Tracking the VIX

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Because the Chicago Board Options Exchange (CBOE) Volatility Index (VIX) is not a tradable asset, investment exposure to the index is achieved principally by trading other volatility-tracking products, such as VIX futures and exchange-traded products (ETPs) based on VIX futures indices. The use of these financial instruments as a substitute for the VIX is misleading, however. The main goal of this study is to investigate the spot VIX tracking efficiency of these volatility-based products. Features examined include correlations, betas, and tracking errors to the spot VIX. The empirical findings suggest limited tracking ability of all the products under review.

This particular study takes an unconventional path, as it examines how well a typical VIX ETP tracks the actual spot VIX and not its respective benchmark index (typically a VIX futures index). The rationale for performing the computations on the spot VIX returns is threefold. First, the underlying VIX futures indices—and correspondingly, the ETPs that track the particular indices—are designed to produce daily returns more correlated with the VIX than a simple or more complex position in the VIX futures contracts.[1] Furthermore, recently, some issuers have launched VIX-linked products that follow more-sophisticated investment strategies in order to produce daily returns more correlated with the VIX.[2] Therefore, this study investigates whether these products are indeed successful in their stated objective, which is to offer exposure to volatility (as measured by the VIX).

Second, a key misconception among many investors exists concerning the relationship between the VIX and respective VIX-related products (Whaley [2013], Liu and Dash [2012], and Jones [2011]). Such products are increasingly provided nowadays, but it is questionable whether investors fully understand their characteristics and applications. Finally, Alexander and Korovilas [2012] show that a single position on VIX futures, or on their respective ETPs, offers no diversification benefits, except during the onset of a major crisis. In short, they conclude that these types of financial instruments should be used by investors solely for speculation purposes. Thus, the current study focuses solely on the effectiveness of these products as short-term volatility directional bets.

Investors may need volatility exposure for diversifying equity risk, hedging an existing short volatility exposure, or for speculation. Traditional volatility investing for many decades involved trading options and over-the-counter variance swaps. But in recent years, volatility-related future contracts and ETPs have emerged, providing investors with accessible tools to gain exposure to volatility. An important caveat

when investing in volatility ETPs is that these securities do not provide direct exposure to a volatility index such as the well-known VIX. In fact, the VIX simply corresponds to information extracted from option prices, while other financial indices, such as equity and bond indices, correspond to actual portfolios of assets. Therefore, volatility indices, such as the VIX, are not directly investable, which is why VIX-related ETPs track benchmark indices that correspond to a systematic VIX futures investment strategy. These futures-based strategies do not necessarily track the performance of the spot VIX index because, among other issues, investors demand a premium for holding a short volatility position; thus, maintaining a long position in VIX futures is costly (Goltz and Stoyanov [2013]).

The relevant literature can be broadly categorized into two strands: The first reviews how volatility-related products function and what their trading characteristics and potential risks are (Alexander and Korovilas [2013] and Liu and Dash [2012]), and the second includes studies that investigate the diversification benefits of these products. Early academic attempts use variance swaps and spot VIX as instruments for diversification, while the proliferation of VIX-based products is analogous to the relevant academic research that studies their characteristics and benefits.

The empirical evidence relating to VIX futures and volatility ETPs as effective instruments for diversification is abundant and, according to Hancock [2013], can generally be categorized into three threads of interest. The first relates to the notion that adding volatility as an asset class results in higher-risk adjusted returns.[3] Several scholars have examined the diversification benefits of VIX assets. In particular, Daigler and Rossi [2006] demonstrate, using a Markowitz portfolio framework, that adding volatility to an S&P 500 stock portfolio substantially reduces risk without significantly affecting return. Moran and Dash [2007] confirm similar diversification benefits, while Szado [2009] evaluates the performance of adding a VIX-replicating portfolio to an existing stock and bond portfolio and finds a significant net reduction in aggregate risk. On a contrary note, Alexander and Korovilas [2012] provide irrefutable evidence that individual positions on ETPs that use direct VIX futures exposure of any maturity (including mid-term and longer-term products) can provide a diversification effect only during the first few months of extreme stress of similar magnitude to the 2008 credit crisis.

Separately, Deng et al. [2012] show that ETPs that track short-term VIX futures indices are not effective hedges for stock portfolios, as they don't necessarily track the VIX increases when large stock market losses occur (they attribute this to the negative roll yield accumulated by such futures-based products). Their findings also suggest that ETPs that track medium-term VIX futures indices suffer less from negative roll yield and therefore offer slightly better hedges for stock portfolios.

A second strand of relevant research studies the optimal portfolio weights of volatility products when combined with equity. Indicatively, Dash and Moran [2005] use a standard mean–variance analysis and conclude that the optimal VIX allocation in efficient portfolios is less than 10%, while Daigler and Rossi [2006] weight volatility by using the previous year's optimal portfolio weights. The third thread of research deals with the appropriate holding period of volatility products. The relevant empirical findings suggest that holding VIX futures over a long time period is inefficient, as the mean return will be zero (Rhodes [2011]).

A number of authors have studied the hedging advantages of VIX-related products, but the academic attempts testing the trading/speculative effectiveness of these products is rather limited. Indicatively, Whaley [2013] evaluates VIX ETPs as a buy-and-hold investment. His findings show that VIX ETPs that track VIX short-term futures indices are virtually certain to lose money through time; in the six-year period that he examines, the VIX short-term total return futures index dropped in value by almost 94%. Based on his findings, he concludes that a significant proportion of VIX-related ETP holders are "either irrational and/or unaware of how these products are structured and perform through time" (p. 106).

Separately, Jones [2011] also confirms that VIX futures are not likely to be an asset class that a prudent investor would buy and hold over time, because this will result in considerable losses after a few years. Hill [2012] reports the extent of historical gains or losses in short-term and mid-term rolled VIX futures during the 10 largest rises and falls (on both a daily and weekly basis) of the spot VIX from May 2006–December 2011 and shows the significant variations in the VIX futures response to the VIX sharp moves. These variations can be partly explained by the fact that investors factor an expected move in the VIX into VIX futures prices.

This article extends the volatility-related literature by testing the tracking ability of both VIX-based ETPs and VIX futures on the spot VIX. In particular, the empirical analysis includes all major volatility-related ETPs and VIX futures and examines whether these instruments are suitable for taking advantage of short-term volatility trends (daily, weekly, and monthly tracking errors are calculated). Whaley [2013] provides an appraisal of VIX ETPs as buy-and-hold investments, while this study provides an evaluation of both VIX ETPs and futures as short-term directional bets.

The rest of the article proceeds as follows. The next section includes a succinct discussion of volatility trading—why trade volatility and how an investor can gain exposure to volatility. The following section introduces the data applied in this study and portrays the methodology employed for investigating tracking performance; it also reports the findings of the three tracking-error measures and analyzes the tracking ability of each product under review. Finally, the fourth section includes the concluding remarks.

VOLATILITY TRADING

Why Trade Volatility

The motives for trading volatility include speculation, tactical tail-risk hedging, and portfolio risk management. The mean reversion characteristic of volatility—that both high and low prices are temporary and will tend to move to the average price over time—makes volatility more predictable than returns. Thus, someone may buy or sell depending on the current level of the VIX relative to its historical average.

Many investors desire to speculate based on market and geopolitical news and data. Extremes levels of the VIX coincide with significant market events and major world crises; an investor monitoring geopolitical events may want to speculate on the direction of short-term expected future realized volatility (Whaley [2013]). Investors are willing to pay a premium in order to reduce exposure to the volatility of the future returns of an asset (the volatility risk premium); therefore, other investors may want to take the other side of the transaction and trade on the difference between the VIX and the realized volatility of the S&P 500. Another more advanced speculative investment strategy may involve capitalizing on the changes of how the market prices implied volatility per se. Since the term structure of VIX futures prices offers a continuous view of market participants' view regarding the value of the spot VIX at future points in time, many investors are trading VIX futures and ETPs in order to capitalize on the shifts in the market's price of implied volatility (Hill [2012]).

Volatility risk management strategies are even more widespread compared with speculative strategies. Volatility changes are negatively correlated with changes in equity prices. Since equity returns exhibit asymmetry, with a greater tail risk on the downside, investing in volatility may be positively skewed. VIX-related instruments are best utilized for diversification purposes and not as pure hedging vehicles. It is important to differentiate between the two—diversification involves decreasing portfolio risk (as measured by variance) by including assets that have low correlation with existing portfolio holdings, while hedging involves taking an offsetting position in an asset that is highly correlated with the existing portfolio, in order to minimize potential losses. Numerous recent articles support the advantages of investing in volatility as an equity diversifier vehicle;[4] for hedging the S&P 500 exposure, its own futures contracts are most effective and have lower transaction costs than VIX-related products (Alexander and Korovilas [2012]).

How to Trade Volatility

Since its introduction in 1993, the CBOE's VIX has evolved into a popular measure of investors' forecast of future volatility, as well as a gauge of "fear" in the stock market. Implied S&P 500 volatility (as measured by the VIX) exposure is tradable in many forms—through S&P 500 options, over-the-counter variance swaps, VIX futures and options, and ETPs based on VIX futures indexes. Different trading vehicles of implied volatility have very different return features because of their distinct characteristics. In this section, focusing on VIX futures and VIX-related ETPs, I attempt to differentiate among the diverse alternatives that investors have nowadays in order to achieve volatility exposure.

VIX Derivatives

In 2004, the CBOE Futures Exchange (CFE) launched futures contracts with the VIX as the underlying asset, while the respective options were

listed on the CBOE in 2006. Since their launch, VIX futures have been actively promoted as having unique characteristics and advantages; in particular, they offer investors opportunities for speculation, diversification, vega hedging, and arbitrage. VIX futures contracts provide a better alternative for achieving volatility exposure compared with traditional delta-neutral combinations of options (such as straddles and strangles).

VIX futures are futures contracts with the CBOE VIX as an underlying asset. Since volatility indices such as the VIX are not directly investable, as they simply represent a non-parametric estimate of future realized volatility implied by current option market prices, it is not feasible to obtain a simple cost-of-carry, arbitrage-free, relationship between VIX futures and the cash VIX. The main difference between VIX futures and the spot VIX is that, at any current point in time, the futures price represents the risk-neutral expectation of VIX at the contract's expiration and thus can vary significantly from the level of VIX actually observed at the current point in time (Goltz and Stoyanov [2013]).

Futures and spot returns on the same underlying often deviate. This divergence is known as the futures roll yield, and its cumulative impact can be quite significant; in some instances, it may even offset the entire investor's holding period return. Nevertheless, despite its importance in futures-related products, there are noticeable misconceptions regarding its nature, measurement, and impact. In the case of the VIX futures market, the roll yield is the difference between the spot VIX and the respective futures price. Practitioners call it a yield because this difference results in a small amount being made or paid every day as the two prices (futures and the spot VIX) converge. The roll yield is positive when the VIX futures term structure is in contango and negative when it is in backwardation.

The important question is whether the spot VIX converges to the futures price or the futures price converges to the spot VIX. For example, if the cash VIX lies at 16% and the futures price is at 19%, every day, as expiration approaches, the two prices should converge. If we assume that the spot price will remain constant, then the futures price will drop gradually every day, and thus an investor with a short position in the futures contract will gain a small amount every day. In the completely opposite scenario, the futures price will remain at the same level, while the spot price will gradually increase. In this case, even though the roll yield still exists, the short position doesn't profit because the futures price stays at 19%.

Of course, in reality, the most likely outcome will be something between the two extremes. The spot price rises while the futures price falls, in order to converge on each other somewhere in the midrange. If, for example, the cash VIX rises to 18% and thus the futures price falls to the same level by expiration, the short futures position does not pocket the whole roll yield but only a part of it; the respective difference will be the volatility risk premium. It should be noted that even at the expiration date, VIX futures prices do not converge exactly to the VIX because of the procedure that determines the settlement price of the futures contract.[5]

Eraker and Wu [2013] collect futures data from the CBOE from January 2006 to April 2013 and show that if an investor had invested in VIX futures in January 2006 and rolled the position at end-of-day futures prices, she would have lost more than 97% of the initial investment by the end of March 2013. This translates into an annualized return of approximately −30%. This number is even more stunning considering the fact that during the first part of the sample period (which includes the 2008 financial crisis), the investor would have more than doubled her initial investment.

Another trading alternative is VIX options, which have as an underlying the expected value of the VIX at expiration, rather than the current VIX value, and thus their price movements can be unrelated to the spot VIX.[6] The inferiority of VIX futures and options in tracking the VIX in the medium and long term partially explains the popularity of VIX futures ETPs in the past few years. ETPs have made volatility trading accessible to investors without the need to access futures markets.

VIX Futures Index Series

In 2009, S&P Indices introduced the S&P 500 VIX Futures Index Series, which is now the basis for a growing list of numerous ETPs listed in the U.S. equity markets. The S&P 500 VIX Short-Term Futures Index Total Returns (SPVXSTR) index estimates the daily returns of a long position in a VIX futures contract with a constant maturity of 30 days, by using the first two series of VIX futures. Every day, the index rolls over from the first-month contract into the second-month contract. Respectively, the S&P 500 VIX Medium-Term Futures Index Total Returns (SPVXMTR) index tracks

the daily returns of a long position in a VIX futures contract with a maturity of approximately six months, by holding exposure to the fourth-, fifth-, sixth-, and seventh-month VIX futures contracts. Every day, the index rolls over from the fourth-month contract into the seventh-month contract, while keeping fixed the positions in the other two series (the fifth-month and sixth-month contracts).

Both indices include interest accrual based on the 91-day U.S. T-bill rate (Deng et al. [2012]). The respective VIX futures indices have a comparable correlation with the S&P 500 as the spot VIX has; Liu and Dash [2012] report correlations of the futures indices with the S&P 500 ranging from –76.59% to –79.17% and correlation of the spot VIX with the S&P 500 at approximately –75%. They also report that futures indices have a positive return 95% of the time the S&P 500 has a loss of greater than 1%.

Futures contract–based volatility indices have three separate sources of return—namely, price, roll, and collateral return. Price return arises from changes in the underlying future prices, while roll return arises from rolling long futures positions forward through time. Roll return is usually negative for VIX-related indices because the VIX futures term structure is almost always in contango,[7] The most plausible explanation of the contango dominance is the positive skewness observed in the distributions of both the VIX and realized S&P 500 volatility. The highest levels of both implied and realized volatility have been significantly higher than their average/median values, and because market participants cannot accurately predict when realized volatility will actually increase, they price VIX futures with longer expiration dates higher in order to price in the higher probability of a significant surge in volatility (Hill [2012]). Finally, collateral return assumes the notional value of the underlying is reinvested at the risk-free interest rate, which is equivalent to assuming an investor posts 100% margin with T-bills (Georgiev [2001]).

Volatility ETPs

Investing directly in the VIX is impractical, while investing in VIX futures involves increased risks (because of the leverage) and day-to-day monitoring. Furthermore, average retail investors lack the sophistication and/or size in order to trade derivatives, while institutions, such as pension funds and endowments, are not allowed to open positions in the derivatives market. The introduction of VIX ETPs provided access to market volatility to every single investor.

ETPs are best defined as open-ended securities listed on a stock exchange, which aim to track the performance of an underlying asset. The term ETP includes, among others, investment vehicles such as exchange-traded funds (ETFs), exchange-traded notes (ETNs), and U.S. grantor and other statutory trusts. ETFs are structured and regulated as mutual funds (or collective investment schemes) and are registered under the Investment Company Act of 1940. ETNs are generally senior, unsecured, unsubordinated debt listed on a stock exchange; they are not collateralized, thus ETN investors have full exposure to the issuer's credit risk. Finally, U.S. grantor and statutory trusts are frequently referred to as ETFs but are not registered under the Investment Company Act of 1940. A grantor trust usually holds physically a defined set of assets, whereas statutory trusts and other partnership structures may open derivative positions and are recognized under federal law as commodity pools. Volatility-related products are structured as ETNs and commodity pools (See Exhibit A1 in the Appendix).

The iPath S&P 500 VIX Short-Term Futures ETN and iPath S&P 500 VIX Mid-Term Futures ETN (VXZ) were the first volatility ETPs, introduced on Jan 29, 2009. There are currently 17 ETPs that utilize a volatility strategy, according to ETF DataBase (ETFdb.com), but a limited number of products account for the lion's share of the assets under management and the daily trading volume. We need to emphasize that these products track constant maturity VIX futures indices rather than the VIX itself, and thus their volatility exposure is affected by rollover costs and the lack of a cash-and-carry arbitrage relationship (Goltz and Stoyanov [2013]). VXX is clearly the most popular VIX ETF on the market; hence, I will concisely describe its portfolio construction as an indicative paradigm.[8]

VXX tracks the performance of the first two front series of VIX futures. The actual dollar weight of each month held by VXX changes each day, as iPath continuously rolls its portfolio in order to maintain a constant maturity weighted-average futures maturity of one month. Summarizing the roll process as described comprehensively in iPath's VXX prospectus, at the beginning of the roll period, all the weight is allocated to the first-month contract, then on each subsequent business day, a fraction of the first-month VIX futures

holding is sold and an equal notional amount of the second-month VIX future contract is bought. This fraction is proportional to the number of first-month VIX futures contracts as of the previous index roll day, and inversely proportional to the length of the current roll period (usually around 21 days). In this way, the initial position in the first-month contract is gradually rolled over to the second-month contract, until the following roll period starts (when the old second-month VIX futures contract becomes the new first-month VIX futures contract).

The roll process has a measurable effect on the price of the ETP (in this case VXX), depending on the shape of the VIX futures term structure. When the term structure is in contango, at the end of each day, iPath must sell a quantity of first-month contracts and buy a respective quantity of second-month contracts at a higher price, resulting in a negative roll yield for the fund. Conversely, when the term structure is in backwardation, at the end of each day, iPath must sell the first month and buy the second one at a lower value, resulting in a positive roll yield for the fund. The exact level of the roll yield depends first on the difference between and first- and second-month series and second on the number of days in the roll period (more days result in a smaller roll yield).

The first VIX ETNs offered long-only exposure to VIX futures–based indices. It was only natural that inverse funds emerged to take advantage of the negative roll yield that long VIX tracker funds suffer most of the time. Furthermore, just as there are ETPs offering leveraged exposure to other underlying assets (stock, bond, and commodity indices), it is now possible for investors to establish magnified daily exposure to VIX-related indices as well.

Exposure to the VIX is no longer limited just to the traditional subsets of long, inverse, or leveraged ETPs (for a graphical taxonomy of available volatility ETPs, see Exhibit A2 in the Appendix). For example, Citigroup calculates a volatility index that combines a daily rolling long exposure to the third- and fourth-month futures contracts on the VIX, with a dynamic short exposure to the S&P 500 Total Return Index. This volatility index serves as a benchmark index for the C-Tracks ETN Citi Volatility Index Total Return (CVOL).

Furthermore, two other large financial institutions have recently introduced products that attempt to exploit the nuances of volatility futures markets. In particular, UBS recently launched the E-TRACS Daily Long-Short VIX ETN (XVIX), a product that follows a strategy involving a 100% long position in the S&P 500 VIX Mid-Term Futures Index Excess Return with a short 50% position in the S&P 500 VIX Short-Term Futures Index Excess Return, with a daily rebalancing of the long–short positions. Separately, Barclays Bank introduced the iPath S&P 500 Dynamic VIX ETN (XVZ), which is also designed to invest in the S&P 500 VIX Short-Term Futures Index Excess Return and the S&P 500 VIX Mid-Term Futures Index Excess Return. This particular product follows a dynamic allocation strategy between the two indices by monitoring the steepness of the implied-volatility curve. These two ETPs attempt to exploit potential inefficiencies in the VIX futures market, as they try to capture the risk premium of the near-term VIX futures contracts relative to the mid-term VIX contracts by holding a consistent long–short exposure ratio between the two series.

Other recent innovative additions to the volatility-related ETPs involve securities that provide exposure to US equities coupled with a dynamic allocation/hedge to implied volatility. These volatility-hedged equity ETPs include PowerShares S&P 500 Downside Hedged Portfolio (PHDG) and Barclays ETN S&P VEQTOR ETN (VQT), which track the S&P 500 Dynamic VEQTOR Index (an index that provides equity market exposure with an implied volatility hedge by dynamically allocating between equity, volatility, and cash); the First Trust CBOE S&P 500 VIX Tail Hedge Fund (VIXH), which tracks the CBOE VIX Tail Hedge (an index that consists of each component of the S&P 500 and a fluctuating amount of one-month call options on the VIX Index); and finally, two ETFs offered by VelocityShares, the VelocityShares Volatility Hedged Large Cap ETF (SPXH) and VelocityShares Tail Risk Hedged Large Cap ETF (TRSK), which track proprietary indices that also offer exposure to the S&P 500 combined with a dynamic volatility hedge.

According to Alexander and Korovilas [2013], the ETPs that track constant-maturity VIX futures and trade on the New York Stock Exchange (NYSE) have some adverse features not shared by futures: First, they retain the credit risk of the issuer (which has been relatively high since the credit crisis); second, since the issuer of these products will only redeem the shares early in large lots, a small investor may be trapped into an illiquid investment; last, many of these products have a callable feature

whereby the issuer can call back the shares at any time, with a short call notice period. On the other hand, ETPs have significantly lower fees and costs compared with other VIX-related instruments (e.g., variance swaps).

VIX ETP PERFORMANCE

Data

Exhibit A1 in the Appendix summarizes selected attributes of all 17 volatility-related ETPs in the United States as of September 1, 2014 (ranked by the assets under management). Data for VIX ETPs were gathered from an ETF database (http://etfdb.com/etfdb-category/volatility/) and Yahoo Finance. All but one of the ETPs listed in Exhibit A1 are benchmarked to S&P 500 VIX futures indices. The difference between the total return and excess return index benchmarks is subtle but important, and it is explained in Whaley [2013]. The only ETP that tracks a different index (Citi Volatility Index Total Return) is the C-Tracks ETN Citi Volatility Index Total Return (CVOL). The exhibit does not include hybrid products (which combine equity and volatility exposure), such as the PowerShares S&P 500 Downside Hedged Portfolio (PHDG) or the Barclays ETN S&P VEQTOR ETN (VQT). While the total number of ETPs related to the CBOE's VIX has increased significantly since 2009, when the first relevant products were launched, during the past couple of years their popularity—as expressed by the total number of offered products and their AuM—has declined. For example, UBS ETRACS closed several VIX ETPs on September 12, 2012, while Barclays also redeemed a couple of VIX ETNs in 2011.[9]

The first volatility products were offered by iPath on January 29, 2009 (the iPath S&P 500 VIX Short-Term Futures ETN and iPath S&P 500 VIX Mid-Term Futures ETN), and the most recent additions are the ProShares Ultra VIX Short-Term Futures ETF (UVXY) and ProShares Short VIX Short-Term Futures ETF (SVXY), which were launched on October 4, 2011. This study does not encompass inverse funds, which allow investors to profit from a decline in volatility, and leveraged funds, which allow investors to amplify the returns of the underlying volatility index. Furthermore, two ETPs were also excluded: the iPath S&P 500 Dynamic VIX ETN (XVZ), because it was introduced in August 2011, and the VelocityShares VIX MT ETN (VIIZ), which had no substantial volume before May 2013. Therefore, the empirical study includes seven volatility-related ETPs and the VIX futures.

The period under review is from January 5, 2011 to March 31, 2014. The ETP returns are calculated based on the closing prices in the stock exchange, rather than the official daily net asset value (NAV). All funds under review do not distribute any form of dividend/ income. The dataset of the current analysis consists of the daily/weekly/monthly returns of the seven ETPs under review and the VIX futures and the daily/weekly/monthly returns of the cash CBOE VIX. The particular frequencies are chosen because, according to Alexander and Korovilas [2012], the average holding time of a VIX futures contract has fallen but still remains between one week and a month. Furthermore, Hancock [2013] also uses one-day, one-week, and one-month holding periods in order to test the sensitivity of risk-adjusted returns of volatility ETNs to different holding periods.

The futures returns are calculated based on the settlement prices of the nearest-to-deliver VIX futures contract. In order to calculate the daily futures returns, the timing of the rollover in the dataset is based on the trading volume and open interest of the respective contracts; when the second shorter-maturity contract surpasses in terms of daily volume and open interest, the first (shortest-maturity contract) is rolled over into the next contract. Regarding the weekly and monthly returns, we can reasonably assume that an investor interested in opening a new position will choose the nearest-to-maturity contract that would not expire during the holding period (week or months), in order to avoid the rollover yield. For example, if an investor wants to have a one-month exposure to VIX, for example, at the beginning of May 2012, she will open a position in the June 2012 contract and not in the May 2012 contract, which expires in between (so there is no need to roll over and therefore the investor avoids a potential rollover yield).

In particular, the continuously rolling VIX futures weekly and monthly returns are constructed by selecting, at the beginning of each week/month, the nearest-to-maturity contract that would not expire during the next week/month. The return from the beginning of week/month t to the next is calculated as

$$R_t = \frac{F_{t,T} - F_{t-1,T}}{F_{t,T}} \quad (1)$$

where $F_{t,T}$ is the futures price at the beginning of week/month t on the nearest contract whose expiration date T is after the end of week/month $t + 1$ and $F_{t-1,T}$ is the price of the same contract at the beginning of week/month $t - 1$.

Methodology

Tracking error measures the difference between the return of a fund and its reference index. The smaller the tracking error, the better the tracking ability of the fund compared with its benchmark. Since VIX futures are good predictors of the spot VIX (Fassas and Siriopoulos [2012]), we expect VIX futures to offer a volatility exposure that is still very highly correlated with the cash VIX. Whaley [2013] shows that the VIX ETPs are reasonably good at tracking the return performance of their respective benchmark indices, however, this study examines the tracking ability of these securities regarding the spot VIX.

The simplest way to measure tracking error is to calculate the difference in returns between the fund/product and the benchmark index at the end of a certain period. Nevertheless, since the objective of these volatility-related products is to provide exposure as accurately as possible to volatility as measured by the VIX and not just match the value at the end of the holding period, this would not be sufficient. Another method involves calculating and comparing the standard deviations of returns. According to Aber et al. [2009], if an ETP tracks accurately an underlying index, it should also have equivalent standard deviations. Therefore, the hypothesis that the daily/weekly/monthly standard deviations of the VIX and respective ETP are equal is tested using an F-test.

In addition, the three most popular tracking-error methodologies are followed in this study.[10] The first involves calculating the standard deviation of the difference in returns between the ETP (and the futures contract) and the VIX index return ($e_{ETPt} = R_{ETPt} - R_{VIXt}$):

$$TE_{1,ETP} = \sqrt{\frac{1}{n-1}\sum_{t=1}^{n}(e_{ETPt} - \overline{e}_{ETP})^2} \qquad (2)$$

The second tracking-error measure involves the calculation of the average absolute return difference between the tracking product and the underlying index return (e_{ETPt}):

$$TE_{2,ETP} = \frac{1}{n}\sum_{t=1}^{n}\left|e_{ETPt}\right| \qquad (3)$$

The final tracking error is expressed as the standard error of the residuals of the following single-market model:

$$R_{it} = \alpha_i + \beta_i R_{VIXt} + \varepsilon_{it} \qquad (4)$$

where R_{it} indicates the daily/weekly/monthly return of ETP i, R_{VIXt} denotes the respective return of the VIX, and ε_{it} is the residual error. In order to find heteroskedasticity and autocorrelation consistent estimates, the Newey–West standard errors are calculated.

In theory, if the ETP mimics its benchmark exactly, the estimated intercept coefficient (α) should not be statistically different from zero and the estimated slope coefficient (β) should not to be statistically different from unity. If beta exceeds one, the ETP moves more aggressively with respect to the underlying index, and if beta is smaller than one, the ETP exhibits lower riskiness. In practice, however, the intercept should be less than zero because of trading costs and fees,[11] and the slope estimate may be different from one because of tracking error. Finally, the R-squared of this specification reflects the proportion of the variance of the VIX ETP's return that is explained by the VIX return and can be considered as an alternative tracking-error measure.

Empirical Results

Descriptive statistics. Exhibit 1 includes the descriptive statistics of the seven ETPs under review, the VIX futures, and the spot VIX returns. All ETPs and VIX futures have negative mean returns in all frequencies. The most plausible explanation is the negative roll yield. Since the VIX futures term structure is usually in contango (i.e., the futures price curve slopes upward), at each rebalancing, there is almost always a negative roll cost (usually small) created by selling the lower-price, shorter-term contract and buying the higher-price, longer-term contract. This minor daily roll-cost builds up to a highly negative long-run return for investors in VIX futures tracker ETPs.

EXHIBIT 1
Summary Statistics of the Returns of ETPs, VIX Futures, and the VIX

	VIX	VIX Futures	VXX	VIXY	VXZ	VIXM	XVIX	VIXX	CVOL
Panel A: Daily Returns									
Mean	–0.0003	–0.0003	–0.0032	–0.0033	–0.0018	–0.0018	–0.0005	–0.0033	–0.0067
Median	–0.0039	–0.0051	–0.0052	–0.0053	–0.0026	–0.0029	0.0000	–0.0048	–0.0086
Maximum	0.4055	0.2293	0.1881	0.1879	0.0977	0.0972	0.0310	0.1888	0.3094
Minimum	–0.3141	–0.2388	–0.1424	–0.1407	–0.0857	–0.0937	–0.0308	–0.1436	–0.2901
Std. Dev.	0.0715	0.0503	0.0399	0.0400	0.0197	0.0196	0.0077	0.0398	0.0649
Skewness	0.77	0.39	0.56	0.56	0.49	0.48	0.05	0.54	0.43
Kurtosis	3.72	2.79	2.29	2.25	2.50	2.61	1.16	2.39	2.78
# Obs.	813	813	813	813	813	813	813	813	813
Panel B: Weekly Returns									
Mean	–0.0012	–0.0014	–0.0155	–0.0156	–0.0086	–0.0086	–0.0025	–0.0155	–0.0324
Median	–0.0012	–0.0075	–0.0166	–0.0174	–0.0035	–0.0038	–0.0028	–0.0170	–0.0234
Maximum	0.3655	0.5699	0.2583	0.2596	0.1221	0.1196	0.0530	0.2592	0.4177
Minimum	–0.4546	–0.3173	–0.2516	–0.2501	–0.1272	–0.1284	–0.0669	–0.2549	–0.4185
Std. Dev.	0.1319	0.1097	0.0856	0.0858	0.0428	0.0422	0.0186	0.0858	0.1362
Skewness	–0.02	0.74	0.23	0.22	0.01	–0.01	–0.15	0.23	0.09
Kurtosis	0.40	3.96	1.01	1.03	0.72	0.68	0.25	1.05	1.41
# Obs.	169	169	169	169	169	169	169	169	169
Panel C: Monthly Returns									
Mean	–0.0096	–0.0074	–0.0652	–0.0656	–0.0354	–0.0355	–0.0098	–0.0652	–0.1360
Median	–0.0244	–0.0500	–0.0653	–0.0645	–0.0375	–0.0392	–0.0118	–0.0736	–0.1483
Maximum	0.4243	0.4387	0.5094	0.5052	0.2523	0.2543	0.0486	0.5140	0.4888
Minimum	–0.3604	–0.4251	–0.3793	–0.3829	–0.2010	–0.1988	–0.0933	–0.3780	–0.7569
Std. Dev.	0.1906	0.1866	0.1812	0.1811	0.0941	0.0929	0.0394	0.1814	0.2665
Skewness	0.30	0.57	0.88	0.86	0.66	0.72	–0.35	0.89	0.30
Kurtosis	–0.42	0.61	1.59	1.54	1.40	1.58	–0.61	1.65	0.55
# Obs.	39	39	39	39	39	39	39	39	39

Considering standard deviation, in all cases, ETPs and futures exhibit lower risk compared with the VIX. This can be attributed to the mean-reversion property of the volatility; VIX futures tend to be lower than the VIX when the VIX is high compared with its historical average, and conversely, VIX future prices are higher when the spot VIX is at record lows. As a result, VIX futures-related products do not have the mean-reversion predictability of the spot VIX because the futures market has this volatility attribute already embedded into the respective futures prices. Therefore, VIX futures prices have lower volatility compared with spot VIX prices, and as a result, VIX futures indices track the cash VIX movement only partially.

As a preliminary analysis tool, the correlation estimates of daily/weekly/monthly returns are calculated (Exhibit 2). In general, almost all correlation coefficients are statistically significant at the 99% confidence interval and decrease as the frequency of returns increases (from daily to monthly). Regarding daily returns, VIX futures exhibit a robust correlation of 90% with the spot VIX, and three ETPs that track the S&P 500 VIX Short-Term Futures Index (namely VXX, VIXY, and VIIX) also have high correlations (slightly lower than 90%). Interestingly, VIX futures weekly and monthly returns are not correlated with the respective spot VIX returns. The three aforementioned ETPs also have the highest correlation with weekly and monthly VIX returns. Finally, the only ETP that exhibits a statistically significant negative correlation with the spot VIX is the UBS E-TRACS Daily Long-Short VIX ETN (XVIX). This latter finding is consistent with Alexander and Korovilas [2013], who find that XVIX offers an almost uncorrelated exposure to VIX.

EXHIBIT 2

Correlation Estimates of the Returns of ETPs and the VIX

	Daily Returns	Weekly Returns	Monthly Returns
VIX Futures	0.841**	0.032	–0.182
VXX	0.891**	0.858**	0.829**
VIXY	0.893**	0.859**	0.830**
VXZ	0.807**	0.726**	0.675**
VIXM	0.801**	0.726**	0.665**
XVIX	–0.208**	–0.313**	–0.311**
VIIX	0.876**	0.859**	0.827**
CVOL	0.832**	0.804**	0.822**

*Note: ** identifies coefficient significant at the 1% level.*

Tracking errors. Exhibit 3 includes the three separate tracking-error (TE) estimates and their average for each product. All tracking errors (for all products under review and under all methodologies) are statistically different from zero at the 1% level. The first method (TE_1)—which estimates the tracking error as the standard deviation of the return differences—results in the highest errors for all funds, while the third one (TE_3)—which estimates the tracking error as the standard errors of the returns regression 4—yields the lowest estimates. According to Pope and Yadav [1994], TE_3 and TE_1 should give the same result if the beta of Regression 4 is exactly equal to unity. If this is not the case, then the regression residuals will differ from TE_1. If betas are substantially below one—which is the case in our regressions—then the residual risk will be downward biased compared with what would be expected if β was equal to one. Because of these potential estimation issues, the average tracking error is computed in order to obtain more justified tracking-error estimates.

The tracking errors increase significantly for all products as the tracking period under review is extended. The average daily tracking error ranges between 2.911% and 4.469%, while the weekly average ranges between 6.527% and 13.638% and the monthly one ranges between 10.464% and 23.104%. Regarding the magnitude of tracking error among the various instruments, the lowest tracking error is observed in the case of three products that track the short-term end of the VIX futures term structure—the iPath S&P 500 VIX Short-Term Futures ETN (VXX), the ProShares VIX Short-Term Futures ETF (VIXY), and the VelocityShares VIX Short-Term ETN (VIIX). VIX futures also exhibit low tracking error in daily returns. This can be attributed to the fact that over short periods of time, spot and futures returns tend to move together closely. For example, the one-day price change of the most active VIX futures contract will typically have the same sign and similar magnitude to the price change of the spot VIX; their correlation exceeds 84%. The dynamic allocation strategy–based UBS E-TRACS Daily Long-Short VIX ETN (XVIX) exhibits the highest average tracking error in daily returns.

The tracking errors regarding longer holding periods exhibit interesting results. In contrast to tracking errors for daily returns, VIX futures have by far the highest tracking error for both weekly and monthly returns. This finding can basically be attributed to the volatility mean-reversion property, which is already reflected in VIX futures prices. More specifically, regarding weekly returns, VXX, VIXY, and VIIX still exhibit lower tracking errors compared with the spot VIX. It should be noted that these three ETPs are also the runner-ups based on the daily tracking errors. Regarding monthly returns, it is challenging to determine statistically which ETP has the best tracking performance because all the respective tracking errors exceed 10%. Interestingly, based on the calculated monthly tracking errors, the ETPs that track the longer end of the VIX futures term structure or follow a dynamic allocation do not track the spot VIX more effectively (compared to the ETPs that track the VIX Short-Term Futures Index).

In theory, because the magnitude of the roll yield depends on the slope of the VIX futures term structure, longer-maturity VIX futures tracker ETPs should not suffer relatively so much from the negative roll yield; the difference in roll-costs between the two serial VIX futures contracts is smaller at the medium- and long-end compared with the short end of the futures term structure. The empirical findings of the current study, however, do not support the notion that medium-term ETPs are better trackers of the spot VIX.

Regression analysis. In this section, the results of the returns Regression 4 between volatility ETPs and VIX futures and the spot VIX are analyzed (reported in Exhibit 4). In general, the performance regression results are consistent with the tracking-error estimates, thus suggesting the limited tracking ability of all the products under review.

EXHIBIT 3
The Tracking Errors of ETPs and VIX Futures

ETP	Standard Deviation of Returns Difference (TE_1)	Mean Absolute Return Difference (TE_2)	Standard Errors of Regression (4) (TE_3)	Average TE
Panel A: Daily Returns				
VIX Futures	3.994	2.845	2.725	**3.188**
VXX	4.027	2.896	1.809	**2.911**
VIXY	4.012	2.881	1.801	**2.898**
VXZ	5.682	4.095	1.166	**3.648**
VIXM	5.704	4.107	1.174	**3.662**
XVIX	7.353	5.298	0.757	**4.469**
VIIX	4.134	2.963	1.920	**3.005**
CVOL	4.010	3.034	3.609	**3.551**
Panel B: Weekly Returns				
VIX Futures	16.881	13.042	10.999	**13.641**
VXX	7.304	5.535	4.4039	**5.748**
VIXY	7.287	5.527	4.4055	**5.740**
VXZ	10.499	8.169	2.952	**7.207**
VIXM	10.528	8.21	2.9087	**7.216**
XVIX	13.881	10.96	1.7699	**8.870**
VIIX	7.288	5.544	4.4053	**5.746**
CVOL	8.404	7.014	8.126	**7.848**
Panel C: Monthly Returns				
VIX Futures	29.007	21.707	18.598	**23.104**
VXX	10.923	9.768	10.2815	**10.324**
VIXY	10.885	9.725	10.247	**10.286**
VXZ	14.478	11.488	7.0342	**11.000**
VIXM	14.634	11.617	7.0372	**11.096**
XVIX	20.629	16.498	3.7973	**13.641**
VIIX	10.966	9.923	10.3279	**10.406**
CVOL	15.43	16.371	15.3675	**15.723**

Notes: TE_1 is the standard deviation of the return difference between the ETP and VIX; TE_2 is the average of the absolute return difference between the ETP and VIX; and TE_3 is the standard errors of Regression 4. All numbers are in percentages.

Interestingly, the lower the frequency of returns, the higher the beta of the ETPs to the VIX, while the opposite is true for VIX futures. In particular, VIX futures prices are more sensitive to daily swings in the VIX than the respective ETPs, while conversely, their sensitivity in weekly or monthly VIX moves is statistically insignificant. This finding confirms the dynamic relation between the VIX cash and futures prices (also documented by Jones [2011]). Additionally, the three products that track the short-term end of the VIX futures term structure (that is the iPath VXX, the ProShares VIXY, and the VelocityShares VIIX) have a beta to the VIX that is twice as large as the two products that track the mid-term end of the VIX futures curve (namely, the iPath VXZ and the ProShares VIXM); this is evidence of their greater sensitivity, as for a 1% daily move in the VIX, the short-term ETPs tend to move around 0.5% and the mid-term ETPs tend to move around 0.2%. Interestingly, the C-Tracks ETN Citi Volatility Index Total Return (CVOL) has the highest beta to the VIX in all frequencies, and the UBS E-TRACS Daily Long-Short VIX ETN (XVIX) has a beta to the cash VIX that is very close to zero (for daily, weekly, and monthly returns), thus confirming the non-correlation with the volatility index.

Finally, the aforementioned conclusions are generally confirmed by the R-squared of each respective regression. The adjusted R-squared figures reflect the

EXHIBIT 4
Performance Regression of ETPs

	α	β	Adj. R^2	# Obs
Panel A: Daily Returns				
VIX Futures	–0.000	0.591**	70.67%	813
	(0.001)	(0.018)		
VXX	–0.003**	0.497**	79.43%	813
	(0.001)	(0.015)		
VIXY	–0.003**	0.499**	79.69%	813
	(0.001)	(0.018)		
VXZ	–0.002**	0.222**	65.08%	813
	(0.000)	(0.009)		
VIXM	–0.002**	0.220**	64.16%	813
	(0.000)	(0.009)		
XVIX	–0.000	–0.022**	42.04%	813
	(0.000)	(0.005)		
VIIX	–0.003**	0.488**	76.78%	813
	(0.001)	(0.017)		
CVOL	–0.007**	0.755**	69.12%	813
	(0.001)	(0.030)		
Panel B: Weekly Returns				
VIX Futures	–0.001	0.0263482	0.01%	169
	(0.006)	(0.057)		
VXX	–0.015**	0.557**	73.54%	169
	(0.004)	(0.037)		
VIXY	–0.015**	0.557**	73.54%	169
	(0.004)	(0.032)		
VXZ	–0.008**	0.236**	52.44%	169
	(0.002)	(0.021)		
VIXM	–0.008**	0.232**	52.49%	169
	(0.002)	(0.021)		
XVIX	–0.003	–0.044**	9.24%	169
	(0.001)	(0.011)		
VIIX	–0.015**	0.559**	73.64%	169
	(0.004)	(0.033)		
CVOL	–0.031**	0.831**	64.42%	169
	(0.005)	(0.066)		
Panel C: Monthly Returns				
VIX Futures	–0.009	–0.179	0.01%	39
	(0.030)	(0.176)		
VXX	–0.058**	0.788**	67.80%	39
	(0.017)	(0.096)		
VIXY	–0.058**	0.788**	67.99%	39
	(0.017)	(0.081)		
VXZ	–0.032**	0.333**	44.11%	39
	(0.010)	(0.058)		
VIXM	–0.032**	0.324**	42.67%	39
	(0.010)	(0.058)		
XVIX	–0.010	–0.064*	7.25%	39
	(0.006)	(0.031)		
VIIX	–0.058**	0.788**	67.59%	39
	(0.017)	(0.081)		
CVOL	–0.124**	1.150**	66.74%	39
	(0.018)	(0.156)		

Notes: This exhibit presents the results of ETPs' performance regression. Particularly, the following single-market model is used: $R_{it} = \alpha_i + \beta_i R_{VIXt} + \varepsilon_{it}$*, where* R_{it} *indicates the daily/weekly/monthly return of ETP i,* R_{VIXt} *denotes the daily/weekly/monthly return of the VIX, and* ε_{it} *is the residual error. Newey–West standard errors are in parentheses; ** identifies coefficient significant at the 1% level; and * identifies coefficient significant at the 5% level.*

proportion of the variance of the VIX ETP return that is explained by the spot VIX return; for example, the VIX futures daily returns regression has an adjusted R-squared of 0.813, which means it tracks the VIX more accurately than the respective volatility ETPs.

CONCLUSION

Volatility has become a widely accepted asset class over the past decade. The financial turmoil caused by the burst of the Internet bubble at the turn of the millennium and the great recession caused by the 2008 credit crisis have resulted in an insatiate investor demand for volatility exposure. Prior to 2004, the only way to take a position on the VIX was through portfolios of S&P 500 options or through the use of over-the-counter instruments, such as variance swaps. Futures contracts on the S&P 500 VIX began trading on the CBOE CFE in March 2004. Today, investors have a variety of instruments linked to the S&P 500 VIX—VIX options, futures, and ETPs based on VIX futures indexes. ETPs are best defined as open-ended securities that are listed on a stock exchange and aim to track the performance of an underlying asset. VIX-related ETPs are equity-like securities designed to provide exposure not to the current implied volatility of the S&P 500 (as measured by the spot VIX) but to the forward level of the VIX. The first such product,

iPath VXX, was offered on January 29, 2009, and its substantial and rapid success very quickly gathered significant competition from other ETP managers. Their success can be partly attributed to the easy and inexpensive exposure to volatility they offer to investors.

The purpose of this article is to provide an appraisal of VIX ETPs and VIX futures as cash VIX–tracking investment vehicles. This research effort is partly motivated by a key misconception among many investors that by buying VIX-related products (especially VIX ETPs), they are buying the well-known CBOE volatility index, VIX. The empirical findings suggest limited tracking ability of all the products under review, as the magnitude of the respective tracking errors is significant. Furthermore, the average tracking error for all instruments increases significantly as the frequency lowers. The average daily tracking error ranges between 2.355% and 6.483%, while the weekly average is twofold and the monthly one is more than triple.

For those investors who, despite the current findings, consider VIX ETPs and VIX futures as short-term directional investments in order to gain exposure to volatility, we offer three suggestions. First, VIX futures are the most effective instrument for achieving daily exposure to the cash VIX, while their tracking performance for lower frequencies (weekly and monthly) is extremely weak. Second, for a weekly or monthly holding period, the three short-term ETPs (iPath VXX, the ProShares VIXY, and the VelocityShares VIIX) are performing indistinctly well and thus the investment decision should be based on other criteria (e.g., liquidity, fees and expenses, assets under management, etc.). Third, the empirical findings of the current study do not support the notion that medium-term ETPs are better trackers of the spot VIX (compared with short-term ETPs).

In conclusion, it should be noted that the empirical findings of the particular study show that even though several volatility products exist, there is potential room for additional VIX-related ETPs that would attempt to track the actual spot VIX (and not VIX futures–based indices) following either a physical (e.g., through investing in S&P 500 options) or a synthetic (e.g., through opening a position in variance swaps) replication method.

APPENDIX

EXHIBIT A1
The Profiles of Volatility ETPs

Product Name	Ticker Symbol	Benchmark Index	Structure	AuM[1]	Avg. Volume[2]	Inception Date	Expense Ratio
iPath S&P 500 VIX Short-Term Futures ETN	VXX	S&P 500 VIX Short-Term Futures Index Total Return	ETN	$1,021	33,815,938	29-Jan-09	0.89%
VelocityShares Daily Inverse VIX Short-Term ETN	XIV	S&P 500 VIX Short-Term Futures Index Excess Return (–100%)	ETN	$691	9,705,984	29-Nov-10	1.35%
ProShares Ultra VIX Short-Term Futures ETF	UVXY	S&P 500 VIX Short-Term Futures Index (200%)	Commodity Pool	$339	7,999,800	04-Oct-11	0.95%
ProShares Short VIX Short-Term Futures ETF	SVXY	S&P 500 VIX Short-Term Futures Index (–100%)	Commodity Pool	$271	846,553	04-Oct-11	0.95%
VelocityShares Daily 2x VIX Short-Term ETN	TVIX	S&P 500 VIX Short-Term Futures Index Excess Return (200%)	ETN	$192	12,786,162	29-Nov-10	1.65%
VelocityShares Daily Inverse VIX Medium-Term ETN	ZIV	S&P 500 VIX Mid-Term Futures Index Excess Return (–100%)	ETN	$137	85,958	29-Nov-10	1.35%
ProShares VIX Short-Term Futures ETF	VIXY	S&P 500 VIX Short-Term Futures Index	Commodity Pool	$110	1,052,523	03-Jan-11	0.85%
iPath S&P 500 VIX Mid-Term Futures ETN	VXZ	S&P 500 VIX Mid-Term Futures Index Total Return	ETN	$56	1,136,889	29-Jan-09	0.89%
ProShares VIX Mid-Term Futures ETF	VIXM	S&P 500 VIX Mid-Term Futures Index	Commodity Pool	$42	78,956	03-Jan-11	0.85%

(continued)

EXHIBIT A1 *(continued)*
The Profiles of Volatility ETPs

Product Name	Ticker Symbol	Benchmark Index	Structure	AuM[1]	Avg. Volume[2]	Inception Date	Expense Ratio
iPath S&P 500 Dynamic VIX ETN	XVZ	S&P 500 Dynamic VIX Futures Total Return Index	ETN	$27	12,661	17-Aug-11	0.95%
UBS E-TRACS Daily Long-Short VIX ETN	XVIX	S&P 500 VIX Futures Term-Structure Index Excess Return	ETN	$12	5,587	01-Dec-10	0.85%
VelocityShares VIX Short-Term ETN	VIIX	S&P 500 VIX Short-Term Futures Index Excess Return	ETN	$7	51,905	29-Nov-10	0.89%
C-Tracks ETN Citi Volatility Index Total Return	CVOL	Citi Volatility Index Total Return	ETN	$4.5	76,009	12-Nov-10	1.15%
Barclays ETN Inverse S&P 500 VIX Short-Term Futures ETN	XXV	S&P 500 VIX Short-Term Futures Index Excess Return (–100%)	ETN	$3.8	926	16-Jul-10	0.89%
iPath Inverse S&P 500 VIX Short-Term Futures ETN	IVOP	S&P 500 VIX Short-Term Futures Index Excess Return (–100%)	ETN	$1.9	12,827	19-Sep-11	0.89%
VelocityShares VIX Medium-Term ETN	VIIZ	S&P 500 VIX Mid-Term Futures Index Excess Return	ETN	$1.5	2,378	29-Nov-10	0.89%
VelocityShares Daily 2x VIX Medium-Term ETN	TVIZ	S&P 500 VIX Mid-Term Futures Index Excess Return (200%)	ETN	$0.84	6,134	29-Nov-10	1.65%

[1]*Assets under management as of September 1, 2014 ($ millions).*

[2]*Average daily volume (number of shares) for May–August 2014.*

EXHIBIT A2
A Graphical Taxonomy of Volatility ETPs

+2x	ProShares Ultra VIX ST Futures ETF (UVXY) VelocityShares Daily 2x VIX ST ETN (TVIX)				VelocityShares Daily 2x VIX MT ETN (TVIZ)
+1x	iPath S&P 500 VIX ST Futures ETN (VXX) ProShares VIX ST Futures (VIXY) VelocityShares Daily Long VIX ST ETN (VIIX)		C-Tracks ETN Citi Volatility Index Total Return (CVOL) E-TRACS Daily Long-Short VIX ETN (XVIX) iPath S&P 500 Dynamic VIX ETN (XVZ)		iPath S&P 500 VIX MT Futures ETN (VXZ) ProShares VIX MT Futures ETF (VIXM) VelocityShares VIX MT ETN (VIIZ)
	1 Month	**2 Months**	**3 Months**	**4 Months**	**5 Months**
–1x	iPath Inverse S&P 500 VIX ST Futures ETN (XXV) iPath Inverse S&P 500 VIX ST Futures ETN II (IVOP) ProShares Short VIX ST Futures ETF (SVXY) VelocityShares Daily Inverse VIX ST ETN (XIV)				VelocityShares Daily Inverse VIX MT ETN (ZIV)
–2x					

ENDNOTES

[1]Quoting from the S&P Dow Jones Indices [2016], *S&P VIX Futures Indices Methodology*: "While the spot VIX is difficult to replicate as a practical matter, there is a market in VIX futures and options, and investors trade them to express their view on the S&P 500's implied volatility" and "as equity markets fall, VIX rises, prompting a corresponding though not identical change in the value of products linked to VIX" (pp. 3–4).

[2]Indicatively, the C-Tracks exchange-traded notes linked to the Citi Volatility Index total return, according to the product description, is "designed to produce daily returns more correlated to the VIX Index than a portfolio of VIX futures contracts and with a similar magnitude to the daily returns of the VIX Index."

[3]Whaley [2013] doubts the idea that volatility should be considered as a distinct asset class; he states that empirical evidence regarding the diversifying ability of volatility is controversial.

[4]See Alexander and Korovilas [2012] and the references cited therein.

[5]The VIX futures settlement employs a special procedure that considers the actual option prices traded at the market open following the last day of futures trading. Typically, at this open, the majority of the option series trades either at the bid or ask price, based on the supply and demand pressures from market participants on the particular date, while the cash VIX calculation is based on the midpoint of the bid–ask spread of the S&P 500 options.

[6]VIX option prices should reflect the forward value of the VIX, which is typically less volatile than the spot VIX.

[7]The pattern where current the spot VIX is lower than expectations for the spot VIX level in the future (an upward-sloping term structure of futures prices) is called "contango" and is the dominant one in the VIX futures market; Liu and Dash [2012] report that, approximately 70% of the time, VIX futures prices increase as we move out in time.

[8]For a thorough description of the volatility ETPs, see Alexander and Korovilas [2013], Goltz and Stoyanov [2013], and Liu and Dash [2012].

[9]In particular, the Long Enhanced S&P 500 VIX Mid-Term Futures ETN (VZZ) and the iPath Inverse January 2021 S&P 500 VIX Short-Term Futures ETN (IVO).

[10]See Frino and Gallagher [2001] for additional information.

[11]According to Whaley [2013], the intercept coefficient may also incorporate an interest component.

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