Market Timing With Implied Volatility Indices

EXECUTIVE SUMMARY

This applied methodology paper introduces an intuitive framework for constructing robust market timing signals based on implied volatility indices. In particular, we define the object of prediction as drawdown events, which tend to coincide with periods of high realized volatility. The simple regime-based approach depends on the hypothesis that option-implied volatility indices possess some predictive power with respect to future realized volatility and hence drawdowns. Compelling empirical evidence supporting this hypothesis is presented, and the study concludes with illustrative applications of the signal for market timing strategies.

Highlights

- Drawdowns tend to coincide with periods of high realized volatility.
- Implied volatility indices tend to lead future realized volatility.
- A simple volatility regime framework may produce robust market timing signals.

OVERVIEW OF THE VIX® ECOSYSTEM

In 1993, the CBOE Volatility Index® (VIX) was the first implied volatility index to be introduced. The index has since become the most widely tracked measure of market volatility and is known as the “fear gauge” of general market participant sentiment. Trading activity in VIX futures and options has significantly expanded in volume in recent years, and there has been a rise in the popularity of exchange-traded products, structured products, and over-the-counter trades referencing the index as well.

The success of VIX was followed by an extension of the implied volatility index family to include different asset classes and geographies.

1. CBOE Volatility Index (VIX)
2. CBOE Interest Rate Swap Volatility Index (SRVIX)
3. CBOE/CBOT 10-Year Treasury Note Volatility Index (TYVIX)
4. S&P/JPX JGB VIX (SPJGBV)
5. CBOE Crude Oil ETF Volatility Index (OVX)
6. CBOE Gold ETF Volatility Index (GVZ)
7. CBOE/CME FX Euro Volatility Index (EUVIX)
Volatility Spikes and Drawdowns

The focus of this empirical study on market timing is the potential use of implied volatility indices to help anticipate future downside events in various markets. While there is no mathematical condition forcing volatility to be directionally correlated with positive or negative security returns, periods of pronounced losses have historically been associated with elevated volatility in the data. Exhibits 1 and 2 illustrate the prevalence of this negative and convex relationship using scatterplots of monthly returns on various securities against contemporaneous 21-day realized volatilities. Theories abound regarding the origins of this phenomenon, which is an interesting topic in and of itself, but our present analysis remains agnostic to this debate and simply uses this observation as an empirical building block.

Exhibit 1: S&P 500® Monthly Returns Versus 21-Day Realized Volatility

Source: Bloomberg. Data as of July 11, 2017. Past performance is no guarantee of future results. Chart is provided for illustrative purposes.

Exhibit 2: USDJPY Monthly Returns Versus 21-Day Realized Volatility

Source: Bloomberg. Data as of July 11, 2017. Past performance is no guarantee of future results. Chart is provided for illustrative purposes.
When viewed as a time series, an additional facet of the relationship between volatility and returns emerges in the form of pronounced drawdowns during periods of high volatility. This temporal clustering of negative returns makes high volatility periods particularly painful for market participants. Exhibits 3 and 4 show how the largest drawdowns in the S&P 500 and 10-Year U.S. Treasury Note futures prices coincide with heightened volatility. This relates to a core concept underpinning the growing interest in factor-based investing in which the long-term premium earned by taking exposure to factors is commonly interpreted as compensation for underperformance during “bad times” when market participants experience pain most acutely; being long volatility is expensive because it pays off when the average market participant needs it the most.

**Exhibit 3: Coincidence of Drawdowns in the S&P 500 With High Realized Volatility Periods**

![S&P 500 Price Chart](source: Bloomberg. Data as of July 21, 2017. Past performance is no guarantee of future results. Chart is provided for illustrative purposes.)

**Exhibit 4: Coincidence of Drawdowns in 10-Year U.S. Treasury Note Futures Price With High Realized Volatility Periods**

![10-Year U.S. Treasury Note Futures Chart](source: Bloomberg. Data as of July 21, 2017. Past performance is no guarantee of future results. Chart is provided for illustrative purposes.)
If drawdowns coincide with high realized volatility periods, it stands to reason that forecasting spikes in realized volatility should also allow market participants to anticipate impending drawdowns. Arguably, the best volatility forecasting expertise can be found in options markets, where traders sink or swim by the accuracy of their views on future volatility, which is the main determinant of option prices. Option quotes are often accompanied by an “implied volatility” number, which is a model-based estimate of future volatility as implied by option prices. In theory, one may interpret option-implied volatility as the aggregate view on how volatile the underlying security will be between a given day and the option expiry, and hence should be as good a predictor as any. In practice, however, standard models, such as Black-Scholes, fail to deliver this interpretation, as options with different strikes often produce different model-implied volatilities for the same underlying security and future time period (also known as the volatility “smile” or “smirk”), which is clearly nonsensical.

The VIX family of implied volatility indices gets around this inherent inconsistency by using a mathematical technique for extracting information about future volatility from options across all strikes and distilling it down into one clean (i.e., model-independent) implied volatility number. Without getting into the technical details, clean implied volatility may be interpreted as the fair strike of a realized volatility swap, which gives it the designation of the market-clearing price of volatility. As such, this study rests on the hypothesis that option traders are skilled at forecasting volatility and that the resulting VIX values serve as effective predictive signals.

**TIME SERIES BEHAVIOR OF VOLATILITY**

In order to frame the prediction problem precisely, one must first define the object of prediction. Traditional assets, such as stocks and bonds, tend to exhibit upward trends in the long run, as dividends and coupons are paid and market capitalization grows with the economy over time. In contrast, the price of volatility has a default state of being low during protracted periods of market calm, mixed with spurts of high periods brought on by various shocks. The ascent of a volatility spike is usually much steeper than the descent, which suggests that heightened volatility tends to linger for some time after the initial burst. In our view, these are the only two time series characteristics that matter for volatility from a high-level fundamental perspective, and we disregard the higher-frequency, lower-amplitude oscillations as noise.

---

1 More precisely, the square root of an annualized strike of a variance swap.
Using fixed cutoff levels of the absolute index values, as marked in the figure, does not lead to consistent identification through time of what our eyes can easily identify as spikes, given the varying amplitudes.

A bird’s eye view of VIX and TYVIX in Exhibits 5 and 6 suggests that the prediction target should be some definition of a volatility spike or, more generally, high volatility. However, even a casual glance could suffice to conclude that using fixed cutoff levels of the absolute index values, as marked in the figures, does not lead to consistent identification through time of what our eyes can easily identify as spikes, given the varying amplitudes. Instead, what market participants experience as a spike is context and level dependent, meaning that an effective definition of a spike must account for
what the world looked like leading up to it; what feels like a blip during a total market meltdown may feel like a jolt during peaceful times. Moreover, the steep ascent likely narrows the window for timely prediction, and therefore any successful signal must be at once sensitive to sudden moves and robust in its resistance to noisy jitters.

**Concept of Volatility Regimes**

A simple and intuitive approach that satisfies the desired criteria discussed above is to define high and low volatility regimes whereby transitions are triggered by the upward and downward crossings of two rolling quantiles. If our hypothesis about clean implied volatility holds, high realized volatility regimes would then be preceded, and hence predicted, by high implied volatility regimes. In other words, the binary regime construct serves as both the object of prediction and the signal.

Exhibits 8 and 10 show high realized volatility regimes for the S&P 500 and 10-Year U.S. Treasury Note futures shaded in light gray, which is based on six-month rolling 10% and 90% quantiles. Exhibits 7 and 9 show the analogous regimes based on VIX and TYVIX. One can see that the thus-defined high regimes generally agree with what the average market participant would consider to be jumps in volatility. It is of course trivial to add more parameters to this framework to catch (in back-testing) every perceived jump and drawdown, but our view is that a sprinkling of misclassification is a small price to pay for the benefits of a parsimonious approach.

**Exhibit 7: VIX With Shaded Regimes and Rolling Quantiles**

Source: Bloomberg. Data as of July 21, 2017. Past performance is no guarantee of future results. Chart is provided for illustrative purposes.
The distance between the two quantiles mitigates erratic switching between the two regimes while setting a threshold for what constitutes a spike, and the rolling window controls how quickly the bands adjust to the most recent returns. One should set these parameters independently for realized and implied volatilities such that they reasonably separate high and low regimes in one’s opinion; this would help avoid overfitting the lead-lag relationship between the two. A caveat is that one may be justified in using different parameter values when dealing with different target assets or when combining two or more volatility indices to define regimes, as we will show in the Applications section.
The merits of the parsimony in our volatility regime framework should not be glossed over as a mere technical point. This framework significantly reduces the dimensionality of an otherwise unruly problem by (a) collapsing the entire range of volatility into two categorical states, (b) using only three parameters to define the regimes, and (c) precisely and identically defining the object of prediction and signal based on economic rationale. While these considerations do not completely remove the possibility of overfitting—the dominant risk when performing any kind of predictive exercise—they significantly reduce it, especially compared with the less principled approaches seen in some volatility-based strategies with more numerous parameters.

Two Empirical Building Blocks

To generalize the visual case studies above regarding the association between high volatility regimes and drawdowns, we expanded the analysis to document the contemporaneous relationship across eight implied volatility indices in the VIX series and 15 major securities. To do so, we identified the peak-to-trough dates of the top 10 drawdowns for each security, and subtracted the sum of returns on high regime days from those on low regime days within the peak-to-trough period. If the hypothesis is that the worst of drawdowns happen in high-realized-volatility regimes, then we should expect this difference to be negative. This analysis is silent on what happens in regimes outside of drawdowns, but this will be implicitly explored in the applications section. Exhibit 13 shows the results of this calculation.

Source: Bloomberg. Data as of July 21, 2017. Past performance is no guarantee of future results. Chart is provided for illustrative purposes.
Exhibit 11 illustrates this analysis with a drawdown in 10-Year U.S. Treasury futures from Nov. 4, 2010, to Feb. 8, 2011. Out of the 68 days from peak to trough, 55 days fall under the high realized volatility regime, with a cumulative difference in return between the high and low regime days of -4.8%. In this instance, the high implied volatility regime can be seen to precede the high realized volatility by about one week.

Exhibit 12: 10-Year U.S. Treasury Note Realized Volatility Drawdown Period

<table>
<thead>
<tr>
<th>DATA POINT</th>
<th>IMPLIED VOLATILITY</th>
<th>REALIZED VOLATILITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low Regime Dates</td>
<td>Nov. 4, 2010, to Nov. 12, 2010</td>
<td>Nov. 4, 2010, to Nov. 23, 2010</td>
</tr>
<tr>
<td>Number of Low Days</td>
<td>6</td>
<td>13</td>
</tr>
<tr>
<td>Cumulative Low Returns (%)</td>
<td>-0.77</td>
<td>-1.19</td>
</tr>
<tr>
<td>Number of High Days</td>
<td>62</td>
<td>55</td>
</tr>
<tr>
<td>Cumulative High Returns (%)</td>
<td>-6.4</td>
<td>-6.0</td>
</tr>
<tr>
<td>Cumulative High Minus Low Return (%)</td>
<td>-5.67</td>
<td>-4.84</td>
</tr>
</tbody>
</table>

Source: Bloomberg. Data from Nov. 4, 2010, to Feb. 8, 2011. Past performance is no guarantee of future results. Table is provided for illustrative purposes.
Realized volatilities are associated with drawdowns across asset class boundaries; when crossed with sound economic rationale, this empirical fact may be used to consider strategies not only for drawdown avoidance but also for asset rotation.

Consistent with our hypothesis, 107 out of the 120 volatility-security combinations are negative. Of the 13 combinations that are positive, five are in gold and treasuries; this is consistent with the fact that those assets are traditionally considered to be flight-to-quality assets that perform well during market upheavals. Another notable observation is that realized volatilities are associated with drawdowns across asset class boundaries; when crossed with sound economic rationale, this empirical fact may be used to consider strategies not only for drawdown avoidance but also for asset rotation, as we will allude to in one of the applications that follow.

The next empirical building block we must generalize in our chain of reasoning is the lead-lag relationship between implied and realized volatility regimes. To this end, we started by analyzing the cross-correlation function (CCF) between realized and implied volatility regimes, and then conducted Granger causality tests to summarize the lead-lag effect.
To construct a CCF, we codified high and low regimes to 1s and 0s and took the first difference to obtain a sequence of -1s (high to low), 0s (no change), and 1s (low to high) for both implied and realized volatilities and calculate their cross correlation at various lags. Exhibits 14 and 15 show the CCF plot between implied and realized volatility regimes of the S&P 500 and 10-Year U.S. Treasury Note. Negative lags indicate correlation between current realized volatility and past values of implied volatility.

Exhibit 14: S&P 500 CCF Plot

Exhibit 15: 10-Year U.S. Treasury Note CCF Plot

Source: Bloomberg. Data as of July 21, 2017. Past performance is no guarantee of future results. Chart is provided for illustrative purposes.
The CCF plots show statistically significant lead-lag effects for both the S&P 500-VIX and 10-Year U.S. Treasury Note-TYVIX pairs, with implied leading realized volatility regimes. To summarize the predictive relationship, we ran Granger causality tests for the eight VIX indices and their respective realized volatilities. Exhibit 16 shows the p-value for the hypothesis that implied volatility regimes do not Granger-cause realized volatility regimes, and the test comfortably rejects this hypothesis in six out of the eight indices at the 5% significance level, with the BPVIX just being on the cusp of rejection. The test fails to reject for oil with a high p-value of 23%. These results provide strong evidence to corroborate our core hypothesis that implied volatility indices are good predictors of future realized volatility across various asset classes, at least when collapsed into binary regimes.

### Exhibit 16: P-Values of the Granger Causality Tests for 8 Implied Volatility Indices

<table>
<thead>
<tr>
<th>IMPLIED VOLATILITY INDEX</th>
<th>P-VALUES</th>
</tr>
</thead>
<tbody>
<tr>
<td>VIX</td>
<td>0.0000</td>
</tr>
<tr>
<td>TYVIX</td>
<td>0.0000</td>
</tr>
<tr>
<td>OVX</td>
<td>0.2331</td>
</tr>
<tr>
<td>GVZ</td>
<td>0.0001</td>
</tr>
<tr>
<td>EUVIX</td>
<td>0.0000</td>
</tr>
<tr>
<td>JYVIX</td>
<td>0.0032</td>
</tr>
<tr>
<td>BPVIX</td>
<td>0.0567</td>
</tr>
<tr>
<td>SPJGBVIX</td>
<td>0.0000</td>
</tr>
</tbody>
</table>

Source: Bloomberg. Data as of July 21, 2017. Past performance is no guarantee of future results. Table is provided for illustrative purposes.

### Applications

With the empirical building blocks solidly in place to support our prediction framework, we turn to two illustrative examples of how they may be used in market timing strategies. An obvious application based on the results already shown is to use one of the VIX indices to time drawdowns of its underlying asset. However, to make things a bit more interesting, we explored applications that cross equity and fixed income VIX indices to create four regimes (high-high, high-low, low-high, and low-low) that profile the relative levels of anxiety in the two markets.

We began in Japan with the Nikkei 225 and the USDJPY carry trade as the investible quantities of interest. We used VIX and SPJGBVIX as broad-based gauges of anxiety in their respective countries to define four regimes:

- SPJGBVIX low/VIX low: Calm in the U.S. and Japan
- SPJGBVIX high/VIX low: Isolated anxiety in Japan
- SPJGBVIX low/VIX high: Isolated anxiety in the U.S.
- SPJGBVIX high/VIX high: Anxiety in the U.S. and Japan
Exhibit 17 shows the return decomposition of the Nikkei 225 and the USDJPY carry trade across the four regimes during 2008-2017 (SPJGBVIX data starts in 2008). Each color block represents the cumulative return of each security attributable to the corresponding regime. The Japanese yen rallied against the U.S. dollar in the SPJGBVIX low/VIX high regime, which was consistent with the economic intuition that capital tends to flow into the Japanese yen as a safe haven currency when general risk aversion is high, while Japanese yen rates remain stable. Given the widely acknowledged near impossibility of predicting FX spot returns and the parsimony of this approach, even a slight return separation is noteworthy here. As a side note, using VIX regimes alone significantly mutes the carry trade return separation. Moreover, the negative Nikkei 225 returns in this regime are consistent with the mainstream narrative that Japanese corporate equity valuations suffer when the Japanese yen rallies, given their heavy reliance on exports.

Exhibit 17: Return Decomposition for Japanese Assets Based on Combined SPJGBVIX and VIX Regimes, VIX Regimes, and SPJGBVIX Regimes

Source: Bloomberg. Data as of July 21, 2017. Past performance is no guarantee of future results. Chart is provided for illustrative purposes and reflects hypothetical historical performance. Please see the Performance Disclosure at the end of this document for more information regarding the inherent limitations associated with back-tested performance.

These return separation results may be turned into simple long-short strategies: (a) a carry trade investor could reverse, or gets out of, the trade in low/high regimes and (b) go short in the Nikkei 225 in low/high regimes and long otherwise. Exhibits 18-21 show cumulative returns for...
These long-short strategies along with their performance statistics compared with being long-only. The outperformance is evident.

**Exhibit 18: Nikkei 225 Long-Short Strategy Based on SPJGBVIX and VIX Regimes**

<table>
<thead>
<tr>
<th>Date</th>
<th>SPJGBVIX High/VIX High</th>
<th>SPJGBVIX Low/VIX High</th>
<th>SPJGBVIX High/VIX Low</th>
<th>SPJGBVIX Low/VIX Low</th>
<th>Nikkei 225 Long-Short Strategy</th>
<th>Nikkei 225 USD Denominated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dec. 31, 2008</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jun. 30, 2009</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dec. 31, 2009</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jun. 30, 2010</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dec. 31, 2010</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jun. 30, 2011</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dec. 31, 2011</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jun. 30, 2012</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dec. 31, 2012</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jun. 30, 2013</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dec. 31, 2013</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jun. 30, 2014</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dec. 31, 2014</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jun. 30, 2015</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dec. 31, 2015</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jun. 30, 2016</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dec. 31, 2016</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jun. 30, 2017</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dec. 31, 2017</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Bloomberg. Data as of July 21, 2017. Past performance is no guarantee of future results. Chart is provided for illustrative purposes and reflects hypothetical historical performance. Please see the Performance Disclosure at the end of this document for more information regarding the inherent limitations associated with back-tested performance.

These return separation results may be turned into simple long-short strategies: (a) a carry trade investor could reverse, or gets out of, the trade in low/high regimes and (b) go short in the Nikkei 225 in low/high regimes and long otherwise.
In the second example, we studied the relative performance across equities, corporate bonds, and U.S. Treasuries within four TYVIX/VIX-based regimes during 2003-2017.

- TYVIX low/VIX low: Calm in equity and bond markets
- TYVIX high/VIX low: Isolated anxiety in bond markets
- TYVIX low/VIX high: Isolated anxiety in equity markets
- TYVIX high/VIX high: Anxiety in equity and bond markets
Exhibit 22 shows return decompositions that are in line with economic intuition. In the low/low regime, equities outperformed credit, which in turn outperformed U.S. Treasuries. In the high/high regime, the order was reversed, with equities negative and a rally in U.S. Treasuries due to a flight to quality. In the high/low regime, equities performed best, while U.S. Treasuries declined and credit was flat, presumably as spreads tightened but yields increased. The low/high regime was the only one that did not align with this narrative, since equities still performed the best, while credit and U.S. Treasuries also gained, but this may be due to the protracted climb in asset values across the board during this time period, especially in equities.

Exhibit 22: Return Decomposition of U.S. Assets Based on TYVIX and VIX Regimes

Source: Bloomberg. Data as of July 21, 2017. Past performance is no guarantee of future results. Chart is provided for illustrative purposes.

One application of the relative return decomposition above is asset rotation based on the four TYVIX/VIX regimes, in which the strategy would overweight (underweight) assets that are likely to do well (poorly) in each regime.
As the two empirical building blocks and efficacy of even the simplest applications suggest, there are endless possibilities for incorporating VIX indices into market timing strategies across various asset classes.

As the two empirical building blocks and efficacy of even the simplest applications suggest, there are endless possibilities for incorporating VIX indices into market timing strategies across various asset classes. The key is to fight the temptation to abuse the empirical building blocks and regime framework, and only invoke this technique in applications based on firm economic rationale that justify its use.
REFERENCES


TYVIX 101. Online primer on TYVIX.  http://www.tyvix101.com
PERFORMANCE DISCLOSURE

The S&P/JPX JGB VIX was launched on October 2, 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.

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

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

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

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

Copyright © 2017 by S&P Dow Jones Indices LLC, a part of S&P Global. All rights reserved. Standard & Poor’s®, S&P 500® and S&P® are registered trademarks of Standard & Poor's Financial Services LLC (“S&P”), a subsidiary of S&P Global. 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 actually 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.