

# THE LOW-VOLATILITY EFFECT: A COMPREHENSIVE LOOK

---

AUGUST 2012

---

## CONTRIBUTORS

**Aye M. Soe, CFA**  
Director  
Index Research & Design  
[aye.soe@spdji.com](mailto:aye.soe@spdji.com)

---

## 1: INTRODUCTION

Among the long-standing anomalies in modern investment theory, perhaps none are as puzzling and compelling as the low-volatility effect. It challenges the traditional equilibrium asset pricing theory that an asset's expected return is directly proportional to its beta or systematic risk, or, in other words, higher-risk securities should be rewarded with higher expected returns while lower-risk assets receive lower expected returns.

Contrary to that theory, the empirical evidence of numerous academic studies has illustrated that low-volatility or low-risk investing outperforms the broad market as well as high-risk strategies over a long-term investment horizon with much less realized volatility (see Academic Literature). In the U.S. equity market, the S&P 500® Low Volatility Index returned 6.95% (10.75% standard deviation) and the MSCI USA Minimum Volatility Index returned 5.1% (12.32% standard deviation) on an annualized basis over the 10 years ended March 31, 2012, with 23% to 30% lower volatility than a market cap-weighted benchmark such as the S&P 500, which returned 4.12% (15.99% standard deviation).

Low-volatility investing is not a new concept, but the financial crisis of 2008 and the market's see-sawing volatility during the second half of 2011 have brought it back to the investment community's attention for risk management purposes. The resurgence of low-volatility investing has also reignited the theoretical debate on the properties of a true market portfolio. In a textbook world of Modern Portfolio Theory, a "market portfolio" is an optimal portfolio (i.e., no other can exist with higher return for a given level risk). However, the market portfolio is unobservable, so a market cap-weighted broad market benchmark is typically used as a proxy. Low-volatility strategies' outperformance compared to a market cap-weighted benchmark over a long-term investment horizon has raised the question of whether the superior performance is due to an anomalous behavior or an incompleteness in the single-factor asset pricing model.

In this paper, we analyze the low-volatility effect in the U.S. equity market with a focus on the common properties of various low-volatility strategies. Drawing from the extensive academic literature that exists on the topic, we examine the two major approaches to constructing low-volatility portfolios and apply them to the U.S. equity market: mean variance optimization-based versus the rankings-based approaches. Our analysis shows that both approaches are equally effective in reducing portfolio volatility over a long-term investment horizon. We then extend our analysis to the international and emerging markets. Our findings confirm that the low-volatility effect is not unique to the U.S. equity markets; it is present on a global scale.

## 2: THE LOW-VOLATILITY EFFECT IN ACADEMIC LITERATURE

Substantial academic literature exists on low-volatility investing. Black, Jensen and Scholes (1972) demonstrated that the expected excess return on a security was not

linearly related to its beta. The authors found that the alphas of high-beta securities were negative while the alphas of low-beta securities were positive. Fama and French (1992) also observed that the positive relationship between average return and beta was weak. The returns of high-beta portfolios had average returns that were close to or less than those of low-beta portfolios. Ang, Hodrick, Xing and Zhang (2006) found that stocks with high idiosyncratic volatility tended to have normal returns during bull periods in the U.S. and in international markets. However, their returns were lower during bear market periods or recessions. On average, the returns were negative, earning -0.02% per month during the 1963 to 2000 study period. The pattern of negative returns associated with the volatility factor was equally noted by Kang (2012), indicating that portfolios tilted to low-risk securities had higher returns than those tilted to high-risk stocks.

The mean-variance framework pioneered by Markowitz (1952) serves as the foundation of the optimization based low-risk investing strategies.<sup>1</sup> Haugen and Baker (1991), using the minimum variance portfolio based on the 1,000 largest U.S. stocks, illustrated that market cap-weighted portfolios were inefficient because there were alternative portfolios with lower volatility and higher returns. Using data from January 1968 to December 2005,

Clark, de Silva and Thorley (2006) constructed minimum-variance portfolios that had annualized realized volatility at three-fourths that of the broad market (11.7% versus 15.4%). At 0.55, the Sharpe ratio of the minimum variance portfolio was higher than the market cap-weighted benchmark's Sharpe ratio of 0.36.

Blitz and Vliet (2007) created decile portfolios based on the rankings of stocks by their three-year realized volatility. Their study showed that the volatility of the top decile portfolio was about two-thirds of the market volatility, while the volatility of the bottom decile portfolio had a standard deviation that was almost twice that of the market. Another important finding in their study was that stocks with low volatility exhibited low beta, while stocks with high volatility exhibited high beta. In other words, using beta or variance as a measure of volatility should produce the same impact on the portfolio's returns and risk profile.

Choueifaty and Coignard (2008) proposed maximizing a diversification ratio, the weighted average of the stocks' volatilities divided by the portfolio volatility, as a way to achieve risk-adjusted returns superior to those of the market cap-weighted portfolios. Based on the results on the universe of U.S. and eurozone securities, the authors concluded that, if all of the stocks in the study's universe possessed the same volatility, then the maximum diversification portfolio was equal to the global minimum-variance portfolio.

Baker, Bradley and Wurgler (2011) demonstrated that despite whether risk was defined as beta or volatility, low-risk portfolios consistently outperformed high-risk portfolios over a long-term investment horizon. Using data from January 1968 to December 2008, stocks were divided into five groups based on their five-year trailing volatility or trailing beta. The results showed that the bottom quintile beta and volatility portfolios outperformed the top quintile portfolios. Applying the principles of behavioral finance and institutional benchmarking limitations, the authors attributed the low-risk anomaly to average investors' preference for positive skewness or lottery-like payoffs with high-volatility stocks and the institutional limitation on using leverage. Carvalho, Lu, and Moulin (2012) proposed that a rankings- or quantile-based low volatility construction approach could be considered as an equal risk budget strategy that does not account for the impact of correlations between stocks.

Blitz and Vliet (2011) theorized that at the end of the day, the purpose of low-volatility investing is to establish a risk-return profile that is superior to an investment in the market cap-weighted market portfolio. A straight comparison of returns is not appropriate because low-volatility portfolios exhibit significantly lower risk than the benchmark. A performance measure that adjusts returns appropriately for risk is more relevant to evaluating the effectiveness of the strategy relative to a benchmark. The authors proposed using simple risk-adjusted performance metrics such as a Sharpe ratio or Jensen's alpha.

### 3: A CLOSER LOOK AT TWO LOW-VOLATILITY STRATEGIES

Based on existing research, there are two principal ways to construct low-volatility strategies. The first is the mean-variance optimized approach, as proposed by Markowitz (1952), in which a portfolio's variance is minimized

---

<sup>1</sup> The minimum variance portfolio is the portfolio with the lowest risk for a given level of expected return.

by considering the correlations among stocks.<sup>2</sup> The second approach involves dividing a universe of securities into quantiles by a measure of volatility, either beta or standard deviation, and forming a portfolio based on the least-volatile stocks. Unlike using the minimum variance approach to create a low-volatility portfolio, the rankings-based approach, in theory, forms a portfolio of low-volatility stocks. Blitz and Vliet (2011) concurred with the earlier academic studies that using a simple and more transparent quantile- or rankings-based approach for low-volatility portfolio construction is equally as effective at reducing volatility as the mean-variance optimized approach.

We evaluated the low-volatility effect in the U.S. equity market using both the quantile- or rankings-based approach and the minimum variance optimization approach. We divided the U.S. equity market into three market cap ranges (large cap, mid cap and small cap) and applied the low-volatility strategy construction approaches to all three. The division allowed us to determine whether low-volatility effect was present in all three market caps.

### 3.1 Rankings-Based Approach

In the rankings-based approach, we divided each market cap segment, as represented by the S&P 500, S&P MidCap 400<sup>®</sup> and S&P SmallCap 600<sup>®</sup>, into quintiles based on the standard deviation of the trailing 252 trading days' price changes. Securities in the bottom quintile constitute the low-risk strategy and were weighted by the inverse of their standard deviation<sup>3</sup>, thereby giving the least-volatile stock the highest weight. Each group is rebalanced on a quarterly basis.

### 3.2 Minimum Variance Approach

The Northfield U.S. Fundamental Model<sup>4</sup> and the Northfield Portfolio Optimizer are utilized to construct minimum variance portfolios. In a standard Markowitz framework, a minimum variance portfolio resides on the farthest left corner of the efficient frontier. It has the lowest risk among all possible portfolios, given the covariance matrix among securities.

We constructed two minimum variance-based strategies for each market cap range: the base unconstrained case and the constrained case. Both are limited to long-only. In the base case, there are no restrictions on the maximum weight of a security or a sector. In the constrained case, we limited the maximum weight of a security to 5%, the minimum weight of a sector to 50% of the benchmark sector's weight, and the maximum weight of a sector to 150% of the benchmark sector's weight. Similar to the rankings-based approach, the minimum variance-based strategies are rebalanced on a quarterly basis.

<sup>2</sup> Portfolio variance is formulaically expressed as

$$\sigma_p^2 = \sum_i w_i^2 \sigma_p^2 + \sum_i \sum_{i \neq j} w_i w_j \sigma_i \sigma_j \rho_{ij}$$

$$^3 w_i = \frac{1}{\text{Volatility}} \frac{1}{\sum_{i=1}^n \text{Volatility}}$$

Volatility = standard deviation of the trailing 252 trading day price changes.

<sup>4</sup> The Minimum Variance Constrained and Unconstrained (Base) Strategies were constructed using the Northfield Portfolio Optimizer and Portfolio Simulator in FactSet. The Northfield U.S. Fundamental Equity Risk Model is a multi-factor risk model designed to help control the portfolio's exposure to endogenous factors. It is a relaxed Capital Asset Pricing Model (CAPM) construct; while acknowledging the importance of beta in measuring the risk of a portfolio, it also acknowledges that certain groups of securities have covariances that are not related to CAPM beta. The model is based on 67 factors: beta, 11 fundamental characteristics, and 55 industry groups. Mathematically, a multi-factor model can be expressed as

$$R_i = \beta_{i1} f_1 + \dots + \beta_{in} f_n + \varepsilon_i$$

We constructed a base portfolio and a constrained portfolio for minimum variance-based strategies because a pure minimum variance portfolio can produce concentrated, unrepresentative stock and sector weights if left unconstrained. For example, in our base minimum variance portfolio, the number of stocks in a portfolio at rebalancing ranged from 17 to 54 and their weights ranged from 0.001% to 26.52% with sector weight differences as great as 54% of the underlying benchmark sector weights. The extreme concentration can be attributed to the presence of estimation errors in the minimum variance approach, in which risk is underestimated for some stocks, as highlighted by Monnier and Rulik (2011). Additional constraints such as maximum weights of the stock, sector and country exposures can be imposed on the portfolio weights to reduce the concentration problem

#### 4: COMMON PROPERTIES OF LOW-VOLATILITY STRATEGIES

In this section, we highlight two key common properties shared by rankings-based and minimum variance-based low volatility strategies. The properties stem from the risk-return behaviors of the strategies observed during different market environments.

##### 4.1 Better Risk-Adjusted Returns

Low-volatility strategies deliver superior risk-adjusted returns compared to market cap-weighted market benchmarks over a long-term investment horizon. Exhibits 1 to 3 present the annualized return-risk profiles of the rankings-based and the constrained and unconstrained minimum variance-based low-volatility portfolios for the U.S large-cap, mid-cap and small-cap equity market segments.

In the large-cap segment, all three low-volatility strategies, despite their varying risk-return profiles, outperformed the benchmark over the intermediate- and long-term with much lower realized volatility. Risk reduction amounted to approximately 30% over a 10-year period and 20% over a 20-year period for all three strategies. With the exception of short-term (one- and three-year) performance figures, the unconstrained minimum variance portfolio produced higher risk-adjusted returns than its constrained counterpart and the rankings-based portfolio. This is to be expected because the truly unconstrained minimum variance portfolio should be the optimal Sharpe portfolio.

The risk-return profiles of the low-volatility strategies were mixed for mid-cap equities when measured over different periods. The minimum variance-based strategies fared dramatically better than the rankings-based strategy over the short-term (three- year) period, as indicated by the higher Sharpe ratios. However, when measured over longer-term (10-, 15-, and 20-year) periods, the minimum variance strategies had lower Sharpe ratios than the market cap-weighted portfolios. The rankings-based strategy appears to have produced the best risk-adjusted performance among the three when measured over intermediate- and long-term investment horizons.

Using the Russell 1000 as the underlying large-cap universe and the Russell 2000 for the small-cap universe, Mezrich (2011) found that, while low-volatility alpha is present in the large-cap space, it is absent in the small-cap space. Mezrich attributed the absence to the Russell 2000's less concentrated market cap distribution feature, unlike its large cap counterpart, which allows for the elimination of the large-cap "fat tail".<sup>5</sup> Nevertheless, our results indicate that the low-volatility effect is indeed present in the small-cap space. The finding could be partly attributed to the choice of underlying small-cap universe and the methodology differences between the S&P SmallCap 600 and the Russell 2000 (Soe, 2009). Nevertheless, our analysis shows that all three low-volatility strategies (with the exception of the minimum variance base portfolio observed over the three-year period) achieved higher Sharpe ratios than that of the benchmark.

---

<sup>5</sup> For example, the largest 5% of stocks in the Russell 1000 amount to 43% of the total market cap of the Russell 1000, whereas the largest 5% of stocks in the Russell 2000 amount to 18% of the total market cap of the Russell 2000.

<b>Exhibit 1: Comparison of Large-Cap Low-Volatility Strategies</b>				
	Minimum Variance		Rankings Based	Large-Cap Benchmark
	Base Case - Unconstrained	Constrained		S&P 500
<b>Annualized Returns</b>				
1 Year	16.52%	13.62%	15.44%	8.54%
3 Year	17.54%	18.33%	21.13%	23.42%
5 Year	5.69%	0.93%	4.68%	2.01%
10 Year	8.30%	6.18%	6.95%	4.12%
15 Year	9.53%	7.94%	8.80%	6.10%
20 year	11.23%	10.77%	10.36%	8.59%
<b>Annualized Standard Deviation</b>				
3 Year	9.51%	9.87%	9.26%	16.23%
5 Year	12.94%	14.97%	12.98%	19.08%
10 Year	11.37%	12.64%	10.75%	15.99%
15 year	12.80%	13.51%	12.15%	16.56%
20 year	11.98%	12.63%	11.32%	15.06%
<b>Sharpe Ratio</b>				
3 Year	1.832	1.845	2.269	1.436
5 Year	0.366	-0.002	0.287	0.055
10 Year	0.572	0.348	0.480	0.146
15 Year	0.528	0.383	0.497	0.201
20 year	0.670	0.599	0.632	0.358

Source: S&P Dow Jones Indices LLC. Data current as of March 31, 2012. The Minimum Variance Constrained and Unconstrained Strategies were constructed using the Northfield Portfolio Optimizer and Simulator. The Rankings Based Low Volatility Strategy (S&P 500 Low Volatility Index) was launched on April 4, 2011 and constructed based on the S&P 500 Index. Past performance is no guarantee of future results. All data referenced in the chart prior to April 4, 2011 reflects hypothetical historical performance. Please see the Performance Disclosure at the end of this paper for more information on the inherent limitations associated with back-tested performance.

**Exhibit 2: Comparison of Mid-Cap Low-Volatility Strategies**

	Minimum Variance		Rankings Based	Mid-Cap Benchmark
	Base Case - Unconstrained	Constrained		S&P MidCap 400
<b>Annualized Returns</b>				
1 Year	21.37%	16.03%	1.94%	1.98%
3 Year	23.92%	22.28%	15.55%	28.55%
5 Year	5.75%	2.26%	6.31%	4.78%
10 Year	8.11%	6.04%	10.26%	7.70%
15 Year	8.44%	7.71%	12.66%	11.02%
20 year	8.53%	9.35%	12.51%	11.69%
<b>Annualized Standard Deviation</b>				
3 Year	10.28%	11.33%	12.26%	20.19%
5 Year	14.65%	15.90%	13.69%	22.83%
10 Year	12.26%	13.29%	11.46%	18.55%
15 year	13.51%	14.21%	12.06%	19.31%
20 year	12.58%	12.95%	11.07%	17.48%
<b>Sharpe Ratio</b>				
3 Year	2.315	1.956	1.259	1.408
5 Year	0.327	0.081	0.390	0.167
10 Year	0.516	0.320	0.739	0.319
15 Year	0.420	0.348	0.821	0.428
20 year	0.424	0.475	0.842	0.486

Source: S&P Dow Jones Indices LLC. Data current as of March 31, 2012. The Minimum Variance Constrained and Unconstrained Strategies were constructed using the Northfield Portfolio Optimizer and Simulator. The Rankings Based Low Volatility Strategy (a/k/a S&P MidCap 400 Low Volatility Index) has not been launched by S&P Dow Jones Indices but has been constructed based on the S&P MidCap 400 Index. Past performance is no guarantee of future results. All data referenced in the chart reflects hypothetical historical performance. Please see the Performance Disclosure at the end of this paper for more information on the inherent limitations associated with back-tested performance.

**Exhibit 3: Comparison of Small-Cap Low-Volatility Strategies**

	Minimum Variance		Rankings Based	Small-Cap Benchmark
	Base Case - Unconstrained	Constrained		S&P SmallCap 600
<b>Annualized Returns</b>				
1 Year	13.05%	3.76%	8.26%	5.03%
3 Year	16.68%	18.65%	23.74%	29.22%
5 Year	4.72%	4.36%	4.15%	3.62%
10 Year	8.63%	8.81%	9.76%	7.58%
15 Year	9.68%	10.28%	11.67%	9.50%
<b>Annualized Standard Deviation</b>				
3 Year	14.96%	14.52%	15.12%	21.93%
5 Year	16.21%	17.20%	18.07%	24.07%
10 Year	13.61%	14.31%	14.68%	20.05%
15 year	14.34%	15.21%	14.48%	20.51%
<b>Sharpe Ratio</b>				
3 Year	1.107	1.276	1.561	1.327
5 Year	0.232	0.198	0.177	0.111
10 Year	0.502	0.491	0.543	0.289
15 Year	0.482	0.494	0.615	0.328

Source: S&P Dow Jones Indices LLC. Data current as of March 31, 2012. The Minimum Variance Constrained and Unconstrained Strategies were constructed using the Northfield Portfolio Optimizer and Simulator. The Rankings Based Low Volatility Strategy (a/k/a S&P SmallCap 600 Low Volatility Index) has not been launched by S&P Dow Jones Indices but has been constructed based on the S&P SmallCap 600 Index. Past performance is no guarantee of future results. All data referenced in the chart reflects hypothetical historical performance. Please see the Performance Disclosure at the end of this paper for more information on the inherent limitations associated with back-tested performance.

**4.2 Asymmetric Payoffs**

Another property of low-volatility strategies is their upside and downside capture abilities. Although low-volatility strategies outperform the market with lower risk in general over the long-term, their behaviors in different environments over the short term can vary greatly. In other words, the strategies generate a consistent risk-return pattern in the aggregate; however, on a micro level, they may not always outperform, depending on the market conditions.

On average, low-volatility strategies outperformed their respective market benchmarks in 47% to 50% of the months studied in our analysis (see Exhibit 4). All three strategies tended to outperform less frequently when the market trended upward. This pattern reversed when the market faced headwinds. All three strategies outperformed the markets approximately 73% to 87% of the times when market returns were negative. This asymmetric response to market movements highlights the ability of low-volatility strategies to provide downside protection in uncertain times.

All three strategies consistently underperformed by approximately 0.55% to 1.7% during up market periods, depending on the market cap segment. The results indicate that low-volatility strategies did not participate fully in up markets and lagged benchmark returns. An opposite pattern emerged during down markets. All three strategies outperformed by 1.4% to 2.5%, depending on the market cap segment. Taken together with the results shown in Exhibit 4, it can be noted that low volatility strategies possess asymmetric risk-return profiles: they outperform the market more frequently and with larger magnitude when it is down.

Across all three market cap segments, relative to the minimum variance strategies, the rankings-based strategy outperformed the least frequently when the market was rallying but outperformed the most frequently when the market was trending down. With regard to the magnitude of outperformance, the rankings-based strategy

outperformed the most during down markets. The difference in market risk level among the three strategies accounts for this behavior.

<b>Exhibit 4: Hit Rate: Percentage of Months that Low-Volatility Strategies Outperformed Market Portfolios</b>			
<b>Large-Cap</b>	<b>Minimum Variance</b>		<b>Rankings Based</b>
	<b>Base Case - Unconstrained</b>	<b>Constrained</b>	
All Periods	51.37%	52.16%	49.41%
Up Months	38.79%	40.61%	31.52%
Down Months	74.44%	73.33%	82.22%
<b>Mid-Cap</b>	<b>Minimum Variance</b>		<b>Rankings Based</b>
	<b>Base Case - Unconstrained</b>	<b>Constrained</b>	
All Periods	46.56%	47.37%	48.18%
Up Months	25.97%	27.27%	24.68%
Down Months	80.65%	80.65%	87.10%
<b>Small-Cap</b>	<b>Minimum Variance</b>		<b>Rankings Based</b>
	<b>Base Case - Unconstrained</b>	<b>Constrained</b>	
All Periods	47.32%	48.29%	49.27%
Up Months	26.92%	26.92%	30.77%
Down Months	82.67%	85.33%	81.33%

Source: S&P Dow Jones Indices LLC. Data current as of December 31, 2011. The Minimum Variance Constrained and Unconstrained Strategies were constructed using the Northfield Portfolio Optimizer and Simulator. The Rankings Based Low Volatility Strategies (a/k/a S&P 500 Low Volatility Index, S&P MidCap 400 Low Volatility Index and S&P SmallCap 600 Low Volatility Index) have been constructed based on the S&P 500, S&P MidCap 400 and S&P SmallCap 600 Indices, respectively. Past performance is no guarantee of future results. The data referenced in this chart may reflect hypothetical historical performance. Please see the Performance Disclosure at the end of this paper for more information on the inherent limitations associated with back-tested performance.

<b>Exhibit 5: Low-Volatility Strategies' Average Monthly Outperformance Relative to Market Portfolios</b>			
<b>Large-Cap</b>	<b>Minimum Variance</b>		<b>Rankings Based</b>
	<b>Base Case - Unconstrained</b>	<b>Constrained</b>	
All Periods	0.14%	0.14%	0.05%
Up Months	-0.84%	-0.55%	-0.98%
Down Months	1.93%	1.40%	1.94%
<b>Mid-Cap</b>	<b>Minimum Variance</b>		<b>Rankings Based</b>
	<b>Base Case - Unconstrained</b>	<b>Constrained</b>	
All Periods	-0.31%	-0.24%	-0.02%
Up Months	-1.69%	-1.36%	-1.54%
Down Months	1.96%	1.60%	2.50%
<b>Small-Cap</b>	<b>Minimum Variance</b>		<b>Rankings Based</b>
	<b>Base Case - Unconstrained</b>	<b>Constrained</b>	
All Periods	-0.06%	-0.01%	0.13%
Up Months	-1.34%	-1.08%	-1.15%
Down Months	2.15%	1.86%	2.34%

Source: S&P Dow Jones Indices LLC. Data current as of December 31, 2011. The Minimum Variance Constrained and Unconstrained Strategies were constructed using the Northfield Portfolio Optimizer and Simulator. The Rankings Based Low Volatility Strategies (a/k/a S&P 500 Low Volatility Index, S&P MidCap 400 Low Volatility Index and S&P SmallCap 600 Low Volatility Index) have been constructed based on the S&P 500, S&P MidCap 400 and S&P SmallCap 600 Indices, respectively. Past performance is no guarantee of future results. The data referenced in this chart may reflect hypothetical historical performance. Please see the Performance Disclosure at the end of this paper for more information on the inherent limitations associated with back-tested performance.

## 5: RISK COMPOSITION

As shown above, all three low-volatility strategies deliver superior risk-adjusted returns relative to a market cap-weighted benchmark portfolio despite significant differences in portfolio construction. However, despite the common thread of their risk-return behavior, they vary greatly in their risk composition.

Exhibit 6 presents the risk exposure compositions of the low-volatility strategies over the past 21 years. The contribution to ex-ante total risk of each strategy in any given year was broken into systematic or market risk, factor risk and stock-specific risk. The risk in each market cap segment was computed against the respective benchmark on a quarterly basis and averaged to create an annual figure. All three low-volatility strategies have systematic risk well below 1. Kang (2012) also found that both minimum variance and the non-optimized strategies had a market beta significantly below 1, as well as strong negative exposure to the volatility factor.

Of the three low-volatility strategies, the rankings-based approach appears to have generated the lowest level of systematic or market risk. The levels of systematic risk for the two minimum variance approaches were similar, with very little discernible difference, even though they were both higher than that of the rankings-based strategy. This was consistent across all three market cap segments. Based on the results, we can conclude that the rankings-based strategy's return behavior can diverge significantly from market returns as well as from the returns of the minimum variance strategies. This supplements our analysis in the previous section on the hit rate and the magnitude of outperformance in various market environments (see Exhibits 4 and 5). The rankings-based strategy outperformed the least frequently in rising markets but outperformed the most frequently and by the largest magnitude in falling markets.

The design differences among the three approaches are also responsible for divergence in the level of factor risk taken. The rankings-based strategy has a substantially larger exposure to factor risk than the minimum variance strategies. This is consistent across all three market cap segments. Similarly, Kang (2012) found that the non-

optimized low volatility strategies exhibited higher active risk and lower market beta compared to a minimum variance strategy. Active constraints on factors and other risk exposures are typically placed on an optimized minimum variance portfolio, so unlike the absence of those in the rankings-based strategy, the minimum variance strategy has controlled exposure to factor risk but higher exposure to market risk. The differences in risk composition have implications on the sources of portfolio returns.

The levels of stock-specific risk taken by all three strategies differ as well, but not as much as the differences observed with market risk and factor risk.

<b>Exhibit 6: Average Contribution to Low-Volatility Strategies' Total Risk</b>			
<b>Large-Cap</b>	<b>Systematic Risk</b>	<b>Factor Risk</b>	<b>Stock-Specific Risk</b>
Minimum Variance - Base	53.63	33.87	12.51
Minimum Variance - Constrained	45.23	37.79	17.24
Rankings Based	41.43	43.28	15.30
<b>Mid-Cap</b>	<b>Systematic Risk</b>	<b>Factor Risk</b>	<b>Stock-Specific Risk</b>
Minimum Variance - Base	58.87	25.97	15.15
Minimum Variance - Constrained	56.70	25.36	17.93
Rankings Based	33.86	44.02	22.12
<b>Small-Cap</b>	<b>Systematic Risk</b>	<b>Factor Risk</b>	<b>Stock-Specific Risk</b>
Minimum Variance - Base	63.24	24.96	11.80
Minimum Variance - Constrained	62.01	24.81	13.18
Rankings Based	43.84	45.89	10.27

Source: S&P Dow Jones Indices LLC. Data current as of December 31, 2011. The Minimum Variance Constrained and Unconstrained Strategies were constructed using the Northfield Portfolio Optimizer and Simulator. The Rankings Based Low Volatility Strategies (a/k/a S&P 500 Low Volatility Index, S&P MidCap 400 Low Volatility Index and S&P SmallCap 600 Low Volatility Index) have been constructed based on the S&P 500, S&P MidCap 400 and S&P SmallCap 600 Indices, respectively. Past performance is no guarantee of future results. The data referenced in this chart may reflect hypothetical historical performance. Please see the Performance Disclosure at the end of this paper for more information on the inherent limitations associated with back-tested performance.

## 6: RISK EFFICIENCY OF A WEIGHTING SCHEME

Market cap-weighted portfolios do not always have the lowest possible volatility given their expected returns (see Haugen and Baker [1991]). Only under the most restrictive set of assumptions<sup>6</sup>, market cap-weighted portfolios can be mean-variance efficient and lie on the efficient frontier. While the weights in the minimum variance portfolios are determined by the covariance matrix of the securities so that overall portfolio risk is minimized, the rankings-based low-volatility portfolio employs an alternative weighting scheme in which constituents are weighted by the inverse of their realized volatility.

<sup>6</sup> The assumptions are:

1. Investors have the same risk and return expectations for all securities.
2. Investors can short sell securities without restriction.
3. Returns are not subject to taxation.
4. The investment opportunity set for all investors holding any security in the index is restricted to the securities in the market cap-weighted index.

In order to determine whether the choice of weighting scheme played a role in the risk efficiency of a strategy, we compared the Sharpe ratios of the inverse risk-weighted, equal-weighted and market cap-weighted low-volatility portfolios to that of the market cap-weighted portfolio (see Exhibit 7). In the U.S. large-cap equity segment, the Sharpe ratios of the inverse risk-weighted and equal-weighted portfolios were the same, 0.63 each, while the market cap-weighted portfolio came in lowest, 0.54. These results imply that market cap-weighting a portfolio of low-volatility stocks fails to capture part of the low-volatility strategy's benefit. In other words, market cap-weighting results in a partial loss of risk efficiency. Nevertheless, all three Sharpe ratios were higher than the Sharpe ratio of the market cap-weighted benchmark portfolio, indicating that volatility as a factor can be a source of excess returns even though weighting a low-volatility portfolio by market cap can result in partial loss of risk efficiency.

U.S. mid-cap and small-cap equity segments produced similar results. In the mid-cap segment, the Sharpe ratio of an inverse risk-weighted portfolio was slightly higher than that of its equal-weighted counterpart, while the market cap-weighted low-volatility strategy had a slightly lower Sharpe ratio. All three Sharpe ratios, despite how they ranked among themselves, were superior to those of the market cap-weighted benchmarks for mid-caps and small-caps. In the small-cap segment, the Sharpe ratio of an equal-weighted rankings-based strategy was the highest; the market cap-weighted and inverse risk-weighted rankings-based strategies obtained lower, nearly identical Sharpe ratios. It is possible that a more uniform market cap distribution in the small-cap space was partly due to an equal-weighted strategy achieving the best risk efficiency.

Carvalho, Lu and Moulin (2012) described inverse weighting as an extension of equal-weight strategy in which risk is equally distributed among the stocks, with riskier stocks receiving smaller weights. In other words, the inverse-weighted low-volatility portfolio is an equal risk-weighted portfolio tilting toward low-volatility stocks. The results from the various weighting mechanisms confirm that an inverse risk-weighted low-volatility strategy achieves similar results as its equal-weight counterpart. More importantly, our studies show that choosing a weighting mechanism can result in partial gain or loss in a low-volatility strategy's risk efficiency, but it does not alter a low-volatility portfolio's ability to produce better risk-adjusted returns than a market cap-weighted benchmark portfolio.

<b>Exhibit 7: Risk Efficiency of Low-Volatility Strategies' Weighting Mechanisms</b>					
<b>Large-Cap</b>	<b>Average Return</b>	<b>Excess Return</b>	<b>Standard Deviation</b>	<b>Sharpe Ratio</b>	<b>t-stat</b>
Equal-Weighted	0.87%	7.20%	11.46%	0.63	4.08
Market Cap-Weighted	0.77%	6.00%	11.21%	0.54	3.70
Inverse-Weighted	0.87%	7.16%	11.32%	0.63	4.10
Benchmark	0.78%	5.39%	15.06%	0.36	2.75
<b>Mid-Cap</b>	<b>Average Return</b>	<b>Excess Return</b>	<b>Standard Deviation</b>	<b>Sharpe Ratio</b>	<b>t-stat</b>
Equal-Weighted	1.06%	9.58%	11.79%	0.81	4.85
Market Cap-Weighted	1.03%	9.16%	11.92%	0.77	4.66
Inverse-Weighted	1.04%	9.32%	11.07%	0.84	5.03
Benchmark	1.05%	8.49%	17.48%	0.49	3.24
<b>Small-Cap</b>	<b>Average Return</b>	<b>Excess Return</b>	<b>Standard Deviation</b>	<b>Sharpe Ratio</b>	<b>t-stat</b>
Equal-Weighted	0.92%	7.51%	15.21%	0.49	2.80
Market Cap-Weighted	0.86%	6.91%	14.34%	0.48	2.78
Inverse-Weighted	1.01%	8.90%	14.48%	0.61	3.25
Benchmark	0.94%	6.73%	20.51%	0.33	2.12

Source: S&P Dow Jones Indices LLC. Data current as of March 31, 2012. The Minimum Variance Constrained and Unconstrained Strategies were constructed using the Northfield Portfolio Optimizer and Simulator. The Rankings Based Low Volatility Strategies (a/k/a S&P 500 Low Volatility Index, S&P MidCap 400 Low Volatility Index and S&P SmallCap 600 Low Volatility Index) have been constructed based on the S&P 500, S&P MidCap 400 and S&P SmallCap 600 Indices, respectively. Past performance is no guarantee of future results. The data referenced in this chart may reflect hypothetical historical performance. Please see the Performance Disclosure at the end of this paper for more information on the inherent limitations associated with back-tested performance.

## 7: THE LOW-VOLATILITY EFFECT IN DEVELOPED AND EMERGING MARKETS

Studies have shown that low-volatility investing is equally effective on a global and regional scale. Based on a universe of European and Japanese large-cap stocks observed from 1986 to 2006, Blitz and Vliet (2007) noted a 5.9% difference in average returns between the top and bottom decile portfolios. Regression results from the monthly returns of decile portfolios against the monthly market returns indicated a negative relation between estimated betas and alphas. On a regional level, the results showed alpha spreads of 10.2% for Europe and 10.5% for Japan. Blitz, Pang and Vliet (2012) extended the study to emerging equity markets and concluded that the empirical relationship between risk and return was negative, and was much stronger when volatility rather than beta was used as a measure of risk to rank securities. Based on the universe of S&P/IFCI Investable Emerging Markets Index constituents, the authors found that the Sharpe ratio of the low-volatility portfolio was more than twice that of the high-volatility portfolio (0.69 versus 0.29).

We extended our analysis of the low-volatility effect to a global scale by examining low-volatility strategies in international developed and emerging markets. Similar to our analysis of the U.S equity markets, we compared the results from the rankings-based and the mean variance optimization-based low-volatility strategies to the broader regional benchmarks. The methodology for the rankings-based strategy for the international developed and emerging markets differs slightly from the one we used for the U.S markets. While we quantile the domestic universe and hold the lowest quintile of stocks ranked by volatility, we hold a fixed number of securities (200 for each market) for our international analysis. The number of stocks in our underlying universe of international developed and emerging market securities varies greatly from period to period, whereas the number of

constituents is fixed for the domestic universe<sup>7</sup>. In addition, we use the MSCI EAFE Minimum Volatility Index to represent the international developed minimum variance-based strategy and the MSCI Emerging Markets Minimum Volatility Index to represent the minimum variance-based strategy for emerging markets.

Comparing the risk-return profiles of portfolios in the international developed and emerging markets shows the effectiveness of low-volatility strategies (see Exhibits 8 and 9). In the developed markets, both low-volatility strategies reduced realized volatility by 29% to 30% compared to the market cap-weighted regional benchmarks over 10- and 20-year periods. Similar to the results in the U.S. markets, the reduction in volatility is achieved without any reduction of returns. As a result, both strategies have higher Sharpe ratios than the benchmarks over multiple timeframes.

In the emerging markets, depending on the strategy, low-volatility portfolios had 29% to 33% lower volatility compared to market cap-weighted benchmarks over a 10-year period. The rankings-based low-volatility strategy had the highest level of risk reduction (almost 33%) among all the strategies we have examined in the various regional equity markets, which is significant because emerging market returns are typically accompanied by even higher volatility.

<b>Exhibit 8: Comparison of Low-Volatility Strategies in International Developed Markets</b>				
	<b>Low-Volatility Strategy</b>		<b>Benchmark</b>	
	<b>Rankings Based</b>	<b>Minimum Variance</b>	<b>MSCI EAFE Index</b>	<b>S&amp;P BMI International Developed LargeMid</b>
<b>Annualized Returns</b>				
1 Year	0.83%	3.91%	-5.31%	-6.30%
3 Year	17.19%	17.06%	17.68%	18.16%
5 Year	1.93%	0.59%	-3.04%	-2.14%
10 Year	12.70%	10.18%	6.16%	6.65%
20 year	10.78%		6.15%	6.80%
<b>Annualized Risk</b>				
3 Year	13.06%	13.27%	20.90%	20.86%
5 Year	15.68%	15.59%	22.92%	22.97%
10 Year	13.07%	13.08%	18.73%	18.69%
20 year	11.95%		16.92%	16.87%
<b>Sharpe Ratio</b>				
3 Year	1.306	1.277	0.840	0.865
5 Year	0.062	-0.024	-0.175	-0.135
10 Year	0.835	0.642	0.234	0.260
20 year	0.634		0.175	0.213

Source: S&P Dow Jones Indices LLC and MSCI. Data current as of March 31, 2012. The Minimum Variance Constrained and Unconstrained Strategies are represented by the MSCI EAFE Minimum Volatility Index. The Rankings Based Low Volatility Strategies is represented by the S&P BMI International Developed Markets Low Volatility Index which was launched on December 5, 2011 and constructed based on the S&P BMI International Developed Markets Index. Past performance is no guarantee of future results. All data referenced in this chart prior to December 5, 2011 reflects hypothetical historical performance. Please see the Performance Disclosure at the end of this paper for more information on the inherent limitations associated with back-tested performance.

<sup>7</sup> We use the S&P BMI International Developed ex. US and South Korea LargeMid Index as our universe for the international developed markets low volatility strategy and the S&P BMI Emerging Markets Plus LargeMid Index as our universe for the emerging markets low volatility strategy. Volatility is computed using daily one-year price changes in local currency.

<b>Exhibit 9: Comparison of Low-Volatility Strategies in International Emerging Markets</b>				
	<b>Low-Volatility Strategy</b>		<b>Benchmark</b>	
	<b>Rankings Based</b>	<b>Minimum Variance</b>	<b>MSCI Emerging Markets Index</b>	<b>S&amp;P BMI Emerging Plus LargeMid</b>
<b>Annualized Returns</b>				
1 Year	5.99%	6.11%	-8.53%	-8.30%
3 Year	30.83%	31.06%	25.41%	25.38%
5 Year	12.19%	10.96%	4.97%	5.44%
10 Year	19.53%	18.58%	14.47%	13.92%
14 year	13.15%		9.16%	9.75%
<b>Annualized Risk</b>				
3 Year	16.93%	18.85%	25.13%	24.82%
5 Year	19.97%	23.38%	29.59%	29.08%
10 Year	16.51%	19.41%	24.52%	24.10%
14 year	17.55%		25.97%	26.38%
<b>Sharpe Ratio</b>				
3 Year	1.814	1.641	1.007	1.018
5 Year	0.562	0.428	0.135	0.154
10 Year	1.075	0.865	0.517	0.503
14 year	0.601		0.253	0.271

Source: S&P Dow Jones Indices LLC and MSCI. Data current as of March 31, 2012. The Minimum Variance Constrained and Unconstrained Strategies are represented by the MSCI Emerging Markets Minimum Volatility Index. The Rankings Based Low Volatility Strategies is represented by the S&P BMI Emerging Markets Low Volatility Index which was launched on December 5, 2011 and constructed based on the S&P BMI International Developed Markets Index. Past performance is no guarantee of future results. All data referenced in this chart prior to December 5, 2011 reflects hypothetical historical performance. Please see the Performance Disclosure at the end of this paper for more information on the inherent limitations associated with back-tested performance.

## 8: CONCLUSIONS

Consistent with the findings of earlier academic research, our study shows that both principal approaches to constructing low-volatility strategies are equally effective in their ability to reduce realized volatility relative to market cap-weighted portfolios over an intermediate- to long-term investment horizon. Using the Sharpe ratio to measure the effectiveness of each strategy on a risk-return tradeoff basis, our analysis shows low-volatility strategies possess superior risk-adjusted performance over a benchmark portfolio. This desirable risk-return characteristic could have a profound portfolio management implication because the portfolio with a higher Sharpe ratio provides better diversification.

Extending the study to the developed and emerging markets also shows the effectiveness of low-volatility strategies on a global scale. In fact, the level of risk reduction over the long term is even higher than that observed in the U.S. equity markets (particularly in the emerging markets).

Lastly, it is nearly impossible to analyze the low-volatility effect without discussing the role of traditional equilibrium asset pricing theory. Hence, in addition to providing above-mentioned risk management capabilities, low volatility effect has reignited the debate on what constitutes a market portfolio or an optimal Sharpe portfolio, a tangency portfolio for which there is no other portfolio with the same or higher expected return with lower volatility. In doing so, it brings new light to the CAPM criticism, as posited by many academic studies, that cross-sectional variation in average returns of stocks cannot be explained by the market risk factor alone.

## INDEX RESEARCH &amp; DESIGN CONTACT INFORMATION

**Global Head**

Frank Luo	+1 212-438-5057	frank_luo@spdji.com
-----------	-----------------	---------------------

**New York**

Berlinda Liu	+1 212-438-7834	berlinda_liu@spdji.com
Aye Soe	+1 212-438-1677	aye_soe@spdji.com
Peter Tsui	+1 212-438-1493	peter_tsui@spdji.com

**Beijing**

Liyu Zeng	+86 10-6569-2947	liyu_zeng@spdji.com
-----------	------------------	---------------------

**Hong Kong**

Priscilla Luk	+852 2532-8050	priscilla_luk@spdji.com
---------------	----------------	-------------------------

**London**

Xiaowei Kang	+020 7176-8443	xiaowei_kang@spdji.com
Daniel Ung	+44 (0) 207 176 8340	daniel_ung@spdji.com

**Sydney**

Simon Karaban	+ 61 2 9255 9847	simon_karaban@spdji.com
---------------	------------------	-------------------------

## ABOUT S&amp;P DOW JONES INDICES RESEARCH &amp; DESIGN

S&P Dow Jones Indices is one of the world's leading index providers, maintaining a wide variety of investable and benchmark indices to meet a wide array of investor needs. Our research team is dedicated to conducting unbiased and in-depth analysis on a broad range of topics and issues facing investors in today's marketplace. Research by S&P Dow Jones Indices' Index Research & Design provokes discussion on investment matters related to benchmarking in the asset management, derivatives and structured products communities. The series covers all asset classes and is often used to float new indexing concepts or explain substantive changes to well-known S&P Dow Jones indices.

For more articles on a broad range of index-related topics or to sign up to receive periodic updates, visit us at [www.spdji.com](http://www.spdji.com).

Like what you read? [Sign up](#) to receive complimentary updates on a broad range of index-related topics and events brought to you by S&P Dow Jones Indices.



**S&P DOW JONES  
INDICES**  
McGraw Hill Financial

## REFERENCES

- Ang, Andrew, Robert J. Hodrick, Yuhang Xing, and Xiaoyan Zhang (2006). "The Cross Section of Volatility and Expected Returns." *Journal of Finance*, Vol. 61, No.1.
- Baker, Malcolm, Brendan Bradley, and Jeffrey Wurgler (2011). "Benchmarks as Limits to Arbitrage: Understanding the Low Volatility Anomaly." *Financial Analysts Journal*, Vol. 67, No. 1.
- Black, Fischer, Michael C. Jensen, and Myron Scholes (1972). "The Capital Asset Pricing Model: Some Empirical Tests". *Studies in the Theory of Capital Markets*. Praeger.
- Blitz, David C., and Pim van Vliet (2007). "The Volatility Effect: Lower Risk without Lower Return," *Journal of Portfolio Management*, Vol. 34, No. 1.
- \_\_\_\_\_ (2011). "Benchmarking Low Volatility Strategies," *Journal of Index Investing*. Vol. 2, No. 1.
- Blitz, David C., Juan Pang and Pim van Vliet (2012). "The Volatility Effect in Emerging Markets," Robeco Research Paper.
- Carvalho, Raul Leote de, Xiao Lu and Pierre Moulin (2012). "Demystifying Equity Risk-Based Strategies: A Simple Alpha plus Beta Description". *Journal of Portfolio Management*, Vol. 38, No. 3.
- Choueifaty, Yves and Yves Coignard (2008). "Toward Maximum Diversification." *Journal of Portfolio Management*, Vol. 35, No. 1.
- Clarke, Roger, Harindra de Silva and Steven Thorley (2006). "Minimum-Variance Portfolios in the U.S Equity Market." *Journal of Portfolio Management*, Vol. 33, No. 1
- \_\_\_\_\_ (2011). "Minimum-Variance Portfolio Composition." *Journal of Portfolio Management*, Vol. 37, No. 2
- Fama, Eugene F., and Kenneth R. French (1992). "The cross-section of expected stock returns". *Journal of Finance*, Vol. 47, No. 2.
- Haugen Robert A. and Nardin L. Baker (1991). "The Efficient Market Inefficiency of Capitalization-Weighted Stock Portfolios," *The Journal of Portfolio Management*, Spring 1991.
- Kang, Xiaowei (2012). "Evaluating Alternative Beta Strategies". S&P Dow Jones Indices Research Paper.
- Markowitz, H (1952). "Portfolio Selection." *Journal of Finance*, Vol. 7, No.1
- Mezrich, Joseph and Yasushi Ishikawa. "Now you see it, now you don't – low volatility alpha as index distribution arbitrage." Nomura Research Paper. July 2011.
- Monnier, Bruno and Ksenya Rulik (2011). "Mechanics of Minimum Variance Investment Approach." Ossiam Research Paper.
- Soe, Aye (2009). "A Tale of Two Benchmarks." S&P Dow Jones Indices Research Paper.

## PERFORMANCE DISCLOSURE

The inception date of the S&P 500 Low Volatility Index was April 4, 2011, at the market close. The Low Volatility Index was constructed based on the underlying S&P 500 Index. All information presented prior to the index inception date is back-tested. Back-tested performance is not actual performance, but is hypothetical. The back-test calculations are based on the same methodology that was in effect when the index was officially launched. Complete index methodology details are available at [www.spdji.com](http://www.spdji.com).

The S&P MidCap 400 Low Volatility Index and the S&P SmallCap 600 Low Volatility Index have not been launched by S&P Dow Jones Indices and therefore all information presented in relation to these indices is back-tested. The Low Volatility Indices were constructed based on their underlying benchmarks, specifically the S&P MidCap 400 Index and the S&P SmallCap 600 Index. The inception date of S&P MidCap 400 Index was August 31, 1991 and of the S&P SmallCap 600 was February 31, 1995. The Rankings based midcap low volatility strategy is based on the S&P MidCap 400 Index which was launched on August 31, 1991. The Rankings based smallcap low volatility strategy is based on the S&P SmallCap 600 Index which was launched on February 31, 1995. The back-test calculations are based on the same methodology that was used in the construction of the S&P 500 Low Volatility Index.

The inception date of the S&P BMI Emerging Markets Low Volatility Index and the S&P BMI International Developed Low Volatility Index was December 5, 2011, at the market close. All information presented prior to the index inception date is back-tested. Back-tested performance is not actual performance, but is hypothetical. The back-test calculations are based on the same methodology that was in effect when the index was officially launched. Complete index methodology details are available at [www.spdji.com](http://www.spdji.com).

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](http://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. It is not possible to invest directly in an Index.

Another limitation of back-tested hypothetical information is that generally the back-tested calculation is prepared with the benefit of hindsight. Back-tested data reflect 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 (or 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 investible 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 3 years, 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).

## DISCLAIMER

Copyright © 2013 by S&P Dow Jones Indices LLC, a part of McGraw Hill Financial. All rights reserved. Standard & Poor's and S&P are registered trademarks of Standard & Poor's Financial Services LLC ("S&P"), a part of McGraw Hill Financial. Dow Jones is a registered trademark of Dow Jones Trademark Holdings LLC ("Dow Jones"). Trademarks have been licensed to S&P Dow Jones Indices LLC. Redistribution, reproduction and/or photocopying in whole or in part are prohibited without written permission. This document does not constitute an offer of services in jurisdictions where S&P Dow Jones Indices LLC, Dow Jones, S&P or their respective affiliates (collectively "S&P Dow Jones Indices") do not have the necessary licenses. All information provided by S&P Dow Jones Indices is impersonal and not tailored to the needs of any person, entity or group of persons. S&P Dow Jones Indices receives compensation in connection with licensing its indices to third parties. Past performance of an index is not a guarantee of future results.

It is not possible to invest directly in an index. Exposure to an asset class represented by an index is available through investable instruments based on that index. S&P Dow Jones Indices does not sponsor, endorse, sell, promote or manage any investment fund or other investment vehicle that is offered by third parties and that seeks to provide an investment return based on the performance of any index. S&P Dow Jones Indices makes no assurance that investment products based on the index will accurately track index performance or provide positive investment returns. S&P Dow Jones Indices LLC is not an investment advisor, and S&P Dow Jones Indices makes no representation regarding the advisability of investing in any such investment fund or other investment vehicle. A decision to invest in any such investment fund or other investment vehicle should not be made in reliance on any of the statements set forth in this document. Prospective investors are advised to make an investment in any such fund or other vehicle only after carefully considering the risks associated with investing in such funds, as detailed in an offering memorandum or similar document that is prepared by or on behalf of the issuer of the investment fund or other vehicle. Inclusion of a security within an index is not a recommendation by S&P Dow Jones Indices to buy, sell, or hold such security, nor is it considered to be investment advice.

These materials have been prepared solely for informational purposes based upon information generally available to the public and from sources believed to be reliable. No content contained in these materials (including index data, ratings, credit-related analyses and data, research, valuations, model, software or other application or output therefrom) or any part thereof (Content) may be modified, reverse-engineered, reproduced or distributed in any form or by any means, or stored in a database or retrieval system, without the prior written permission of S&P Dow Jones Indices. The Content shall not be used for any unlawful or unauthorized purposes. S&P Dow Jones Indices and its third-party data providers and licensors (collectively "S&P Dow Jones Indices Parties") do not guarantee the accuracy, completeness, timeliness or availability of the Content. S&P Dow Jones Indices Parties are not responsible for any errors or omissions, regardless of the cause, for the results obtained from the use of the Content. THE CONTENT IS PROVIDED ON AN "AS IS" BASIS. S&P DOW JONES INDICES PARTIES DISCLAIM ANY AND ALL EXPRESS OR IMPLIED WARRANTIES, INCLUDING, BUT NOT LIMITED TO, ANY WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE OR USE, FREEDOM FROM BUGS, SOFTWARE ERRORS OR DEFECTS, THAT THE CONTENT'S FUNCTIONING WILL BE UNINTERRUPTED OR THAT THE CONTENT WILL OPERATE WITH ANY SOFTWARE OR HARDWARE CONFIGURATION. In no event shall S&P Dow Jones Indices Parties be liable to any party for any direct, indirect, incidental, exemplary, compensatory, punitive, special or consequential damages, costs, expenses, legal fees, or losses (including, without limitation, lost income or lost profits and opportunity costs) in connection with any use of the Content even if advised of the possibility of such damages.

S&P Dow Jones Indices keeps certain activities of its business units separate from each other in order to preserve the independence and objectivity of their respective activities. As a result, certain business units of S&P Dow Jones Indices may have information that is not available to other business units. S&P Dow Jones Indices has established policies and procedures to maintain the confidentiality of certain non-public information received in connection with each analytical process.

In addition, S&P Dow Jones Indices provides a wide range of services to, or relating to, many organizations, including issuers of securities, investment advisers, broker-dealers, investment banks, other financial institutions and financial intermediaries, and accordingly may receive fees or other economic benefits from those organizations, including organizations whose securities or services they may recommend, rate, include in model portfolios, evaluate or otherwise address.