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Trading Volatility:
At What Cost?

Abstract
Volatility trading is in vogue. Launched in January 2009, exchange-traded products (ETPs) linked to the CBOE Market Volatility Index (VIX) have enamored no small number of traders judging by the billions of dollars invested in these new products. Why exactly is unclear. The most popular VIX ETPs are not suitable buy-and-hold investments and are virtually guaranteed to lose money through time. Indeed, since product launch, ETPs linked to the S&P 500 VIX short-term futures indexes have chalked up losses of nearly $4 billion. Yet the market continues to grow. The purpose of this paper is to describe these products, explaining how and why they lose money.

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Trading Volatility: 
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Volatility trading is in vogue. Launched in January 2009, exchange-traded products (ETPs) linked to the CBOE Market Volatility Index (VIX) have enamored no small number of traders. More than 30 VIX ETPs are now listed with an aggregate market investment value of nearly $4 billion, generating a daily trading volume in excess of $800 million. Unlike other securities traded on stock exchanges, however, these securities are not suitable buy-and-hold investments and are virtually guaranteed to lose money through time. Indeed, the March 23, 2012 prospectus of VelocityShares, the exchange-traded notes issued by Credit Suisse AG says

“The long term expected value of your ETNs is zero. If you hold your ETNs as a long term investment, it is likely that you will lose all or a substantial portion of your investment.” (pages 27-28).

What, then, is the attraction of VIX ETPs? Unfortunately, it seems that many investors believe that they are buying the CBOE’s popular market volatility index, VIX. Launched in 1993, VIX has become a popular measure of investor anxiety, spiking upward at times of political and economic turmoil and hovering at low levels during times of calm. But, alas, they are not. VIX is not a traded security. VIX ETPs, on the other hand, are traded securities created from complicated VIX futures trading strategies. These strategies demand daily rebalancing and are subject to a host of management fees and expenses including futures commissions and trading fees, licensing fees, and, in some cases, foregone interest income. But, even in the absence of fees and expenses, the strategies these products follow are destined to lose money from a “contango trap” in which VIX futures prices are systematically drawn downward toward the level of the VIX index. What is equally surprising is that most VIX ETP investors cannot gauge the magnitude of the losses they will incur since they do not have access to real-time (or, in

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2 The VIX can be created from a basket of out-of-the-money S&P 500 index options. The portfolio of options would have to be rebalanced daily so trading costs would be prohibitive for all but market makers would be prohibitive. The current construction of the VIX is provided in CBOE (2003).
many cases, end-of-day) VIX futures prices. Yet, amazingly, in spite of the fact that holders of ETPs linked to the S&P 500 VIX futures short-term indexes have chalked up more than $4 billion in losses since product inception, the market continues to grow.

The purpose of this paper is to provide an appraisal of VIX ETPs as buy-and-hold investments. First, we explain the motives for trading volatility. Second, we describe the first generation of VIX products—VIX futures and options. These contracts were launched in March 2004 and February 2006, respectively, and experienced modest success. VIX derivatives, however, cannot completely satiate investor demand for trading volatility due to restrictions. Many institutions such as pension funds and endowments, for example, are barred from buying futures and option contracts by charter. In addition, many retail customers are simply too small to trade in the derivatives market or lack the necessary trading sophistication. Third, we show how VIX ETPs have filled the void by providing access to volatility trading through the stock market. We explain how the VIX ETPs are created and show why they generally lose money through time. Finally we estimate the losses incurred by VIX ETP holders over the past few years. The paper closes with a summary.

I. Why trade volatility?

Trading arises from the active management of expected return and risk. Some trading is risk-enhancing. Based upon fundamental economic analysis or historical price patterns, traders speculate on the direction of prices or interest rates. Other trading is risk-reducing. Airlines, for example, may hedge the price risk of their fuel costs by buying petroleum futures or call options. Diversification is also risk-reducing. Because the returns of different asset classes are less than perfectly positively correlated, combining asset classes reduces risk. Traditionally, asset classes included only such staples as stocks, bonds, and money market instruments, however, the opportunity set has been augmented in recent years to include absolute return or alternative investments such as hedge funds and commodity-linked exchange-traded products.

The motives for trading volatility are no different. Some speculate based on analysis of geopolitical news and data. Figure 1 shows the level of the CBOE Market Volatility Index (VIX) during its history. Spikes in VIX occur around major world crises.
and market events. Someone closely monitoring geopolitical events may develop strong views on the direction of short-term expected future volatility and want to try to profit by buying or selling VIX products. Others may speculate based on technical analysis. Some technical traders believe volatility follows a mean reverting process and buy and sell depending on current level of VIX relative to its historical average. Others may trade on the difference between VIX and the realized volatility of the S&P 500. Volatility risk-management strategies are also commonplace. Fearing that volatility may spike in the near-term, some institutions hedge by buying VIX call options or VIX futures as tail-risk insurance. Other institutional investors treat volatility as an asset class and buy it to diversify their investment portfolio holdings.\(^3\)

**II. Volatility trading opportunities**

The first generation of exchange-traded volatility products traded in the U.S. were futures and option contracts written on the VIX.\(^4\) VIX futures contracts were launched by the CBOE Futures Exchange (CFE) on March 26, 2004, and VIX options were launched by the CBOE on February 24, 2006. To analyze the trading activity of VIX futures, daily open-high-low-close price data, together with volume and open interest data, for the VIX futures were obtained from the CFE website. Daily data for the VIX options were purchased from the CBOE’s Market Data Express.

As Figure 2 shows, the trading activity in the VIX derivatives markets has had three distinct phases. VIX futures, launched in March 2004, got off to a slow start. The average daily trading volume of the VIX futures during the first phase was about 5,000 contracts.\(^5\) When the VIX options were introduced in February 2006, VIX futures volume

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\(^3\) The debate regarding whether volatility should be considered an asset class is contentious. Szado (2009) is often cited as providing evidence that a long volatility exposure is a good diversification tool. See *Volatility Indexes at CBOE* [http://www.cboe.com/micro/VIX/pdf/VolatilityIndexQRG2012-01-30.pdf]. Unfortunately, Szado’s evidence is based on a short sample period that includes a market crash. In a more careful systematic framework, Alexander and Korovilas (2011) conclude that, unless one is able to predict market crashes, volatility is a poor diversifier.

\(^4\) The VIX is a market-implied estimate of the expected stock market volatility over the next 30 days calculated based on real-time S&P 500 index option price quotes. Whaley (2009) describes its historical development.

\(^5\) The trading volume of the VIX futures is multiplied by 10 to put the units of trading of the futures and options on the same scale. So, the actual number of contracts traded was only 500. The mini-VIX futures trading volume has been meager since its introduction so the mini-VIX futures is not included in this analysis.
picked up. During the second phase, the average daily trading volume was nearly 34,000 contracts, close to a 600% increase. The lift in trading activity had at least two contributing factors. First, the simultaneous presence of the two complementary markets provides the opportunity for market makers to hedge their inventories. With competitive markets bid-ask spreads are reduced, thereby promoting increased trading activity. Second, the marketplace was finally afforded the opportunity to buy tail-risk insurance. The demand for tail-risk insurance grew quickly, with VIX option volume surpassing VIX futures volume almost immediately. Figure 3 shows that VIX call option volume is significantly higher than put option volume. The third phase began in January 2009 with the launch of VIX ETPs. Because VIX ETP’s require issuers to hedge the short volatility exposure in the VIX futures market, VIX futures trading volume surged ahead of VIX option volume by late 2010. The average daily VIX futures contract volume during the third phase was in excess of 270,000 contracts, a 700% increase from the second phase.

VIX ETPs, the second generation of volatility products, were introduced in 2009. The first product launch was by Barclays Bank PLC, who, on January 29, 2009, issued notes on the S&P 500 VIX Short-Term (ticker symbol: VXX) and Mid-Term (ticker symbol: VXZ) total return futures indexes. The novelty and wide-spread interest of these products spawned competition. Twenty-eight more VIX ETPs have been introduced in the U.S. within a span of only three years. Fueling the growth were institutions, hedge funds, and retail customers who do not or cannot trade in derivatives markets.

Exchange-traded products are structured and managed in different ways. The term, exchange-traded product, refers to a security that is designed to provide a price exposure that investors may find difficult to obtain on their own. The price exposure is defined in terms of a readily identifiable benchmark (e.g., the S&P 500 index, the price of crude oil). Within the family of ETPs are exchange-traded funds (ETFs) and exchange-trade notes (ETNs). The main distinction between the two products is that ETFs are transparent and specify exactly what instruments are used to generate the benchmark index return. They also provide the owner with a direct claim on the assets of the

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6 Note that is exactly the opposite behavior observed in the S&P 500 index option market where the demand for portfolio insurance results in greater trading activity in index puts than index calls.
7 The public access provided by stock markets swamps that of futures markets. Exchange officials estimate that there are as many as 100 times more stock market trading accounts than futures trading accounts.
underlying portfolio. ETNs, on the other hand, are notes that promise the benchmark return over their stated maturity. They have no coupons and are secured not by the assets used to generate the benchmark index return but rather by good faith and collateral of the issuer. The closing indicative value, the price at which the shares can be redeemed in cash at the end of the day, is updated daily based on the index return.

ETFs are either asset-based or futures-based. The first asset-based ETF was the SPDR® S&P500® ETF (ticker symbol SPY) launched in January 1993. Its structure is straightforward. The shares of SPY convey the ownership of a portfolio whose composition matches that of the S&P 500 index portfolio. “Creation/redemption” transactions ensure the price per share of the ETF equals the net asset value (NAV) per share of the fund at the end of each day. These transactions are between market makers who have been granted “authorized participant” (AP) status and the issuer. Before the market opens, the issuer identifies the composition of the basket of stocks that define an ETF “creation unit.” In the course of the day’s trading, buyer demand for SPY shares may result in the market maker or AP amassing a large short position. As the position accumulates during the day, the market maker hedges the position by buying the shares of the stock that constitute the creation unit. Just before the close, the AP may request that the issuer deliver fund shares in return for the creation unit. This in-kind transaction involves the AP delivering the individual shares of stock to the issuer and the issuer delivering shares of the ETF to the AP. The issuer does not deliver the ETF shares from an inventory it holds, but rather “creates” or “issues” new shares. Thus, unlike a typical common stock, the number of ETF shares outstanding varies on a daily basis. “Redemptions” work in the opposite way. Suppose that the market maker winds up with a large long position in the shares of SPY at the end of the day and has hedged by shorting the index stocks. In this case, the AP redeems the ETF shares by delivering the shares of the ETF and receiving the shares of the stocks that form the portfolio, which he, in turn, uses to cover his short position. Upon redemption, the number of shares outstanding of the ETF falls.

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8 These trades are relatively frictionless in the sense that they are not official trades, are not reported on the consolidated tape, and are not a taxable event. There is only a flat transaction fee for both creations and redemptions ranging from a few hundred to a few thousand dollars.
Futures-based ETFs do not hold securities but rather mimic the benchmark index returns by holding cash (i.e., short-term money market instruments) and futures, usually in a third-party custodian account. The specific holdings of the fund are published each day, so the benchmark-mimicking portfolio may be replicated. The creation/redemption process works the same as for asset-based ETFs, except that the in-kind transaction is in cash. If the AP accumulates a short position in the ETF throughout the day, he will buy the underlying futures to hedge. Just before the close, the AP may request a creation. If the issuer approves the request, the AP delivers the cash, closes his futures position, and receives newly created shares of the ETF (which he, in turn, uses to cover his short position). Conversely, if the AP is long the ETF and short the futures, he will request a redemption. If approved, the AP delivers the shares of the ETF, receives the cash equivalent, and closes his futures position. Again, as a result of ongoing creations and redemptions, shares outstanding can vary on a daily basis. Finally, as noted earlier, ETNs are unsecured notes that promise the daily rate of return of a benchmark index and can be redeemed in cash each day at closing indicative value. This means less tracking error. At the same time, the ETN holder does not have direct claim on the assets underlying the portfolio. Exactly how a bank generates the futures index return exposure need not be disclosed and is usually accomplished using a variety of hedge instruments.

Data for VIX ETPS were gathered from Bloomberg. Table 1 summarizes selected attributes of the eight most active VIX ETPs in the U.S. as of March 30, 2012. While the total number of VIX ETPs is 30, the average daily trading volume of all 22 products not reported in the table is only about seven thousand shares. In contrast, the average daily trading volume of the products included in the table is about seven million shares each. Not surprisingly, the most active VIX ETP is VXX. It, together with VXZ, were the first VIX ETPs launched and have enjoyed a first-mover advantage. VXX traded more than 32 million shares a day during January through March 2012 and had a market capitalization exceeding $1.86 billion on March 30, 2012. To place this in context, VXX’s trading volume is about the same as the shares of Ford when measured as dollar volume, and the market cap is about the same as the smallest stocks in the S&P 500 index.

VXX is benchmarked to the S&P 500 VIX short-term (ST) total return (TR) futures index. VXX has a multiplier of 1, which means that the ETN promises one times
the daily index return (less management fees and expenses). The second most active VIX ETP is TVIX, which is benchmarked to the S&P 500 VIX ST excess return (ER) futures index. It has a multiplier of 2, which means that it promises 2 times the daily return of the benchmark index. The third is XIV, which is benchmarked to also S&P 500 VIX ST ER futures index, but promises –1 times the daily futures index return. Note that five of the eight products listed in the table are ETNs. VIX ETFs were introduced by ProShares in January 2011, nearly two years after the introduction of the VIX ETNs. They are slowly gaining traction in terms of trading volume and market capitalization, probably due to the reduced credit risk of the ETF structure (as discussed earlier). Finally, the table shows that yearly management fees range from 0.85% to 1.65% annually.

All of the ETPs listed in Table 1 are benchmarked to S&P 500 VIX futures indexes. The difference between the total return and excess return index benchmarks is subtle, but important. ETPs benchmarked to excess return futures indexes are implicitly embedding an additional management fee. To see this, assume an investor creates a fully collateralized volatility investment by buying the VIX futures and depositing the notional amount of the futures in money market instruments. His investment return will come in two parts: (a) interest income on the money market instruments (i.e., the risk-free interest rate), and (b) price appreciation on the futures contract (i.e., the risk premium or excess return). But, as noted earlier, certain participants cannot trade in the futures market. ETP issuers step in and create the fully collateralized volatility investments on the investor’s behalf and charge a management fee for their service. In the case VIX ETPs benchmarked to TR futures indexes, the promised return structure should be identical to the fully collateralized investment described above. VXX, for example, is benchmarked to the VIX ST TR futures index and promises the return on a 91-day T-bill (i.e., the risk-free rate) plus the rate of price appreciation on the VIX ST ER index (i.e., the risk premium). On the other hand, the VIX ETPs introduced since VXX and VXZ are generally benchmarked to excess return futures indexes. Some of these products promise the daily return (i.e., price appreciation) on excess return futures index plus a daily interest accrual. VIIX, for example, is an ETN linked to the return of VIX ST ER index and also has a daily interest accrual based on the 91-day T-bill rate. Others do not include an interest component. VIXY, for example, is an ETF that seeks only to match the
performance of VIX ST ER. This means that the investor is implicitly forfeiting the interest income he should be earning on the cash invested in the ETP and is, thereby, paying an additional, albeit implicit, management fee. While the difference between TR and ER futures indexes is seemingly innocuous at current short-term interest rate levels, it will undoubtedly grow as the economy recovers.

The VIX futures indexes are intended to mimic the behavior of dynamic futures trading strategies that involve rolling VIX futures in a manner that maintains a constant futures maturity. The VIX ST ER futures index, for example, holds long positions in the nearby and second nearby futures in proportions that create an average time to maturity of one month (say, 30 days). The position is held for one day recognizing any gains or losses, and then rebalanced or rolled to move the weighted average maturity from 29 days back to 30 (i.e., selling some of the nearby contracts and buying more of the second nearby contracts). The MT ER futures index is similarly rebalanced daily so as to maintain five-month constant maturity and uses the fourth, fifth, sixth, and seventh futures contracts. The futures trading strategies underlying the TR indexes are the same as the ER indexes.

The final feature of Table 1 worthy of discussion is institutional ownership. The final column includes the percent of the shares outstanding of the ETP controlled by institutional investment managers reported in Form 13F filings. An institutional investment manager is a person or entity that owns or exercises investment discretion over $100 million or more in securities. Included are investment advisors, banks, insurance companies, broker-dealers, money managers, hedge funds, mutual funds, pension funds, and corporations—the most sophisticated investors in the marketplace. Because filings are made quarterly, they provide only periodic snapshots of institutional ownership, making it difficult to determine how long the position has been held beforehand or afterward. Nevertheless, these numbers offer some crude insight. The table shows that the percent institutional ownership is modest, ranging from 1% for TVIX to 40.6% for XIV. The market value weighted average institutional ownership based on the funds in Table 1 is 28.7%. This is starkly different from the institutional ownership of a

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typical U.S. stock. The market value weighted average institutional ownership of S&P 500 stocks, for example, was 77.4% at the end of March 2012. Based on this evidence, it seems that the holders of VIX ETPs are less sophisticated investors such as small institutional traders and retail customers.\textsuperscript{10}

III. VIX ETP performance

In assessing the viability of buying volatility as tail-risk insurance or an asset class, we need to have some sense of expected performance. Typically, expected performance is projected on the basis of historical performance. In this case, historical performance has two dimensions. First, how well does a typical VIX ETP track its benchmark index, and, second, how well does the benchmark perform as an asset class? We address each question in turn.

A. Tracking performance

The data for the VIX ETPs and the S&P 500 VIX futures indexes were drawn from Bloomberg. One test of a VIX ETP’s performance is to see how well it tracks its benchmark. To evaluate this performance, we regress the daily returns of the eight ETPs listed in Table 1 on the daily returns of their respective benchmarks, that is,

\[ R_{i,t} = \alpha_i + \beta_i R_{BM,t} + \epsilon_{i,t}, \]

where \( i \) denotes the \( i \)-th ETP whose day \( t \) return is \( R_{i,t} \) and whose day \( t \) benchmark return is \( R_{BM,t} \). For the levered and inverse products, the underlying index returns are scaled by their respective multipliers. In theory, if the ETP mimics its benchmark exactly, the estimated intercept will be equal to zero and the estimated slope will be equal to one. In practice, however, the slope may be less than one due to tracking error, and the intercept should be less than zero due to management fees and other expenses such as licensing fees and trading costs and fees.\textsuperscript{11} All available historical returns are used for each ETP, so the length of the time-series varies by ETP depending on the product launch date.

\textsuperscript{10} Some retail customer trading such as that managed by brokerage in wrap accounts will be included as institutional trading.

\textsuperscript{11} The intercept may also reflect an interest component. VIX, for example, promises the daily return on the VIX ST ER index plus the daily return on a 91-day T-bill, in which case the intercept should include the
The performance regression results are reported in Table 2. The adjusted R-squared figures reflect the proportion of the variance of the VIX ETP’s return that is explained by the benchmark return. VXX, for example, has an adjusted R-squared of 0.957, which means it tracks the VIX ST TR futures index quite well. The regression coefficients are consistent with expectations. For the most part, the intercept terms are negative, although none of them are significantly different from zero. The slope coefficients are all significantly less than one, although the amount of deviation is small from an economic perspective. The last three columns of the table measure tracking error directly. Note that the mean differences between the daily returns of the ETPs and their benchmarks are all near zero, while the mean absolute and root mean squared deviations are all above zero. What this means is that, while the hedging activity of the ETP creator was effective on average, some days they overshoot the benchmark index and other days they undershoot.

The hedging error arises from at least two sources. First, for VIX ETFs, perfect hedging would require that the manager rebalance the VIX futures positions at exactly the prices used by S&P in the computation of their futures indexes. As a practical matter that is not possible since S&P uses settlement prices, which are determined after the market is closed. The VIX ETF manager must rebalance before the close. Second, for the VIX ETNs, volatility risk management is done at an aggregate level with a combination of futures, options, and swaps. Under these circumstances, exactly mimicking the return of the benchmark would be virtually impossible. All things considered, however, the results of Table 2 indicate that the VIX ETPs track the performance of their respective benchmark indexes reasonably well.

As a sidebar, it is worth noting that the performance of TVIX is somewhat anomalous. The slope coefficient is lowest among all ETPs and the MAD and RMSD are highest. The reason is that Credit Suisse stopped issuing new shares in the ETN on February 21, 2012 “…due to internal limits on the size of ETNs.” Without arbitrage average daily T-bill return over the estimation period. But, since interest rates were negligible over the estimation period, the effect is trivial.

12 Beginning on November 4, 2012, the CBOE instituted Trade at Settlement (TAS) transactions whereby market participants can enter orders during the day to trade at the VIX futures settlement price at the end of the day. This new practice should mitigate some of the tracking error, particularly for the VIX ETFs. For more details, see http://ir.cboe.com/releasedetail.cfm?ReleaseID=619298.
between the ETN and its underlying hedged portfolio, the price per share of the ETN can rise well above (or below) the net asset value per share. Indeed, this is exactly what transpired. By March 21, 2012, the price per share of TVIX had an 89% premium over the net asset value per share. On March 22, 2012, Credit Suisse announced it would again allow for new creation units, albeit on a limited basis. With the creation process in place, the TVIX price and NAV quickly re-aligned. The final row of Table 2 shows the results for TVIX regression when the daily returns for the subperiod from February 21 through March 22 are eliminated. The slope coefficient estimate rises to 0.9104, and both the MAD and RMSD fall. Clearly the noise introduced by the suspension of the creation process had an effect.

B. S&P 500 VIX futures index return performance

The results of Table 2 indicate that the VIX ETPs do reasonably well at tracking the return performance of their respective benchmarks. The question that arises is “Are the indexes worth tracking, and, if so, in what investment context?” To answer these questions, we rely on the daily returns of a number of indexes. Included are the SPY ETF to proxy for the S&P 500 stock market return (SPY), the VIX (VIX), short-term and mid-term VIX TR indexes (ST TR and MT TR), the VIX ST ER index (ST ER), two times the VIX ST ER (2(ST ER)) index, and the so-called “inverse” VIX ST ER index (−1(ST ER)). The rationale for performing the computations on the VIX futures index returns rather than the VIX ETP returns is twofold. First, the return series is longer. The VIX futures index histories date back to December 20, 2005, whereas the longest VIX ETP history dates to only January 29, 2009. Since we have already established that the VIX ETPs track their respective VIX futures index benchmarks reasonably well, working with the longer history in our return analysis ensures that our sample includes as many volatility cycles as possible. Figure 4 shows the different volatility benchmarks since December 20, 2005, with the figure being divided into pre- and post-VIX ETP launch date periods. In terms of understanding the return performance of VIX ETPs, the pre-launch date period is particularly important since the VIX level spiked during the October

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13 In essence, what was an open-ended fund became a closed-end fund
2008 financial crisis, a time during which VIX ETPs should show particularly strong
return performance. Second, the return analysis will be free of the effects of management
fees and expenses and will focus exclusively on the merits of the different futures
indexes. The specific indexes used in the analysis are the most common benchmarks.
Recall from Table 1 that VXX and VXZ benchmark to the ST TR and MT TR futures
indexes, respectively, TVIX benchmarks to the 2(ST ER) and XIV benchmarks to –1(ST
ER).

Table 3 contains summary statistics of the daily returns of the different indexes as
well as the correlations between the different return series. The results are interesting in a
number of respects. First, note that the correlation of SPY returns and VIX futures index
returns is virtually the same for all VIX futures indexes, on order of –0.78. Holding other
factors constant, this means that all of the volatility indexes are equally effective at
diversifying stock portfolio risk, at least to the degree that the S&P 500 index portfolio
reflects traditional portfolio risk. Of course, other factors are not held constant. Return
means and standard deviations also weigh in.

Second, note the abysmal performance of the VIX ST TR futures index, which
fell by 93.16% since inception. Expressed as a compound annual growth rate (CAGR),
the return is –34.81%. Even worse is the return performance of the 2(ST ER) futures
index, with a holding period return of –99.96% and a CAGR of –71.69%. This is eerily
consistent with the Credit Suisse warning about VelocityShares quoted in the
introduction of the paper. While TVIX, the Credit Suisse two times VIX ST ER return
product, lost only –93.6% since its inception on November 29, 2010, had it had a long
history the story could have been worse.

The culprit is the contango in the VIX futures market. A futures market is said to
be in contango when the futures price curve is upward sloping. When futures prices curve
is downward sloping, the market is in normal backwardation.15 Figure 5 shows the VIX
futures price curve on March 14, 2012. The market is in contango. The VIX cash index
level is 15.31. The nearby VIX futures contract has 7 days remaining to expiration and a

15 Technically, while these definitions are widely used in practice, they are only loosely correct. Contango
refers to a market in which futures prices exceed expectations of the futures spot price, and normal
backwardation refers to a market in which the opposite holds. See Keynes (1930).
price of 17.80, the second nearby futures has 35 days to expiration and a price of 22.10, and so on. Now, suppose this curve (not the dots on the curve) remains the same shape through time. Day by day the dots on the curve (i.e., the futures prices) would march downward to the left along the curve as the VIX futures days to expiration grow short, finally converging at the VIX cash index level on settlement day. Why this relation is so important is that if a futures price curve (in any market) is consistently upward sloping through time, a long position in the futures will tend to lose money through time relative to a long position in the cash index level. Conversely, if the price curve is downward-sloping, a long futures position will tend to make money relative to a long position in cash.

Fact of the matter is that the VIX futures market is usually in contango. To illustrate, we compute the slope of the term structure at maturities of 30, 60, 90, 120, 150 and 180 days each day since VIX futures were initially listed. In our analysis, slope is defined as the difference between the prices of the two futures contracts whose expirations straddle the constant maturity (e.g., 30 days) divided by the number of days between the futures expirations. Table 4 contains summary statistics. Panel A of Table 4 shows that the mean slope at 30 days to expiration across all days in the sample is 0.0230. This means that the 30-day futures price is expected to drop by 0.0230 per day on average. The median slope is 0.0304, which means that on a typical day the 30-day futures is expected to drop by 0.0304. Panel B contains summary statistics for days on which the slope is positive. Note that the term structure is upward sloping on 1,633 of the 2,021 trading days of the sample period, nearly 81% of the VIX futures history. When the slope is positive, the mean and median are 0.0465 and 0.0393, respectively. The maximum slope is 0.1946 and occurred only recently on March 16, 2012. Panel C contains summary statistics for days on which the slope is negative. The slope is negative about 19% of the days in the sample. When it is, we expect the futures price to increase

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16 At first blush, the upward sloping curve may seem counterintuitive. Since the “cost of carrying” volatility is zero, one might expect the futures price curve to be flat. But, the usual cost of carry model does not hold here since buying or selling the VIX cash index is not possible. Hence, the futures price curve is determined largely by hedging demand. In this market, we have the reverse of Keynesian normal backwardation in that the demand is long (not short) as a result of portfolio insurance buyers.
by 0.0759 per day on average. The typical (median) price increase is 0.0376, which means that the slope distribution contains some unusually large negative values.

Panels B and C also show that the 30-day slope tends to be positive and stable for long periods of time, and turns negative and erratic for short periods of time. When the slope is positive, for example, the standard deviation of the slope is 0.0322. When the slope is negative, it is more than three times higher at 0.1087. When the slope is positive, it stays positive for 27.2 days on average, and, when the slope is negative, it stays negative for only 6.6 days. The volatility spread reported in the last column of Table 1 is defined as the difference between the 150-day VIX futures price and the VIX cash index level. On average, the 150-day futures is 173 basis points higher than the VIX cash index level. The median is 274 basis points. The lowest value is –41.44 on October 24, 2008, the height of the 2008 financial crisis.

Figure 6 shows the level of VIX and the volatility spread over the history of the VIX futures contract. Two observations are particularly noteworthy. First, the volatility spread has been consistently positive over the full sample period. Occasionally, it goes negative when VIX spikes, but then quickly reverts back to being positive, as was already documented in Table 1. Second, the size of the volatility spread has increased on average since the launch of VIX ETPs in January 29, 2009. The mean daily volatility spread in the period before and including January 29, 2009 is 0.63 and is significantly different from 0 at the 5% probability level. The mean daily volatility spread in the period after January 29, 2009 is 3.40, significantly greater than that in the pre-ETP period. The slope of the term structure has increased significantly since the advent of VIX ETPs.

Returning to the results of Table 3, it is not immediately obvious that the VIX futures indexes like the ST index will lose money due to contango since they maintain a constant maturity. But, alas, they do not. While the ST index may have 30 days to expiration at the close today, it will have 29 days to expiration tomorrow when the futures index portfolio is rebalanced. In the interim, the futures index, which is a weighted average of the nearby and second nearby VIX futures contract prices, has slid downward toward the VIX cash index level.
The CAGR for the VIX MT TR futures index, 0.92%, is dramatically higher than that of the VIX ST TR futures index. For the mid-term futures index, the contango effect is much lower. While the VIX futures term structure is typically upward sloping, it is much more steeply sloped for shorter maturities than for longer maturities. Recall that in Panel A of Table 4 we reported that the slope of the VIX term structure was 0.0230 at 30 days to expiration, nearly six times higher than the 0.0041 at 150 days to expiration. And, not only is the mean return higher for the VIX MT TR futures index (0.9% vs. –34.8%), its annualized volatility rate is lower (32.4% vs. 62.1%). From a practical standpoint, this means that VIX ETPs based on the mid-term VIX futures index strictly dominate those based on the short-term index in terms of providing diversification if historical performance is a reliable indicator of future performance.\textsuperscript{17} This result is helpful in the sense that, perhaps, an argument can be made for considering volatility as an asset class. At the same time, it is curious. The strongest interest in VIX ETPs remains in those benchmarked to the VIX ST indexes. Of the $3.3 billion in VIX ETPs shown in Table 1, 75.9% is in direct ETPs ($L = 1$ and $L = 2$) benchmarked to the VIX ST indexes, 14.4% is in inverse ETPs ($L = -1$) benchmarked to the VIX ST indexes, and only 9.7% in benchmarked to VIX MT indexes. VXX alone accounts for 56.4%. But, consider VXX’s record, as shown in Figure 7. Although VXX has lost 93.6% of its value since it was launched, shares outstanding are at unprecedented levels.

With the evidence clearly suggesting that buyers of ST volatility index futures are looking for a substitute for the VIX cash index, we perform a final analysis of VIX futures index returns to demonstrate that (a) VIX futures indexes (and, consequently, VIX ETPs) are watered down and noisy versions of VIX, and (b) VIX futures index returns are predictable based on the slope on the VIX futures price curve yesterday. On a given

\textsuperscript{17} The summary statistics reported in Table 3 leave open the possibility that the inverse products based on the short-term futures indexes may be superior diversifiers than the direct mid-term products. Using the parameters of Table 3 as expectations of the mean, standard deviations, and correlations of the future returns and a 0.5% risk-free interest rate, the maximum Sharpe ratio is 0.232 for a risky asset portfolio with fraction 0.6258 invested in SPY and 0.3742 invested in the VIX MT TR futures index. For the inverse index, the maximum Sharpe ratio is 0.1419 for a risky asset portfolio with fraction 1.1233 invested in SPY and –0.1233 invested in the –(ST ER) futures index. So, not only is the Sharpe ratio less, the optimal risky asset portfolio involves short selling the inverse index. The mid-term index appears to be the strongest diversification prospect of the available VIX ETPs.
day, the VIX futures index moves for at least two reasons. The first is the innovation to true short-term market volatility, presumably resulting from new information disseminating into the marketplace. To proxy for this volatility shock, we use the daily percentage change in the VIX cash index level, $R_{VIX,t}$. The second is the deterministic and, typically, downward pull of the VIX futures index toward the VIX cash index level. To proxy for this return, we use minus the slopes of the VIX futures price term structure at 30 and 150 days divided by the constant maturity VIX futures price at 30 and 150 days VIX futures prices for the short-term and mid-term total return indexes, respectively. It is important to note that this variable, $R_{slope,t-1}$, is measured on the day before the futures index return and is therefore predictive in nature. The regression equation is

$$R_{FI,t} = \beta_0 + \beta_1 R_{VIX,t} + \beta_2 R_{slope,t-1} + \epsilon_t$$

and the regression is performed for both the VIX ST TR and VIX MT TR futures indexes.18

The regression results are reported in Table 5. The VIX short-term futures index has a $\beta_1$ coefficient estimate of 0.4629. This means that if VIX moves upward by 1% on a given day, the VIX short-term futures will rise by slightly less than a half a percent. Similarly, the $\beta_1$ coefficient estimate of the VIX mid-term futures index is only 0.2200, which means that it responds by about one-quarter of one percent for a one percent movement in VIX. What this means is that the VIX futures indexes upon which the VIX ETNs are based, are muted versions of an investment in the VIX. Positions in the ST and MT futures indexes would need to be levered upward by factors of two and four, respectively, to achieve the same price action as VIX.19 This is consistent with Table 3 where we show that the return volatilities of the ST and MT indexes are about one-half and one-quarter the return volatility of the VIX, respectively. But, beware. The adjusted

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18 The results for the excess return indexes are similar, and, therefore, not included in the table or its discussion.
19 The fact that the MT futures index is only half as responsive as the ST futures index has not gone unrecognized. Indeed, Standard and Poor’s has already created the S&P 500 VIX Futures Term-Structure Index Excess Return (Bloomberg ticker symbol: SPVXTSER) from taking a 100% long position in the S&P 500 VIX Short-term Index Excess Return and a 50% short position in the S&P 500 VIX Mid-term Index Excess Return, and it serves as the benchmark for the UBS ETRACS Daily Long-Short VIX ETN, which trades under the ticker symbol XVIX.
R-squared values are far below one, which means that movements in the value of these levered positions may deviate substantially from movements in the VIX. And, in levering the indexes, the effects of contango are also being levered. Note that the estimates of the coefficient $\beta_2$ for the ST and MT indexes in Table 5 are positive and significantly different from zero at the 5% probability level. To interpret these coefficient magnitudes, consider the fact that, due to the persistent contango in the VIX futures market, the mean value of $R_{\text{slope}, t-1}$ in the VIX ST futures index return regression is $-0.133\%$. Multiplying by the coefficient estimate, this means that a VIX ETP based on a VIX ST futures index is expected to fall by 0.286\% a day on average without leverage. Assuming 22 trading days in a month, this means losing more than 6\% a month on average with a buy-and-hold strategy based on the index. And, again, recall that the direct VIX ETPs based on the VIX ST futures indexes are by far the most popular based on their market capitalization and trading volume.

The return performance of the short-term VIX futures indexes provide compelling evidence that VIX ETPs based on the VIX short-term indexes are not suitable as buy-and-hold investments. But, someone is holding them. Otherwise, the number of shares outstanding would fall to zero. To illustrate how out of hand the situation has gotten, we assess the amount of money lost by investors, presumably unsophisticated investors, as a result of holding VIX ETPs benchmarked to the VIX ST futures indexes.

The methodology is straightforward. The dollar amount of VIX derivatives that is required to hedge the short volatility exposure of a VIX ETP at the close of trading on a given day $t$:

$$DH_t = n_t S_t L,$$  \hspace{1cm} (3)

where $n_t$ is the number of shares outstanding, $S_t$ is the net asset value per share of the ETP, and $L$ is the leverage factor. Where $L$ is 2, the index exposure is twice the level of total net asset value because of the promised return of 200\% of the index return. Where $L$ is $-1$, the promised return is $-100\%$ of the index return. Based on (3), the change in the value of this futures hedge from day $t-1$ to day $t$ is

$$DH_{t-1} R_t = n_{t-1} S_{t-1} LR_t,$$  \hspace{1cm} (4)
where $R_t$ is the VIX futures index return on day $t$. Finding cumulative dollar losses for all VIX ETPs involves summing the values of (4) for each VIX ETP each day, and then summing through time. Note that, in this computation, the gains of direct ETPs are offset by the losses of inverse ETPs, and vice versa.

Plotted in Figure 8 are the results. The figure contains the total market value of all direct ETPs benchmarked to the VIX ST futures index and the total market value of all inverse ETPs, as well as and the cumulative dollar gains in millions of dollars of the direct and inverse ETPs. Only the seven most active ETPs are used. As the figure shows, direct ETPs dominate in the sense that their market value is five times the market value of inverse ETPs—$2.50 billion versus $0.48 billion as of March 30, 2012. They also dominate in terms of racking up losses. When the gains and losses are summed through time, direct ETPs lose a whopping $3.89 billion while inverse ETPs lose only $57.4 million. The results are perplexing indeed. In spite of the fact that investors in direct VIX ETPs benchmarked to the short-term futures index lost nearly $4 billion since inception, strong interest in holding them remains.

IV. **Summary and conclusions**

The purpose of this paper is to evaluate VIX ETPs as a buy-and-hold investment. The evidence is not good. The nature and performance of VIX ETPs suggests that a significant proportion of holders either (a) are unaware of how these products are structured and perform through time, and/or (b) are irrational. Among the findings is that VIX ETPs benchmarked to the VIX short-term futures indexes are virtually certain to lose money through time. Indeed, over its six-year history, the VIX short-term total return futures index dropped in value by nearly 94%. This completely discounts the notion that this VIX investment can or should be used as a buy-and-hold asset class in the manner of stocks and bonds. While its returns are highly negatively correlated with the returns of traditional asset classes, its poor return performance renders it ineffective. Indeed, over their three-year history, the holders of ETPs benchmarked to the VIX Short-Term Futures Indexes have lost nearly $4 billion.

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20 One of the ETPs in Table 8 is benchmarked to the VIX MT futures index.
But, if the holders of VIX ETPs are losing money, is it possible to make money by being on the other side of the trade? The answer is possibly. These securities are hard to borrow and rebate rates are often thousands of basis points below the general collateral rate. Another alternative is to buy an inverse ETP. The inverse of the S&P 500 VIX Short-Term Excess Return Futures Index experienced a 6.0% annualized return over the period December 2005 through March 2012. Perhaps this accounts for the fact that XIV has the highest institutional ownership. The returns of inverse VIX ETPs are highly positively correlated with stock returns, however, and do not provide much diversification power.

For those considering VIX ETPs as long term holdings, two suggestions are offered. First, buy VIX ETPs that are based on the VIX mid-term rather than the VIX short-term futures index. The term structure of VIX futures prices is much flatter in the region at the Mid-Term index’s five-month month maturity than at the Short-Term index’s one month maturity. This means the losses due to the contango trap are considerably lower (i.e., are incurred at a much slower rate). Indeed, over the six-year period in which S&P reported futures index returns, the holding period return of the MT index was 5.9% compared to the ST index return of –93.9%. At the same time, the MT index returns are almost as negatively correlated with stock returns (−0.77) as the ST index returns (−0.78) so there is no loss in diversification effectiveness. Second, holding other factors constant, consider only VIX ETPs that provide interest accrual, whether it by benchmarking to the Total Return indexes (e.g., VXX and VXY) or promising the return of the Excess Return indexes plus an explicit interest accrual (e.g., VIIX). The risk-free return on the capital tied up in the VIX ETPs properly belongs to the investor, and, when the economy fully recovers and interest rates return to more normal levels, this income may amount to several hundred basis points a year.
References


Table 1: Attributes of the eight largest VIX ETPs traded in the U.S. as of March 30, 2012. Average volume is average daily trading volume over the past three months. Yearly fee is annual management fee and is charged on a daily basis. The benchmarks are denoted by ST and MT, which represent the VIX short-term and mid-term futures indexes, respectively. The notation TR and ER denotes the total return and the excess return versions of the indexes. The multiplier of the ETP is applied to the daily return of the futures index. A multiplier of 1 implies that the ETP promises the daily rate of return on the underlying futures index. A multiplier of 2 implies that the ETP promises two times the return of the index, and −1 implies that the ETP promises minus the daily return of the index. The source of the ETP data is http://etfdb.com/etfdb-category/volatility/. The percentage of institutional ownership is drawn from http://www.nasdaq.com/. Institutional holdings information is drawn from form 13-F filings with the Securities and Exchange Commission.

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Name</th>
<th>Average volume</th>
<th>Asset value in USD millions</th>
<th>Date of inception</th>
<th>Yearly fee</th>
<th>Benchmark</th>
<th>Inst. owner.</th>
</tr>
</thead>
<tbody>
<tr>
<td>VXX</td>
<td>iPath S&amp;P 500 VIX Short Term Futures ETN</td>
<td>32,104,131</td>
<td>1,864.6</td>
<td>20090129</td>
<td>0.89%</td>
<td>ST TR</td>
<td>30.4%</td>
</tr>
<tr>
<td>TVIX</td>
<td>VelocityShares Daily 2x VIX Short-Term ETN</td>
<td>13,344,642</td>
<td>355.7</td>
<td>20101129</td>
<td>1.65%</td>
<td>ST ER</td>
<td>1.0%</td>
</tr>
<tr>
<td>XIV</td>
<td>VelocityShares Daily Inverse VIX Short-Term ETN</td>
<td>7,739,089</td>
<td>446.9</td>
<td>20101129</td>
<td>1.35%</td>
<td>ST ER</td>
<td>40.6%</td>
</tr>
<tr>
<td>UVXY</td>
<td>Proshares Ultra VIX Short-Term Futures ETF</td>
<td>1,478,367</td>
<td>125.4</td>
<td>20110104</td>
<td>0.95%</td>
<td>ST ER</td>
<td>30.4%</td>
</tr>
<tr>
<td>VXZ</td>
<td>iPath S&amp;P 500 VIX Mid-Term Futures ETN</td>
<td>467,066</td>
<td>320.1</td>
<td>20090129</td>
<td>0.89%</td>
<td>MT TR</td>
<td>38.0%</td>
</tr>
<tr>
<td>VIXY</td>
<td>ProShares VIX Short-Term Futures ETF</td>
<td>273,392</td>
<td>127.9</td>
<td>20110103</td>
<td>0.85%</td>
<td>ST ER</td>
<td>22.3%</td>
</tr>
<tr>
<td>SVXY</td>
<td>Proshares Short VIX Short-Term Futures ETF</td>
<td>111,773</td>
<td>29.1</td>
<td>20110104</td>
<td>0.95%</td>
<td>ST ER</td>
<td>5.0%</td>
</tr>
<tr>
<td>VIIX</td>
<td>VelocityShares VIX Short-Term ETN</td>
<td>91,465</td>
<td>35.0</td>
<td>20101129</td>
<td>0.89%</td>
<td>ST ER</td>
<td>14.9%</td>
</tr>
</tbody>
</table>
Table 2: Summary results from regressions of daily VIX ETP returns on benchmark returns. Each time-series begins on the day that the ETP was launched and ends on March 30, 2012. The $t$-ratios correspond to the null hypotheses that the intercept equals 0 and the slope coefficient equals 1, respectively. Last three columns are based on the daily return differential between the ETP and its benchmark. MAD is the mean absolute deviation, and RMSD is the root mean squared deviation. The final row of the table with the ticker symbol TVIX* includes the regression time-series regression results when the daily returns for the subperiod February 21 through March 22, 2012 are eliminated.

<table>
<thead>
<tr>
<th>Ticker</th>
<th>No. of obs</th>
<th>$R^2$</th>
<th>$\alpha$</th>
<th>$t(\alpha)$</th>
<th>$\beta$</th>
<th>$t(\beta)$</th>
<th>Mean</th>
<th>MAD</th>
<th>RMSD</th>
</tr>
</thead>
<tbody>
<tr>
<td>VXX</td>
<td>799</td>
<td>0.957</td>
<td>-0.0003</td>
<td>-1.09</td>
<td>0.9319</td>
<td>-9.73</td>
<td>-0.0001</td>
<td>0.0062</td>
<td>0.0086</td>
</tr>
<tr>
<td>TVIX</td>
<td>336</td>
<td>0.886</td>
<td>-0.0007</td>
<td>-0.42</td>
<td>0.8731</td>
<td>-7.42</td>
<td>-0.0002</td>
<td>0.0182</td>
<td>0.0322</td>
</tr>
<tr>
<td>XIV</td>
<td>336</td>
<td>0.951</td>
<td>-0.0001</td>
<td>-0.25</td>
<td>0.8991</td>
<td>-9.03</td>
<td>-0.0003</td>
<td>0.0075</td>
<td>0.0109</td>
</tr>
<tr>
<td>UVXY</td>
<td>123</td>
<td>0.957</td>
<td>-0.0026</td>
<td>-1.49</td>
<td>0.8961</td>
<td>-6.01</td>
<td>-0.0010</td>
<td>0.0170</td>
<td>0.0219</td>
</tr>
<tr>
<td>VXZ</td>
<td>799</td>
<td>0.930</td>
<td>-0.0001</td>
<td>-0.32</td>
<td>0.9515</td>
<td>-5.25</td>
<td>0.0000</td>
<td>0.0039</td>
<td>0.0054</td>
</tr>
<tr>
<td>VIXY</td>
<td>312</td>
<td>0.960</td>
<td>-0.0004</td>
<td>-0.69</td>
<td>0.9050</td>
<td>-9.08</td>
<td>-0.0002</td>
<td>0.0072</td>
<td>0.0101</td>
</tr>
<tr>
<td>SVXY</td>
<td>123</td>
<td>0.952</td>
<td>0.0006</td>
<td>0.65</td>
<td>0.9208</td>
<td>-4.24</td>
<td>0.0000</td>
<td>0.0088</td>
<td>0.0111</td>
</tr>
<tr>
<td>VIIX</td>
<td>307</td>
<td>0.939</td>
<td>-0.0004</td>
<td>-0.56</td>
<td>0.9019</td>
<td>-7.45</td>
<td>-0.0001</td>
<td>0.0088</td>
<td>0.0123</td>
</tr>
<tr>
<td>TVIX*</td>
<td>314</td>
<td>0.952</td>
<td>-0.0011</td>
<td>-1.03</td>
<td>0.9104</td>
<td>-7.73</td>
<td>-0.0009</td>
<td>0.0146</td>
<td>0.0215</td>
</tr>
</tbody>
</table>
Table 3: Summary statistics of daily returns for stock and volatility indexes during the period December 20, 2005 through March 30, 2012. SPY denotes SPDR S&P500 ETF, VIX is CBOE Market Volatility Index, ST TR and MT TR are the VIX short-term and mid-term total returns futures indexes, respectively, ST ER is the VIX short-term excess return futures index, 2(ST ER) is the two times the return of the ST ER futures index, and –1(ST ER) is minus the return of the ST ER futures index.

### Panel A: Summary statistics

<table>
<thead>
<tr>
<th>Daily returns</th>
<th>SPY</th>
<th>VIX</th>
<th>ST TR</th>
<th>MT TR</th>
<th>ST ER</th>
<th>2(ST ER)</th>
<th>-1(ST ER)</th>
</tr>
</thead>
<tbody>
<tr>
<td>n</td>
<td>1,580</td>
<td>1,580</td>
<td>1,580</td>
<td>1,580</td>
<td>1,580</td>
<td>1,580</td>
<td>1,580</td>
</tr>
<tr>
<td>Mean</td>
<td>0.026%</td>
<td>0.286%</td>
<td>-0.095%</td>
<td>0.024%</td>
<td>-0.102%</td>
<td>-0.204%</td>
<td>0.102%</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>1.520%</td>
<td>7.478%</td>
<td>3.911%</td>
<td>2.041%</td>
<td>3.911%</td>
<td>7.822%</td>
<td>3.911%</td>
</tr>
<tr>
<td>Annualized standard deviation</td>
<td>24.1%</td>
<td>118.7%</td>
<td>62.1%</td>
<td>32.4%</td>
<td>62.1%</td>
<td>124.2%</td>
<td>62.1%</td>
</tr>
<tr>
<td>Holding period return</td>
<td>26.6%</td>
<td>38.5%</td>
<td>-93.2%</td>
<td>5.9%</td>
<td>-93.9%</td>
<td>-100.0%</td>
<td>44.2%</td>
</tr>
<tr>
<td>Compound annual growth rate</td>
<td>3.8%</td>
<td>5.3%</td>
<td>-34.8%</td>
<td>0.9%</td>
<td>-36.0%</td>
<td>-71.7%</td>
<td>6.0%</td>
</tr>
</tbody>
</table>

### Panel B: Correlation estimates

<table>
<thead>
<tr>
<th>Panel B: Correlation estimates</th>
<th>SPY</th>
<th>VIX</th>
<th>ST TR</th>
<th>MT TR</th>
<th>ST ER</th>
<th>2(ST ER)</th>
<th>-1(ST ER)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPY</td>
<td>1</td>
<td>-0.760</td>
<td>-0.782</td>
<td>-0.767</td>
<td>-0.782</td>
<td>-0.782</td>
<td>0.782</td>
</tr>
<tr>
<td>VIX</td>
<td>-0.760</td>
<td>1</td>
<td>0.878</td>
<td>0.801</td>
<td>0.878</td>
<td>0.878</td>
<td>-0.878</td>
</tr>
<tr>
<td>ST TR</td>
<td>-0.782</td>
<td>0.878</td>
<td>1</td>
<td>0.905</td>
<td>1</td>
<td>1</td>
<td>-1</td>
</tr>
<tr>
<td>MT TR</td>
<td>-0.767</td>
<td>0.801</td>
<td>0.905</td>
<td>1</td>
<td>0.905</td>
<td>0.905</td>
<td>-0.905</td>
</tr>
<tr>
<td>ST ER</td>
<td>-0.782</td>
<td>0.878</td>
<td>1</td>
<td>0.905</td>
<td>1</td>
<td>1</td>
<td>-1</td>
</tr>
<tr>
<td>2(ST ER)</td>
<td>-0.782</td>
<td>0.878</td>
<td>1</td>
<td>0.905</td>
<td>1</td>
<td>1</td>
<td>-1</td>
</tr>
<tr>
<td>-1(ST ER)</td>
<td>0.782</td>
<td>-0.878</td>
<td>-1</td>
<td>-0.905</td>
<td>-1</td>
<td>-1</td>
<td>1</td>
</tr>
</tbody>
</table>
Table 4: Average slope of VIX futures prices curve at different times to expiration across all days in the sample period March 26, 2004 through March 30, 2012. The volatility spread is defined as the difference between the 150-day VIX futures prices and the VIX cash index level.

<table>
<thead>
<tr>
<th></th>
<th>30-day</th>
<th>60-day</th>
<th>90-day</th>
<th>120-day</th>
<th>150-day</th>
<th>180-day</th>
<th>Volatility spread</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. All observations</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Total days</td>
<td>2.021</td>
<td>2.021</td>
<td>2.021</td>
<td>2.021</td>
<td>2.021</td>
<td>2.021</td>
<td>2.021</td>
</tr>
<tr>
<td>Mean</td>
<td>0.0230</td>
<td>0.0124</td>
<td>0.0058</td>
<td>0.0051</td>
<td>0.0041</td>
<td>0.0036</td>
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</tr>
<tr>
<td>Standard deviation</td>
<td>0.0737</td>
<td>0.0391</td>
<td>0.0282</td>
<td>0.0216</td>
<td>0.0166</td>
<td>0.0131</td>
<td>5.79</td>
</tr>
<tr>
<td>Minimum</td>
<td>-0.7536</td>
<td>-0.3486</td>
<td>-0.1821</td>
<td>-0.1543</td>
<td>-0.0971</td>
<td>-0.0800</td>
<td>-41.44</td>
</tr>
<tr>
<td>Median</td>
<td>0.0304</td>
<td>0.0156</td>
<td>0.0105</td>
<td>0.0086</td>
<td>0.0061</td>
<td>0.0043</td>
<td>2.74</td>
</tr>
<tr>
<td>Maximum</td>
<td>0.1946</td>
<td>0.1232</td>
<td>0.0857</td>
<td>0.0857</td>
<td>0.0554</td>
<td>0.0589</td>
<td>11.99</td>
</tr>
<tr>
<td>B. Slopes greater than or equal to 0.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of days</td>
<td>1,633</td>
<td>1,566</td>
<td>1,507</td>
<td>1,488</td>
<td>1,494</td>
<td>1,502</td>
<td>1,603</td>
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<tr>
<td>Percent of total days</td>
<td>80.8%</td>
<td>77.5%</td>
<td>74.6%</td>
<td>73.6%</td>
<td>73.9%</td>
<td>74.3%</td>
<td>79.3%</td>
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<tr>
<td>Mean</td>
<td>0.0465</td>
<td>0.0273</td>
<td>0.017</td>
<td>0.0139</td>
<td>0.0109</td>
<td>0.0088</td>
<td>2.32</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>0.0322</td>
<td>0.0201</td>
<td>0.0126</td>
<td>0.0115</td>
<td>0.0096</td>
<td>0.0087</td>
<td>2.32</td>
</tr>
<tr>
<td>Median</td>
<td>0.0393</td>
<td>0.0239</td>
<td>0.0143</td>
<td>0.0113</td>
<td>0.0091</td>
<td>0.0071</td>
<td>3.52</td>
</tr>
<tr>
<td>Maximum</td>
<td>0.1946</td>
<td>0.1232</td>
<td>0.0857</td>
<td>0.0857</td>
<td>0.0554</td>
<td>0.0589</td>
<td>11.99</td>
</tr>
<tr>
<td>Mean length of run</td>
<td>27.2</td>
<td>27.5</td>
<td>22.8</td>
<td>19.1</td>
<td>18.2</td>
<td>19.3</td>
<td>24.7</td>
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<tr>
<td>C. Slopes less than 0.</td>
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<tr>
<td>Number of days</td>
<td>388</td>
<td>455</td>
<td>514</td>
<td>533</td>
<td>527</td>
<td>519</td>
<td>418</td>
</tr>
<tr>
<td>Percent of total days</td>
<td>19.2%</td>
<td>22.5%</td>
<td>25.4%</td>
<td>26.4%</td>
<td>26.1%</td>
<td>25.7%</td>
<td>20.7%</td>
</tr>
<tr>
<td>Mean</td>
<td>-0.0759</td>
<td>-0.0387</td>
<td>-0.0269</td>
<td>-0.0193</td>
<td>-0.0153</td>
<td>-0.0116</td>
<td>-6.13</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>0.1087</td>
<td>0.0450</td>
<td>0.0349</td>
<td>0.0244</td>
<td>0.0168</td>
<td>0.0118</td>
<td>7.98</td>
</tr>
<tr>
<td>Minimum</td>
<td>-0.7536</td>
<td>-0.3486</td>
<td>-0.1821</td>
<td>-0.1543</td>
<td>-0.0971</td>
<td>-0.0800</td>
<td>-41.44</td>
</tr>
<tr>
<td>Median</td>
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<td>-0.0196</td>
<td>-0.0132</td>
<td>-0.0120</td>
<td>-0.0086</td>
<td>-0.0075</td>
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<tr>
<td>Mean length of run</td>
<td>6.6</td>
<td>8.0</td>
<td>7.8</td>
<td>6.8</td>
<td>6.5</td>
<td>6.7</td>
<td>6.5</td>
</tr>
</tbody>
</table>
Table 5: Summary of results from regressing VIX short-term total return (ST TR) and mid-term total return (MT TR) Futures Index returns on VIX returns and previous day’s term structure predicted return over the period December 20, 2005 through March 30, 2012. The regression specification is

\[ R_{FI,t} = \beta_0 + \beta_1 R_{VIX,t} + \beta_2 R_{slope,t-1} + \varepsilon_t. \]

<table>
<thead>
<tr>
<th></th>
<th>No. of Index obs.</th>
<th>Adj R²</th>
<th>( \beta_0 )</th>
<th>t(( \beta_0 ))</th>
<th>( \beta_1 )</th>
<th>t(( \beta_1 ))</th>
<th>( \beta_2 )</th>
<th>t(( \beta_2 ))</th>
</tr>
</thead>
<tbody>
<tr>
<td>ST TR</td>
<td>1,580</td>
<td>0.7919</td>
<td>0.0006</td>
<td>1.18</td>
<td>0.4629</td>
<td>77.01</td>
<td>2.1489</td>
<td>12.61</td>
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<tr>
<td>MT TR</td>
<td>1,580</td>
<td>0.6468</td>
<td>0.0001</td>
<td>0.33</td>
<td>0.2200</td>
<td>53.76</td>
<td>2.4911</td>
<td>5.31</td>
</tr>
</tbody>
</table>
Figure 1: History of daily VIX levels from January 1986 through March 30, 2012 and related geopolitical and market events.

- October 1987: Stock market crash
- August 1990: Iraq invades Kuwait
- January 1991: US begins military action in Iraq
- September 2001: Terrorists attack World Trade Center
- October 2008: Credit market collapse
- October 2008: S&P downgrades US credit rating
- September 2001: Terrorists attack World Trade Center
- April 2011: S&P downgrades US credit rating

Key Dates:
- 1/2/1986
- 6/25/1991
- 12/15/1996
- 6/7/2002
Figure 2: Average daily trading volume by month for VIX futures and option contracts during the period March 26, 2006 through March 30, 2012. Futures volume is multiplied by a factor of 10 to account for the difference in the contract denomination of the futures (1,000 times index level) and the options (100 times index level). Phase 1 begins on March 26, 2004, when VIX futures were launched. Phase 2 begins on February 24, 2006, when VIX options were launched. Phase 3 begins on January 29, 2009, the launch date of the first VIX ETPs.
Figure 3: Average daily trading volume by month for VIX call and put option contracts during the period February 24, 2006 through March 30, 2012.
Figure 4: VIX returns series during the period December 20, 2005 through March 30, 2012. ST TR and MR TR are the VIX short-term and mid-term total return futures indexes, 2(ST ER) is a futures index that represents two times the VIX short-term excess return index, and –1(ST ER) is a futures index that represents minus one times the VIX short-term excess return index. VIX is the CBOE Market Volatility Index. All series are scaled to 100 on December 20, 2005. Vertical bar is at January 29, 2009, the launch date of VIX ETPs.
Figure 5: VIX futures price curve on March 14, 2012. Price on vertical axis (where days to expiration is 0) is VIX cash index level. Prices at longer maturities are the settlement prices of VIX futures contracts.
Figure 6: Level of VIX and volatility spread during the period March 26, 2004 through March 30, 2012. Spread is defined as the difference between the 150-day VIX futures price and the cash VIX level. Dark horizontal bar is at 0. Dark vertical bar is launch date of the first VIX ETPs, January 29, 2009.
Figure 7: Daily share price and daily shares outstanding of VXX since product inception on January 29, 2009 through March 30, 2012. Source: Bloomberg.
Figure 8: Total market value and cumulative gains of direct and inverse ETPs benchmarked to VIX short-term futures indexes during the period December 20, 2005 through March 30, 2012.