Trading the VIX Futures Roll Using Exchange-Traded Funds

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Futures based on the volatility index (VIX) have become very popular since their introduction in 2004. The desire for individual investors to trade the level of the volatility index has led to the introduction of volatility exchange-traded funds (ETFs) and exchange-traded notes (ETNs). Much like VIX futures, trading in VIX-related exchange-traded products (ETPs) has also become much more common in recent years. According to the *Wall Street Journal*, VIX-related exchange-traded products reached an unprecedented level of trading in August 2017 (see Dieterich [2017] and MacKintosh [2017]).

VIX-related products have been shown to be a useful tool for portfolio management. Moran and Dash [2007] demonstrate that VIX call options and futures can be used to hedge a portfolio, reducing overall risk without a significant loss in return. Szado [2009] examines the results of employing VIX-related products during the financial crisis and concludes that they provide protection during market downturns. Additionally, several studies discuss the tendency for VIX futures contracts to trade in contango. Whaley [2013] shows that the VIX futures price curve was mostly upward sloping between 2004 and 2012. Zhang, Shu, and Brenner [2010] show that VIX futures prices are upward sloping on 67.6% of trading days between 2004 and 2009. Huskaj and Nossman [2013] and Luo and Zhang [2012] also analyze the term structure of VIX futures. Additional studies on the characteristics of VIX futures include Zhang and Zhu [2006], Fu et al. [2016], Bollen et al. [2017], and Barnea and Hogan [2012]. Jones and Allen [2015] investigate the volatility of the premiums and discounts in the VIX futures prices and also conclude that the futures contracts trade in contango most of the time.

Other studies have suggested trading strategies to exploit this tendency; Simon and Campasano [2014], for example, develop a trading strategy using VIX futures and S&P 500 mini futures alternatively based on the level of contango or backwardation. Simon [2017] successfully uses option-trading strategies that exploit the tendency for VIX futures to rise when the curve is in backwardation and fall when the curve is in contango.

Literature examining the ETF and ETN markets includes Whaley [2013], which examines eight ETFs and ETNs. The study finds that the funds closely track the performance of their respective benchmarks. However, the use of volatility-based ETFs or ETNs as part of a buy-and-hold strategy is not a good investment over the long run, a fact also illustrated by Liu and Dash [2012]. Additionally, Clowers and Jones [2016] demonstrate that the performance of VIX-based ETFs and ETNs do not correlate well with the VIX itself.

EXHIBIT 1
Descriptions of the Sample ETFs

Name	Ticker	Investment Goal	Inception	Average Daily Volume	Return Since Inception
ProShares VIX Short-Term Futures	VIXY	Return on the VIX	January 4, 2011	1,548,757	–98.90%
ProShares Ultra VIX Short-Term Futures	UVXY	Two times the Return on the VIX	October 3, 2011	17,799,640	–100.00%
ProShares VIX Mid-Term Futures	VIXM	Return on the VIX Mid-Term futures Index	January 3, 2011	53,627	–84.40%
ProShares Short VIX Short-Term Futures	SVXY	Inverse Return on the VIX	October 3, 2011	2,325,017	764.80%

Note: Average daily volume and returns are from inception until December 30, 2016.

More recently, Petajisto [2017] examines the pricing of a large cross-section of ETFs and ETNs and finds that their prices frequently trade above or below net asset value (NAV). Volatility ETFs, in particular, have a low average premium relative to NAV, but the volatility of the premium is relatively high.

This article expands upon results from previous studies, particularly Whaley [2013], to develop a trading strategy based on ETFs in the volatility market. Specifically, individual investors could exploit the tendency of VIX futures contracts to trade in contango by using VIX ETFs. The ETF strategy significantly beats the market and has lower risk-adjusted returns as measured by the Sharpe ratio. The same strategy employed using VIX futures results in a similar performance as the ETF strategy.

DATA AND METHODOLOGY

We collect daily levels of the VIX and VIX futures from the Chicago Board Options Exchange (CBOE) website and the S&P 500 Index from the Center for Research in Security Prices (CRSP) from January 2007 to December 2016. The data result in 2,518 observations over the 10-year period. From these data, a comparison is made of prices of the nearest contract to those of the next, second next, third next, and fourth next contracts on each day.

In addition to the data on VIX futures, we examine several ETNs and ETFs that were established to match the performance of the VIX. Since investors cannot trade the VIX directly, these funds use VIX futures to gain exposure to the index, and more importantly, are accessible to individual investors. Long, short, and levered versions of the funds exist. A search of the Morningstar Direct Database indicates a total of 21 ETFs and ETNs categorized as volatility funds. Of these, 14 are ETNs and 7 are ETFs. We do not consider the ETNs for two reasons: because they are not listed on CRSP and because of the possible credit risk associated with the funds.[1] Furthermore, the analysis does not consider two of the ETFs, as one began trading too recently to be included and another uses the VIX as only a small part of the fund strategy. The remaining four ETFs have been trading for more than five years, have returns based completely on VIX futures, and are the focus of the forthcoming analysis.

For the ETFs in the sample, we collect prices from CRSP from the inception of the fund to December 30, 2016. Exhibit 1 summarizes these four ETFs. The ProShares VIX Short-Term Futures ETF (Ticker: VIXY) maintains long positions in the first and second month futures with a weighted average of one month to expiration. The ProShares Ultra VIX Short-Term Futures ETF (Ticker: UVXY) seeks to match the return of two times the performance of the VIX. Similar to the VIXY, it does this by holding long positions in the first and second month VIX futures contracts with a weighted average of one month to expiration. The ProShares Mid-Term VIX Futures ETF (Ticker: VIXM) maintains a long position in VIX futures contracts with a weighted average of five months to expiration. The ProShares Short VIX Short-Term Futures ETF (Ticker: SVXY) seeks to match the inverse return of the performance of the VIX. It does this by holding short positions in the first and second month VIX futures contracts with a weighted average of one month to expiration.

For this study, the focus is on developing a trading strategy using the VIXY ETF and SVXY ETF in order to compare the performance to a similar strategy using the VIX futures. Both of these funds are liquid based on average daily volume. We select these two ETFs because we can directly compare a long or short trading strategy using VIX futures. The analysis begins by examining the trading characteristics of the funds.

THE PERFORMANCE OF VOLATILITY ETFs

This section of the analysis includes two main goals. First, we show the overall performance of the sample ETFs in order to give a better picture of the VIX-related ETF market. Second, we demonstrate the link between the performances of the various funds with the cost of rolling into the following futures contract. This link is essential to formulating the trading strategy in the following sections.

As shown in Exhibit 1, the returns on these funds are striking. The VIXY and UVXY have lost 98.9% and 100% of their value, respectively, while the VIXM has lost 88.3% of its value since inception.[2] Because of the need to roll to the next futures contract each month and the tendency for the futures contracts to trade in contango, a long position in the VIX futures contract systematically loses money over a long period. This is consistent with Whaley [2013]. Each of the four ETFs listed in Exhibit 1 faces roll costs daily, as the funds maintain its respective targeted weighted average for time to expiration of its holdings.

Using data on the VIX futures contracts, we replicate the trading strategies used by the ETFs based on the trading levels of the nearest and next futures contracts. To compute the cost or benefit of rolling the futures contract, we assume that the fund moves from the nearest to the next contract on the closest trading date to the 10th of the month.[3] For each ETF, we estimate the value based on the monthly roll costs and then compare the adjusted closing prices of the ETFs. The analysis uses adjusted values to account for any splits or reverse splits during the period. For example, for the UVXY, the adjusted starting price for the ETF is 1,262,399. This is due to six reverse splits since inception (1:6, 1:10, 1:10, 1:4, 1:5, and 1:5), which results in a cumulative adjustment factor of 60,000.

Exhibit 2, Panel A, shows the performance of a long position of the VIXY as well the amount of the performance that comes from the roll of the futures contracts. Other than the upward spike in late 2011, the exhibit demonstrates that the adjusted close value of the VIXY closely follows the estimated values generated using the additional costs of rolling from one futures contract to the next on a monthly basis. As a result, we can state that the loss of value in the VIXY is nearly all due to the higher costs of the following month futures contract. Exhibit 2, Panel A, also underscores the importance of the ProShares message about the risks of holding shares of their volatility ETFs for anything other than short term, as the long-term long position tends to lose value over time.[4]

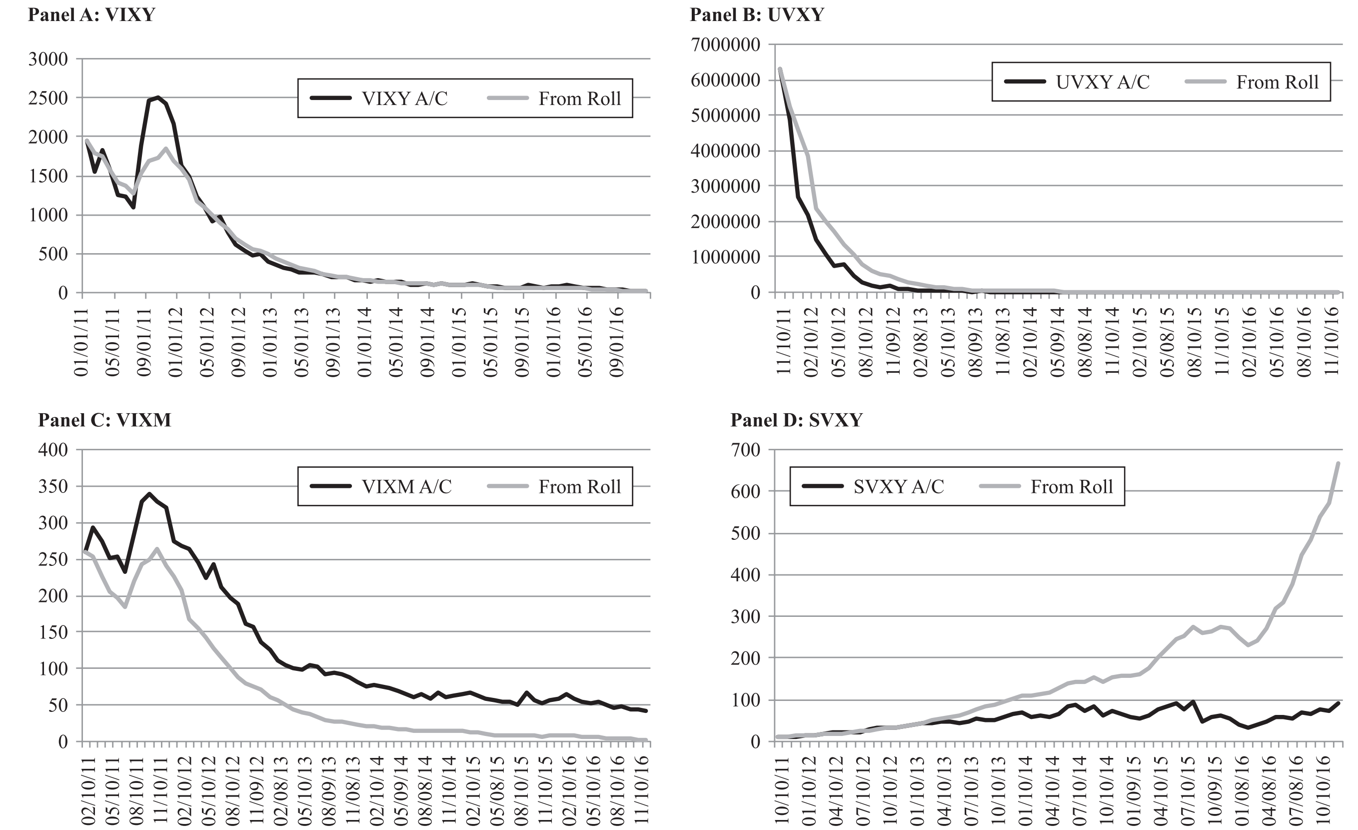
For the VIXY, there is considerable similarity between the monthly cost of rolling into the next futures contract and the percentage change in the adjusted close of the ETF.

Over the sample period, the average cost of rolling from the current futures contract to the following one is 6.16%. The average decline in the adjusted closing value of the VIXY over the sample is 6.34%. However, the volatility of these two curves is very different—the cost of rolling the futures contract has a standard deviation of 0.0682, while the adjusted closing values of the VIXY have a standard deviation of 0.1667. We interpret this as further evidence that immediate market fluctuations influence the shorter-term values of the ETF, but over longer periods, the costs of rolling into the next futures contract are responsible for nearly all reductions in value. This is consistent with Jones and Allen [2015] who analyze the premiums and discounts embedded in VIX futures prices.

We perform a similar comparison of adjusted closing prices and estimates of the costs of rolling futures contracts monthly for the UVXY from its inception. Exhibit 2, Panel B, presents those results. The similarities in the trends over the sample period is very similar to that of the VIXY, though there appears to be a small lag in the curve estimated using the costs from rolling from one contract to the next. This occurs mostly because of the large decrease in the adjusted close of the UVXY (59.5%) versus a smaller difference in the cost of rolling

EXHIBIT 2

ETF-Adjusted Close (A/C) and Estimates from Roll Costs



Notes: These figures compare the performance of each ETF to the estimated performance from rolling to the appropriate futures contract. The starting price is adjusted for reverse splits, where necessary. The return attributed to roll is computed by assuming the VIX futures contracts are rolled monthly based on the strategy of the ETF.

to the next futures contract (11.6%). After that point, the two curves are very similar in their trend. As one might expect from the nature of the ETF, the monthly return is much more volatile than the estimates generated by the rolling of the futures contracts. The average change in the monthly-adjusted closing of the UVXY is −19.4% with a standard deviation of 29.0%. The average increase in the cost of rolling to the following futures contract is 14.3% with a standard deviation of 11.4%.[5]

Panel B of Exhibit 2 demonstrates the higher volatility of the monthly changes in the adjusted closing prices when compared to the cost of rolling into the next futures contract. In nearly two-thirds of the sample months (38 of 61), the negative change in the adjusted close price exceeded that of the cost of rolling into the next futures contract. As with the VIXY, the immediate market fluctuations have a pronounced effect on the adjusted closing price, and the nature of the ETF magnifies these effects in the case of the UVXY. However, over the longer period of the sample, the cost of rolling into the next futures contract is responsible for much of the change in value.

The mid-term volatility ETF, the VIXM, behaves slightly differently than the VIXY or UVXY, as the fund holds futures contracts for several months out. Hence, for the VIXM, rolling into the next futures contract entails rolling from a futures contract that expires in three months to one that expires in six. A quick survey of the futures contracts shows that these contracts are much closer in price than the price difference between the near and next month's futures contract. Therefore, the expectation is that the cost of rolling into the following month futures contract for the VIXM would be less than that of the VIXY. Additionally, the fund rolls into the following futures contract at a slower rate than that of the VIXY or UVXY.

Exhibit 2, Panel C, presents the adjusted closing price and the estimated cost of rolling into the following futures contract. As expected, the estimated costs of rolling into the following futures contract follow a much smoother path than that of the adjusted closing costs, and the month-to-month changes are much smaller for both curves. The average monthly changes are very similar: 2.60% for the adjusted closing price and 2.50% for the estimated cost of rolling into the following futures contract. However, as with the VIXY and UVXY, the standard deviation of the monthly change is much higher for the adjusted closing price (8.27%) than the cost of rolling into the following futures contract (1.40%).

The average difference between the monthly change in the adjusted closing price and the cost of rolling the futures contract is smaller for the VIXM than any of the other ETFs. For the VIXM, there is an average of a 5.86% difference between the monthly change in closing price and the estimated cost of rolling into the next contract, as compared to an average 9.08% difference for the VIXY and an average 17.2% difference for the UVXY. This confirms the expectation that, for longer-term analysis, the cost of rolling into the following futures contract estimates the changes in the value of the ETF very well, as market fluctuations have less of an impact on the value of ETFs with longer horizons.

The SVXY behaves considerably differently than the VIXY, UVXY, and VIXM. The overall trend of the adjusted closing price is similar to that of the estimated *increase* in value caused by rolling into the next futures contract as the ETF's holdings are short the futures contracts. Exhibit 2, Panel D, presents these values, graphed since the inception of the ETF. The estimated value of the ETF based on rolling to the next futures contract overstates the actual adjusted gain in the value of the ETF, and over time, the two continue to diverge. The cumulative effect of the difference in the estimated change and the actual change in the value of the ETF causes this divergence.

For the SVXY, the adjusted closing price changes by an average of 3.23% per month. For the estimated changes based on rolling the futures contract to the next month, the average monthly change is 6.93%.

EXHIBIT 3

Description of the Relative VIX Futures Pricing: January 2007–December 2016

	Nearest	Next	2nd Next	3rd Next	4th next
Percentage Spread from VIX spot rate					
Average	0.04	0.05	0.09	0.11	0.14
Maximum	0.29	0.34	0.48	0.59	0.66
Minimum	–0.38	–0.33	–0.44	–0.46	–0.46
St. Dev.	0.07	0.07	0.11	0.14	0.16
n	2518	2518	2518	2518	2518
Days in Contango					
Total	1907	2023	2028	2032	2036
Average	9.49	22.99	28.97	32.25	35.72
Maximum	66	178	280	277	291
Minimum	1	1	1	1	1
Days in Backwardation					
Total	604	482	483	483	480
Average	3.02	5.81	7.32	8.19	8.57
Maximum	68	63	142	144	144
Minimum	1	1	1	1	1

Notes: Days in contango (backwardation) measures the number of days that a particular contract is priced above (below) the spot VIX level. Also reported are the average, maximum, and minimum of the number of consecutive days that the particular contract is in contango or backwardated. Percentage spread is calculated as the difference between the futures price and the spot VIX level divided by the spot VIX level.

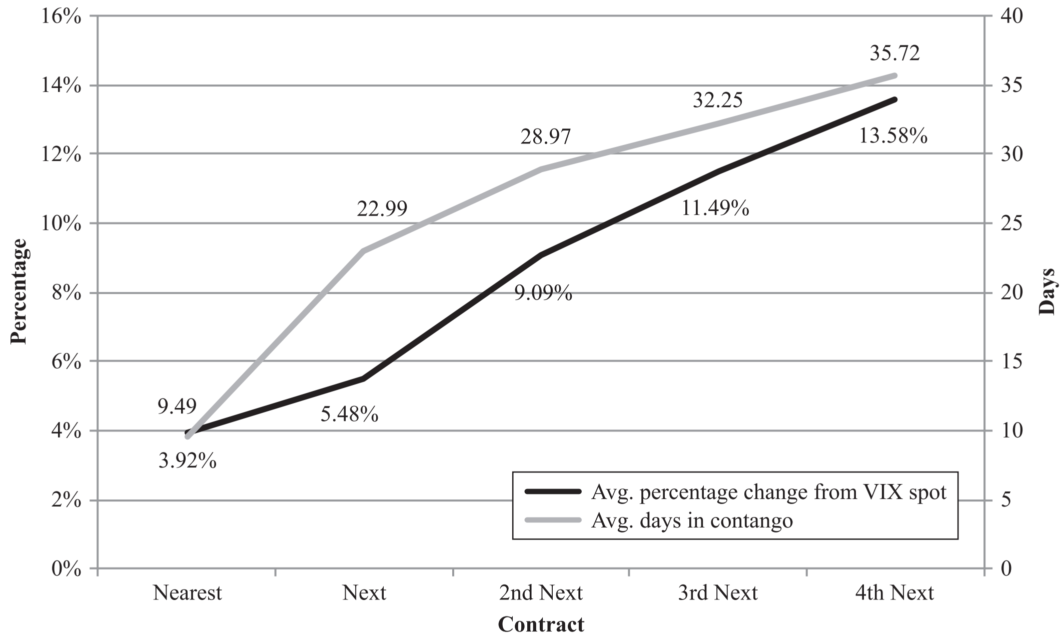
This discrepancy between the average changes illustrates the reason for the divergence over time. Market fluctuations actually mitigate the gains implied from rolling to the next futures contract.[6] The monthly changes, much like the other ETFs considered, are more volatile than the estimates from the rolling of the futures contracts, as evidenced by the 16.5% standard deviation compared to 5.90%, respectively. However, because the long-term average is positive, there are potential gains from holding SVXY over time.

MARKET TRADING STRATEGIES

Over the 10-year sample period, the VIX futures market is primarily in contango. Exhibit 3 describes the relationship between the VIX and the nearest, next, second next, third next and fourth next futures contracts. We divide the sample by the number of days the contract is in contango or backwardation. Clearly, the futures contract is in contango over most of the period. This is true for the nearest contract in a ratio of more

EXHIBIT 4

Average Percentage Change from VIX Spot Rate and Days in Contango



than 3:1 (1907:604) and for the next contract of more than 4:1 (2023:482).

In addition, the nearest contract stays in contango an average of 9.49 days compared to 3.02 days in backwardation. The average percentage spread to the nearest contact is 0.04 with a maximum of 0.29 and a minimum of −0.38. Over the sample period, the developed trading strategy shows bias toward going short in the VIX futures contract due to the tendency for the market to be in contango. Exhibit 4 illustrates the upward-sloping tendency of the VIX futures contracts compared to the VIX spot rate.

We modify the strategy introduced by Simon and Campasano [2014] to formulate trading rules within the ETF market. Whereas Simon and Campasano [2014] use a trading strategy based on VIX and mini-S&P 500 futures positions, the trading strategy presented here uses VIX ETFs in a way that individual investors could potentially employ. Similar to Simon and Campasano [2014] and Simon [2017], we measure the daily roll in VIX futures points, defined as the spread between the VIX and the nearest futures contract divided by the number of trading days to settlement.

The development of a trading strategy begins with an examination of a test period based on the period from January 4, 2007, to December 31, 2010. Using daily futures prices on the nearest contract, we form an ex post optimal trading strategy based on alternative long and short positions on the VIX futures contract. We use alternative decision rules on the level of contango or backwardation to maximize the return during this test period. The optimum strategy consists of selling the VIX futures contract when the daily roll reaches +0.0197 VIX futures points. If the VIX futures market is in backwardation and the daily roll reaches −0.240 futures points, the investor takes a long position in VIX futures. If the daily roll enters the range below +0.0197 futures points and above −0.240 futures points, the investor holds a cash position until the spread reaches one of the thresholds. Hence, the relative levels of the VIX and the nearest futures contract at the end of the day before the execution of the trade is the main driver of the trade decision.

Exhibit 5 shows the results of the optimal trading strategy during the test period.

The results are significant for the optimal strategy. The strategy results in an increase of the initial investment from $1.00 to $7.13, and represents a compound annual growth rate of 63.46% over the four-year test period.

Exhibit 5
VIX Futures Trading Strategy Test Period

Notes: Result of $1 initial investment; Maximum performance during test period: January 4, 2007–December 31, 2010.

Next, we use the information from the test period to conduct a trading strategy based on VIX ETFs and VIX futures. For VIX ETFs, we use the SVXY and VIXY, as these two ETFs represent a short (SVXY) and long (VIXY) position in the VIX without leverage. The sample begins on October 4, 2011, the first day SVXY began trading, and continues through December 30, 2016. The investor takes a short position by buying the SVXY if the VIX futures point measure reaches the optimal level of +0.0197 from the test period. Alternatively, the investor takes a long position by buying the VIXY if the VIX futures point measure reaches −0.240. We assume that the investor makes all decisions based on the information from the previous day's close.

For comparison, we also consider using the same decision rules in a separate strategy that entails buying or selling the VIX futures using the same thresholds. Finally, we also include a buy-and-hold strategy on a long position in the S&P 500 ETF. In this manner, a comparison can be made of two ETF strategies that individual investors can easily employ to a VIX futures strategy available to institutional investors.

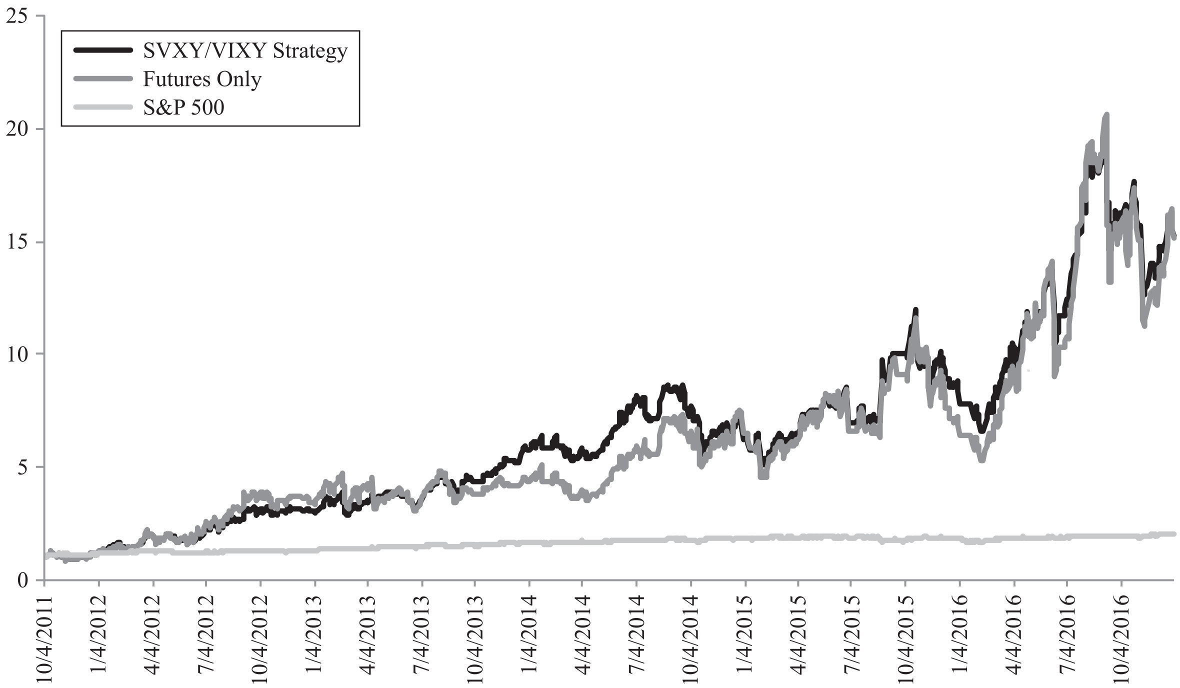
The VIX ETF strategy results in an increase of the initial investment from $1.00 to $15.23, and represents a compound annual growth rate of 68.10%. The VIX futures strategy results in a similar increase in value to $15.18 or a compound annual growth rate of 67.99%. Over the same period, an initial $1.00 investment in the S&P 500 ETF increases to $1.99. This represents a compound annual growth rate of 14.04%. Exhibit 6 shows these results.

Exhibit 7 presents a comparison of the return results. While the returns are much higher for both VIX strategies, the volatility is also considerably higher than that of the buy-and-hold S&P 500 strategy. The daily returns for the ETF strategy range from −19.120% to 17.878% with a standard deviation of 3.285%. The daily returns on the VIX futures strategy are more volatile, with returns ranging from −30.980% to 26.256% with a standard deviation of 4.298%.

The S&P 500 strategy has daily returns ranging from −3.941% to 4.332% with a standard deviation of 0.866%. While the Sharpe ratio is highest for the VIX ETF strategy at 7.95%, the Sortino ratio is highest for

EXHIBIT 6

Trading Strategy Results Using VIX ETF and Futures; Long Position in S&P 500 ETF



Notes: Estimates are of $1.00 invested using the developed trading strategy with VIX ETFs and futures, or a long position in the S&P 500 ETF, October 4, 2011–December 30, 2016.

the S&P 500 buy-and-hold strategy at 9.00%. This is because the semi-standard deviation of the VIX ETF and VIX futures strategies, 2.950% and 3.946%, respectively, are much higher than that of the S&P 500 strategy, 0.866%. The lower Sortino ratio indicates that excess returns on the two VIX strategies come at the burden of considerable excess risk on the downside.

CONCLUSIONS

We develop a trading strategy based on ETFs in the volatility market with significant results. Although the use of VIX-related strategies is risky, individual investors are active in these markets. Further, individual investors can use the trading strategy developed here to exploit the tendency of the VIX futures contract to trade in contango. We compare this strategy to two other strategies: a similar strategy that uses VIX futures and a simple buy-and-hold strategy in the S&P 500 ETF. Individual investors can easily employ both of the ETF strategies.

Initially, the analysis demonstrates that the performance of VIX ETFs relates directly to the costs of rolling into the following futures contract. We use this fact, combined with the tendency of the VIX futures market to trade in contango, to develop a trading strategy available to individual investors. Over a 10-year period, the VIX futures market is in contango more than 75% of the time. To exploit this tendency, we develop an ex post trading strategy over a test period of January 2007 to December 2010. Based on the results, we construct an ex ante trading strategy and test it from the first trading date of the short VIX ETF (SVXY), October 4, 2011, to December 30, 2016.

The results indicate that using both the VIX ETF strategy and the VIX futures strategy provides significant excess returns. The volatility of the returns is highest for the VIX futures strategy. Based on Sortino ratios, the buy-and-hold S&P 500 ETF strategy is a better risk-adjusted strategy than the VIX-based strategies.

EXHIBIT 7
Summary of Trading Strategy Results

	ETF Strategy	Futures Strategy	S&P 500
Terminal Value	15.234	15.183	1.992
Compound Annual Return	68.10%	67.99%	14.04%
Avg Return	0.26%	0.30%	0.06%
	(2.197)**	(2.035)**	
Median Return	0.00%	0.00%	0.04%
Max Return	17.88%	26.26%	4.33%
Min Return	–19.12%	–30.98%	–3.94%
Variance	0.11%	0.18%	0.01%
	(14.404)***	(24.656)***	
St. Dev.	0.033	0.043	0.009
Semi-St. Dev.	0.030	0.039	0.006
Sharpe ratio	0.079	0.070	0.064
Sortino ratio	0.088	0.076	0.090
Number of Trades	186	186	1
Days Long	1048	1048	1319
Days Short	26	26	0
Days in Market	1074	1074	1319

*Notes: Terminal value represents the value on December 30, 2016, of $1.00 invested in each of the strategies on October 4, 2011. Semi-standard deviations are computed on negative returns only. Sharpe ratio is computed as average daily excess returns divided by standard deviation of daily returns. Sortino ratio is computed as average daily excess returns divided by semi-standard deviation of daily returns. Number of trades is the total number of times the strategy is switched between long and short. Test statistics are in parenthesis; ** and *** represent significance at the 5.00% and 1.00% level, respectively.*

ENDNOTES

[1]The credit risk associated with ETNs is a function of the issuer's credit rating, as any ETN is an unsecured debt obligation of the particular issuer. Because this varies by issuer and such credit risk is inherent in all ETNs, the analysis will focus on volatility ETFs, whose values are derived from the assets held by the funds and are not influenced by such credit risks.

[2]The three funds with long positions in the VIX futures must periodically reverse split their shares in order to maintain a trading range. This leads to large losses in a prolonged bull market.

[3]We choose the 10th of the month (or closest trading date) because trading in the nearest contract will still be liquid.

[4]"The funds are intended for short-term use. When holding the funds beyond short-term periods (even periods as short as one day), investors risk potentially losing a substantial portion of their investment. The longer the holding period, the greater the potential for loss" (http://www.proshares.com/vix_futures_etfs/).

[5]Note that the average monthly cost of rolling into the next futures contract for the UVXY is twice that of the VIXY. However, the analysis presented here for the VIXY and UVXY differs in the range of dates considered.

[6]Fees and expenses would potentially also play a role here, though the difference is still greater than the approximate 1.2% expense.

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