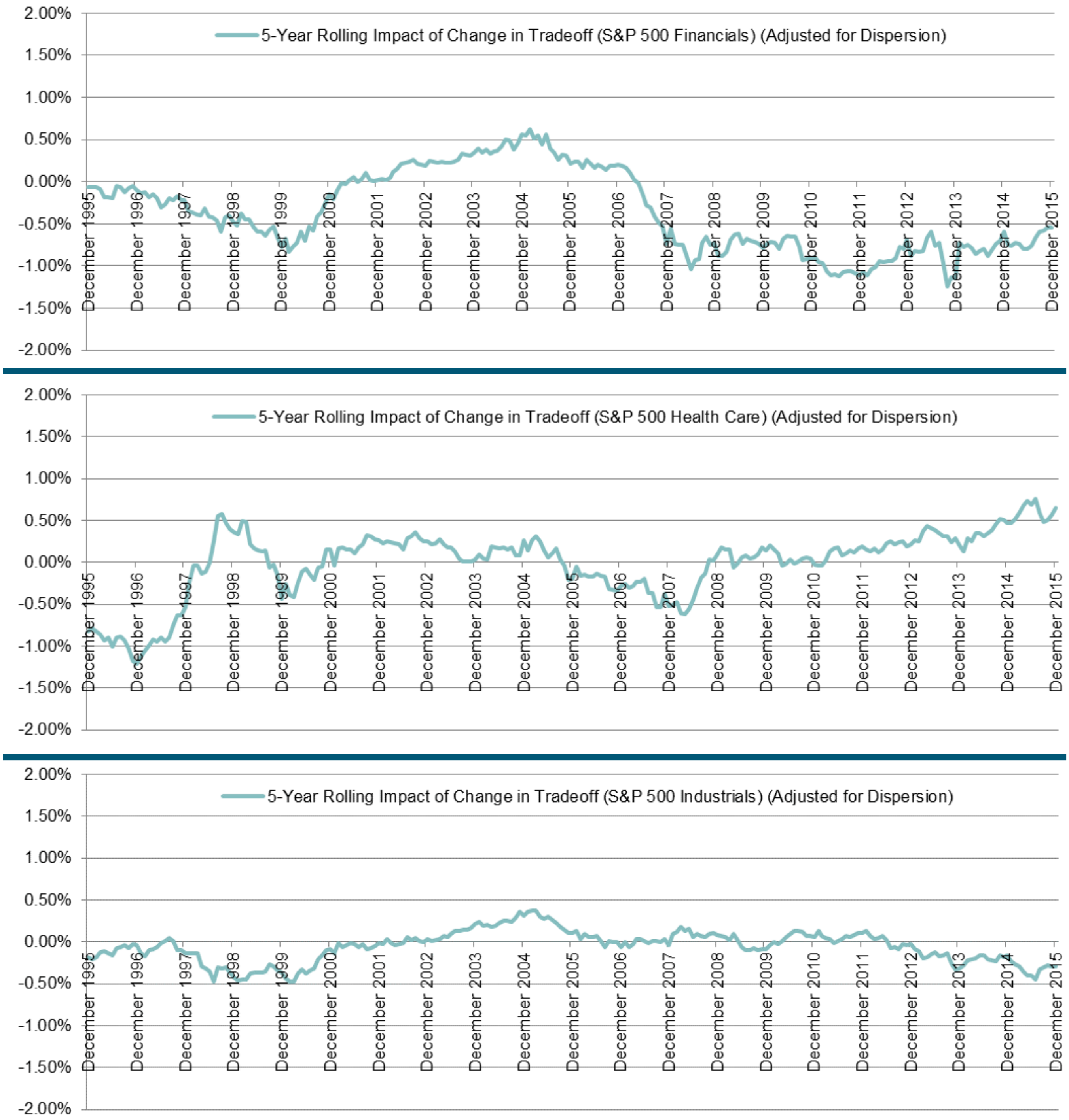
APPENDIX B: 5-YEAR ROLLING TRADEOFF FOR S&P 500 SECTORS

Exhibit 18: 5-Year Rolling Tradeoff for S&P 500 Sector Indices



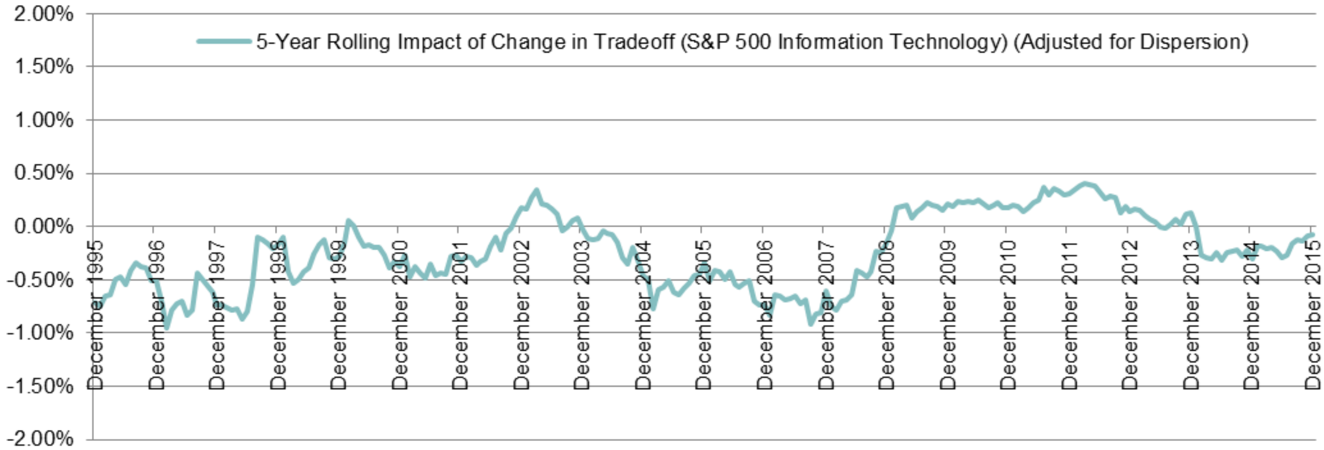
Source: S&P Dow Jones Indices LLC. Data from Dec. 31, 1990, to Dec. 31, 2015. Past performance is no guarantee of future results. Charts are provided for illustrative purposes.

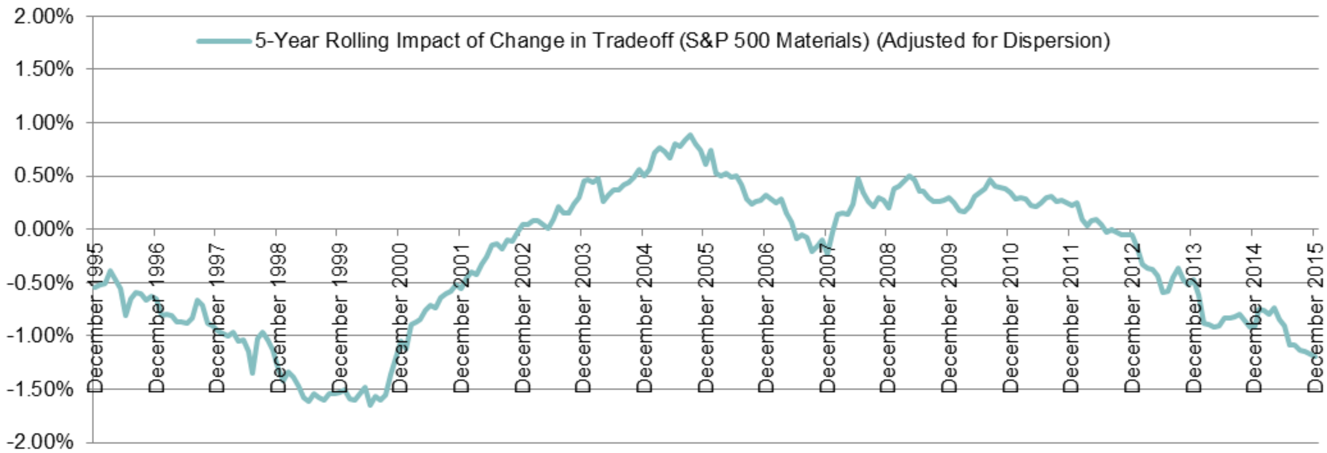
Exhibit 18: 5-Year Rolling Tradeoff for S&P 500 Sector Indices (cont.)

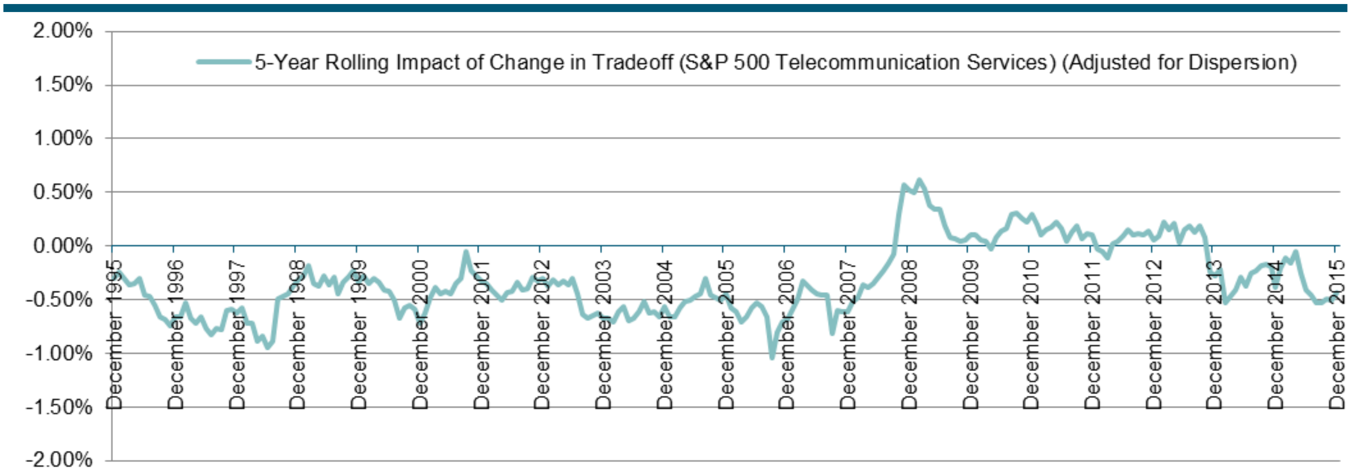


Source: S&P Dow Jones Indices LLC. Data from Dec. 31, 1990, to Dec. 31, 2015. Past performance is no guarantee of future results. Charts are provided for illustrative purposes.

Exhibit 18: 5-Year Rolling Tradeoff for S&P 500 Sector Indices (cont.)

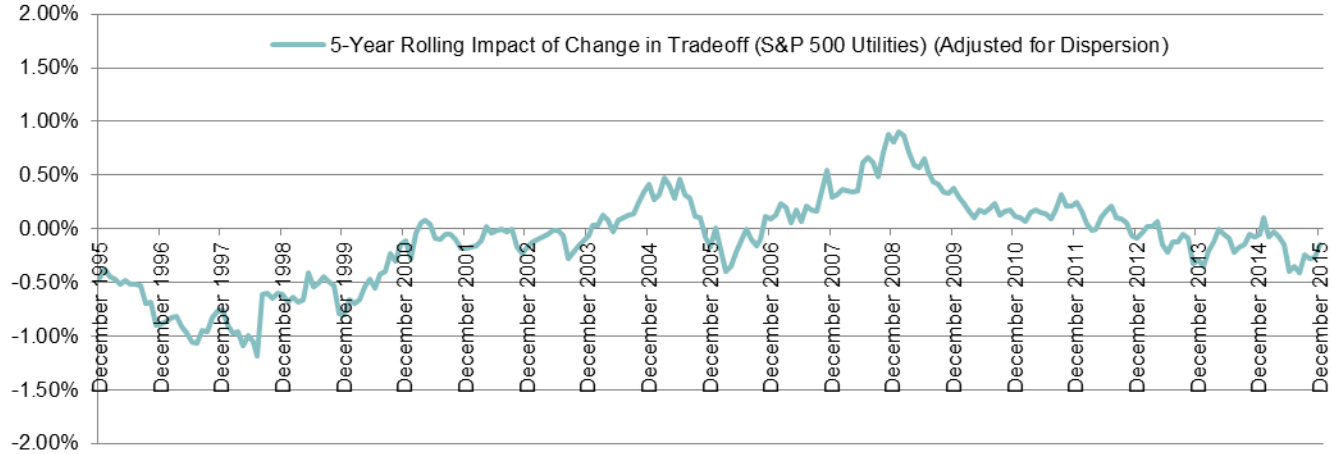






Source: S&P Dow Jones Indices LLC. Data from Dec. 31, 1990, to Dec. 31, 2015. Past performance is no guarantee of future results. Charts are provided for illustrative purposes.

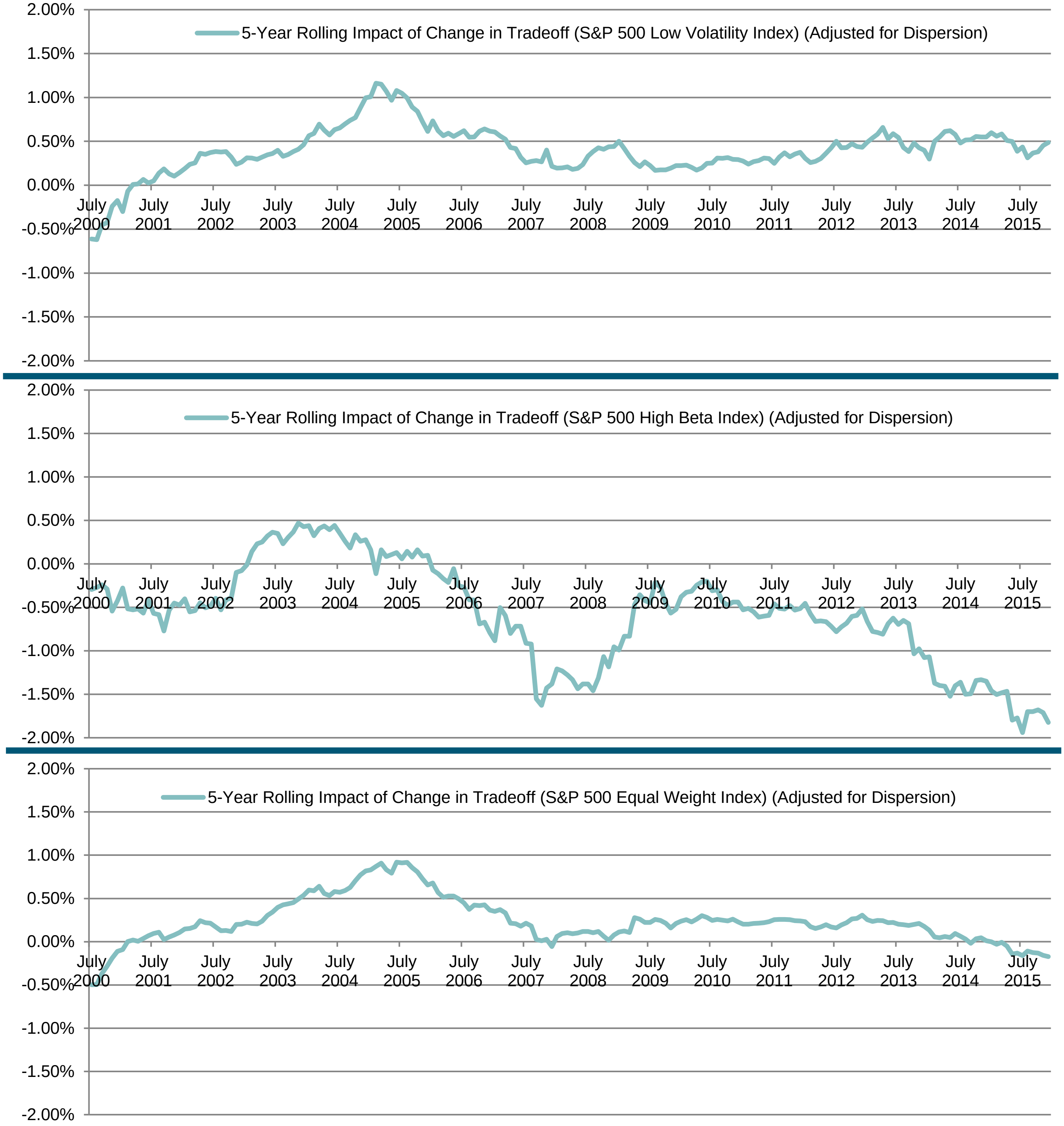
Exhibit 18: 5-Year Rolling Tradeoff for S&P 500 Sector Indices (cont.)



Source: S&P Dow Jones Indices LLC. Data from Dec. 31, 1990, to Dec. 31, 2015. Past performance is no guarantee of future results. Chart is provided for illustrative purposes.

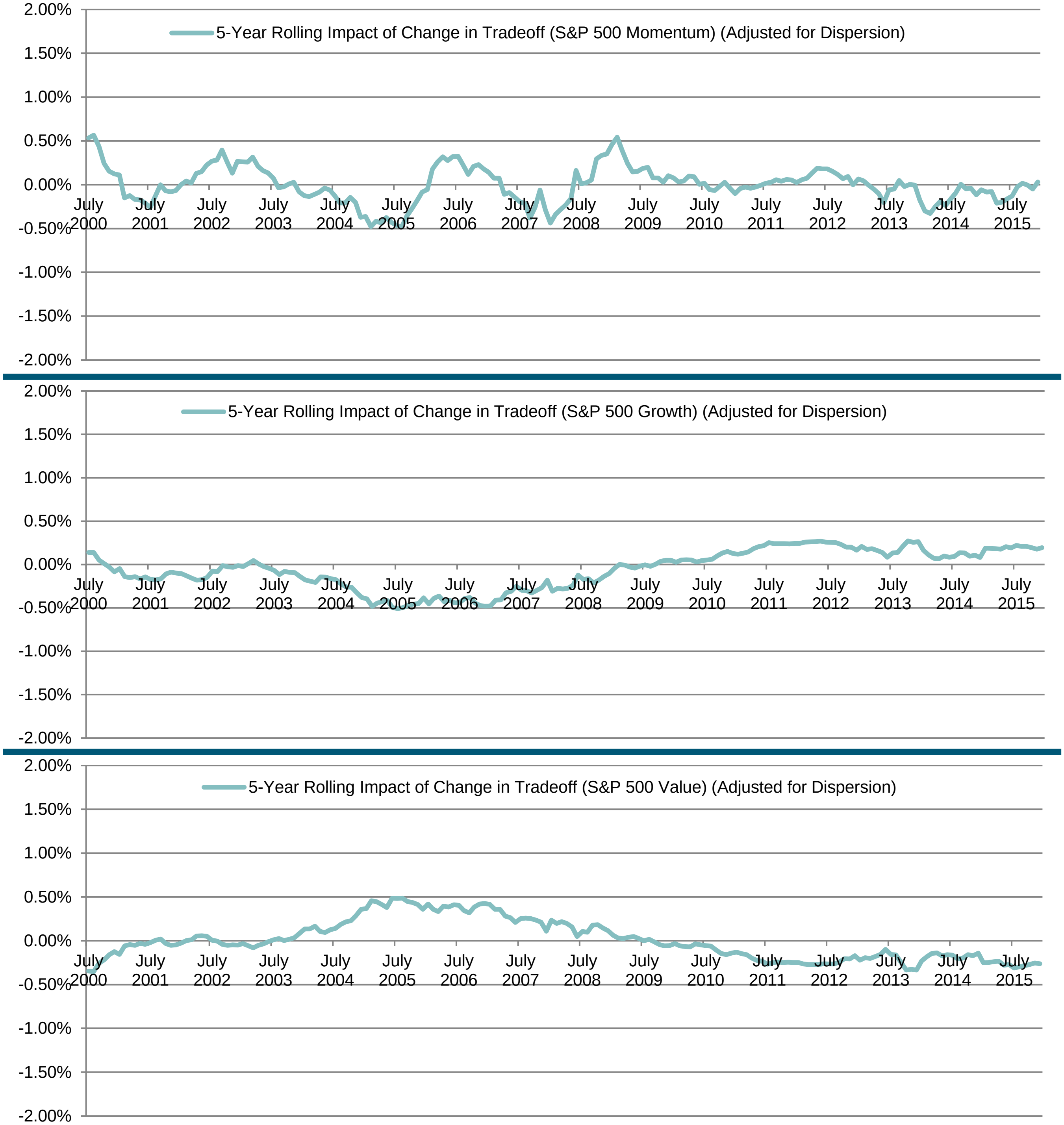
APPENDIX C: 5-YEAR ROLLING TRADEOFF CHARTS FOR VARIOUS FACTOR INDICES

Exhibit 19: 5-Year Rolling Tradeoff for S&P 500 Factor Indices



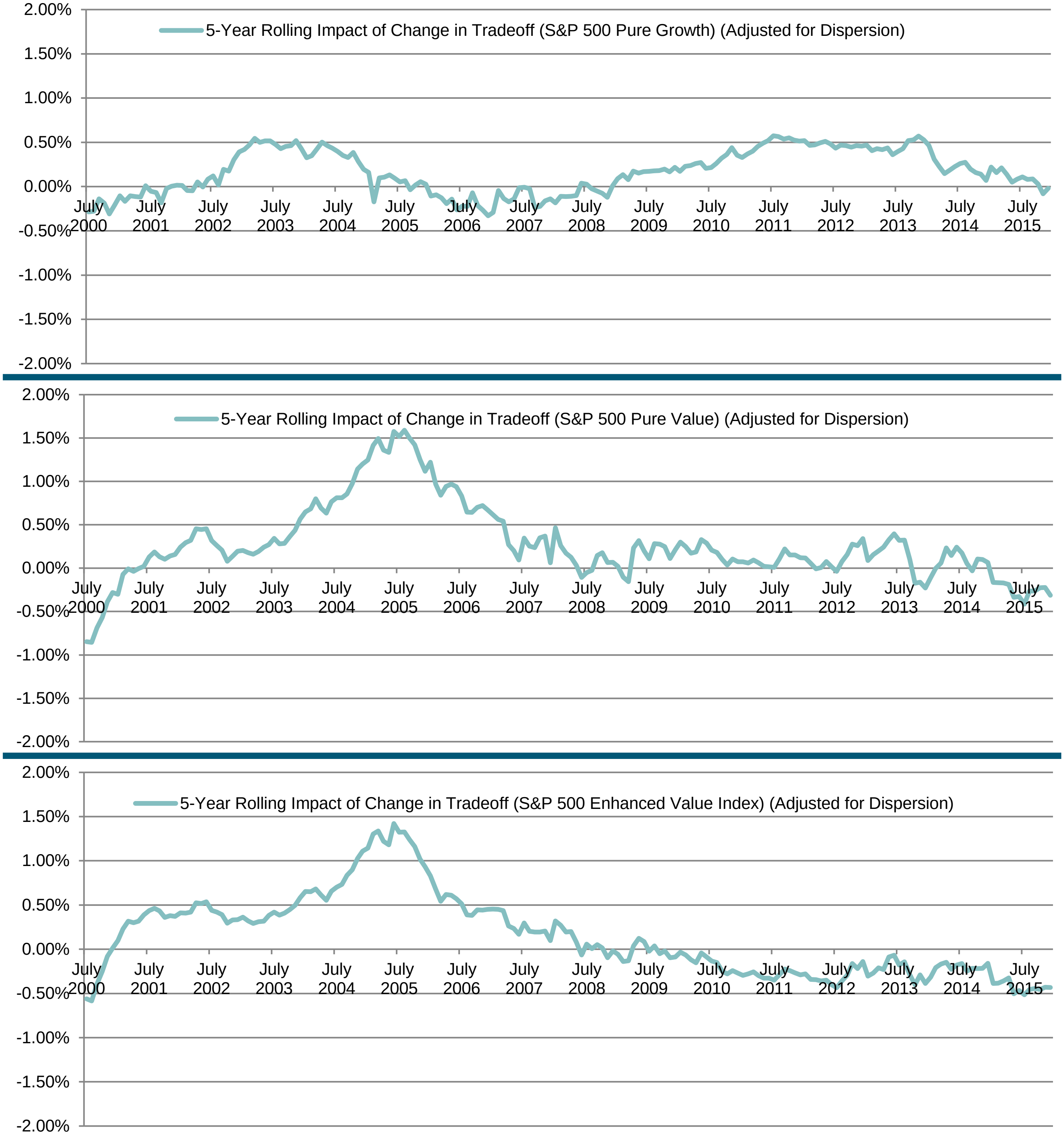
Source: S&P Dow Jones Indices LLC. Data from June 30, 1995, to Dec. 31, 2015. The S&P 500 Low Volatility and S&P 500 High Beta Indices were launched on April 4, 2011. The S&P 500 Equal Weight Index was launched on January 8, 2003. All data prior to those dates are back-tested Past performance is no guarantee of future results. Charts are provided for illustrative purposes and reflect hypothetical historical performance. Please see the Performance Disclosures at the end of this document for more information regarding the inherent limitations associated with back-tested performance.

Exhibit 19: 5-Year Rolling Tradeoff for S&P 500 Factor Indices (cont.)



Source: S&P Dow Jones Indices LLC. Data from June 30, 1995, to Dec. 31, 2015. The S&P 500 Momentum Index was launched on November 18, 2014. All information prior to that date are back-tested. Past performance is no guarantee of future results. Charts are provided for illustrative purposes and reflect hypothetical historical performance. Please see the Performance Disclosures at the end of this document for more information regarding the inherent limitations associated with back-tested performance.

Exhibit 19: 5-Year Rolling Tradeoff for S&P 500 Factor Indices (cont.)



Source: S&P Dow Jones Indices LLC. Data from June 30, 1995, to Dec. 31, 2015. The S&P 500 Pure Growth and the S&P 500 Pure Value Indices were launched on December 16, 2005. The S&P 500 Enhanced Value Index was launched on April 27, 2015. All data prior to those dates are back-tested. Past performance is no guarantee of future results. Charts are provided for illustrative purposes and reflect hypothetical historical performance. Please see the Performance Disclosures 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 and the S&P 500 High Beta Index were launched on April 4, 2011. The S&P 500 Dividend Aristocrats was launched on May 2, 2005. The S&P 500 Low Volatility High Dividend Index was launched on September 17, 2012. The S&P 500 Pure Growth and the S&P 500 Pure Value were launched on December 16, 2005. The S&P 500 Equal Weight Index was launched on January 8, 2003. The S&P 500 Momentum was launched on November 18, 2014. The S&P 500 Enhanced Value Index was launched on April 27, 2015. 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.

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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.

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