Tracking the VIX index

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Abstract

Volatility has emerged as an important distinct asset class over the past decade. The popularity of volatility stems from its unique properties, namely its negative correlation with equity returns and its usefulness as insurance against tail risk. Trading applications of volatility-related securities and financial instruments involve among others short-term trading in order to exploit shifts in volatility (realized, implied or expected implied volatility), hedging an equity exposure and modifying the risk of an asset allocation mix.

This paper examines the tracking performance of VIX futures and seven popular volatility Exchange Traded Products (ETPs) on the spot VIX index. The empirical findings suggest limited tracking ability of all the products under review as the magnitude of the respective tracking errors is significant. Therefore, even though there is a plethora of volatility products nowadays, there is still potential room for additional VIX ETP offerings that would attempt to track spot VIX following either a physical or a synthetic replication method.

Keywords: Exchange Traded Funds; tracking ability; volatility; VIX index; VIX futures
JEL Classification Codes: G19, G23

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INTRODUCTION

The main goal of this study is to investigate the spot VIX tracking efficiency of tradable volatility-based products, such as VIX futures and Exchange Traded Products (ETPs) based on VIX futures indices. Features examined include correlations, betas and tracking errors to the spot VIX index. The empirical findings suggest s limited tracking ability of all the products under review.

The particular study takes an unconventional path as it examines how well a typical VIX ETP tracks the actual spot VIX index and not its benchmark index. The rationale for performing the computations on the spot VIX returns, rather than the VIX futures index returns, is twofold. First, the underlying VIX futures indices – and correspondingly the ETPs that track the particular indices – are designed to produce daily returns more correlated to the VIX index than a simple or more complex position in the VIX futures contracts. Therefore, this study investigates if these products are indeed successful in their stated objective, which is to offer exposure to volatility (as measured by the VIX). Second, a key misconception among many investors exists concerning the relationship between VIX and the respective VIX-related products. Such products are increasingly provided nowadays, but it is questionable if investors fully understand their characteristics and applications. Alexander and Korovilas (2012) show that a single position on VIX futures, or on their respective ETPs, offers no diversification benefits, except during the onset of a major crisis. In short, they conclude that these types of financial instruments should be used by investors solely for speculation purposes. Thus, the current study focuses solely on the effectiveness of these products as short-term volatility directional bets.

Investors may need volatility exposure for diversifying equity risk, hedging an existing short volatility exposure, or for speculation. Traditional volatility investing for many decades involved trading options and over-the-counter variance swaps. But in recent years, volatility-related future contracts and Exchange Traded Products (ETPs) have emerged providing investors with accessible tools to gain exposure to volatility. An important caveat when investing in volatility ETPs is that these securities do not provide direct exposure to a volatility index such as the well-known VIX. In fact, VIX index simply corresponds to information extracted from option prices, while other financial

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indices, such as equity and bond indices, correspond to actual portfolios of assets. Therefore, volatility indices, as VIX, are not directly investable and that's the reason that VIX-related ETPs track benchmark indices which correspond to a systematic VIX futures investment strategy. These futures-based strategies do not necessarily track the performance of the spot VIX index since, among other issues, investors demand a premium for holding a short volatility position and thus maintaining a long position in VIX futures is costly (Goltz and Stoyanov, 2013).

The relevant literature can be broadly categorized into two strands: the first one relates with reviewing how volatility-related products function and what their trading characteristics and potential risks are (indicatively Alexander and Korovilas, 2013 and Liu and Dash, 2012). The second strand includes studies that investigate the diversification benefits of these products. Early academic attempts use variance swaps and spot VIX as instruments for diversification, while the proliferation of VIX-based products is analogous to the relevant academic research that studies their characteristics and benefits. The empirical evidence relating to VIX futures and volatility ETPs as effective instruments for diversification is abundant and according to Hancock (2013) can generally be categorized into three threads of interest; the first one relates to the notion that adding volatility as an asset class[1] results into higher-risk adjusted returns. Several scholars have examined the diversification benefits of VIX assets. In particular, Daigler and Rossi (2006) demonstrate, using a Markowitz portfolio framework, that adding volatility to an S&P 500 stock portfolio substantially reduces risk without significantly affecting return. Moran and Dash (2007) confirm similar diversification benefits, while Szado (2009) evaluates the performance of adding a VIX-replicating portfolio to an existing stocks and bonds portfolio and finds a significant net reduction in aggregate risk. In a contrary note, Alexander and Korovilas (2012) provide irrefutable evidence that individual positions on ETPs that use direct VIX futures exposure of any maturity (including mid-term and longer-term products) can only provide a diversification effect during the first few months of extreme stress of similar magnitude to the 2008 credit crisis. Separately, Deng et al (2012) show that ETPs which track short-term VIX futures indices are not effective hedges for stock portfolios as they don't necessarily track the VIX

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

increases when large stock market losses occur (they attribute this to the negative roll yield accumulated by such futures-based products). Their findings also suggest that ETPs which track medium-term VIX futures indices suffer less from negative roll yield and therefore appear slightly better hedges for stock portfolios. A second strand of relevant research studies the optimal portfolio weights of volatility products when combined with equity. Indicatively, Dash and Moran (2005) use a standard mean-variance analysis and conclude that the optimal VIX allocation in efficient portfolios is less than 10%, while Daigler and Rossi (2006) weight volatility by using the previous year's optimal portfolio weights. The third thread of research deals with the appropriate holding period of volatility products. The relevant empirical findings suggest that holding VIX futures over a long time period is inefficient as the mean return will be zero (Rhodes, 2011).

A number of authors have studied the hedging advantages of VIX-related products, but the academic attempts testing the trading/ speculative effectiveness of these products is rather limited. Indicatively, Whaley (2013) evaluates VIX ETPs as a buy-and-hold investment. His findings show that VIX ETPs that track VIX short-term futures indices are virtually certain to lose money through time; in the six-year period that he examines, the VIX short-term total return futures index dropped in value by almost 94%. Based on his findings, he concludes that a significant proportion of VIX-related ETPs holders are "either irrational and/or unaware of how these products are structured and perform through time" (p. 106). Separately, Hill (2012) reports the extent of historical gains or losses in short-term and mid-term rolled VIX futures during the ten largest rises and falls (on both a daily and weekly basis) of spot VIX for the period May 2006 to December 2011 and shows the significant variations in the VIX futures response to the VIX sharp moves. These variations can be partly explained by the fact that investors factor in VIX futures prices an expected move in the VIX.

This paper extends the volatility-related literature by testing the tracking ability of both VIX-based ETPs and VIX futures on spot VIX. In particular the empirical analysis includes all major volatility-related exchange traded products and VIX futures and examines if these instruments are suitable for taking advantage of short-term volatility trends (daily, weekly and monthly tracking errors

are calculated). Whaley (2013) provides an appraisal of VIX ETPs as buy-and-hold investments, while this study provides an evaluation of both VIX ETPs and futures as short-term directional bets.

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

VOLATILITY TRADING

Why trade volatility

The motives for trading volatility include speculation, tactical tail-risk hedging and portfolio risk management. The mean reversion characteristic of volatility – the essence that both high and low prices are temporary and that they will tend to move to the average price over time – makes volatility more predictable than returns. Thus, someone may buy or sell depending on current level of VIX relative to its historical average. Many investors desire to speculate based on market and geopolitical news and data. Extremes levels of VIX coincide with significant market events and major world crises; an investor monitoring geopolitical events may want to speculate on the direction of short-term expected future realized volatility (Whaley, 2013). Investors are willing to pay a premium in order to reduce exposure to the volatility of the future returns of an asset (the Volatility Risk Premium); therefore, other investors may want to take the other side of the transaction and trade on the difference between VIX and the realized volatility of the S&P 500. Another more advanced speculative investment strategy may involve capitalizing on the changes of how the market prices implied volatility per se. Since the term structure of VIX futures prices offers a continuous view of market participants' view regarding the value of spot VIX at future points in time, many investors are trading VIX futures and ETPs in order to capitalize on the shifts in the market's price of implied volatility (Hill, 2012).

Volatility risk management strategies are even more widespread compared to speculative strategies. Volatility changes are negatively correlated with changes in equity prices. Since equity returns exhibit asymmetry, with a greater tail risk on the downside, investing in volatility may be positively skewed. VIX-related instruments are best utilized for diversification purposes and not as pure hedging vehicles. It is important to differentiate between the two; diversification involves decreasing portfolio risk (as measured by variance) by including assets that have low correlation to existing portfolio holdings, while hedging involves taking an offsetting position in an asset that is highly correlated with the existing portfolio, in order to minimize potential losses. Numerous recent papers support the advantages of investing in volatility as an equity diversifier vehicle[2], while for hedging the S&P500 exposure its own future contracts are most effective and have lower transaction costs than VIX related products (Alexander and Korovilas, 2012).

How to trade volatility

Since its introduction in 1993, the Chicago Board of Options Exchange's (CBOE's) Volatility Index (VIX) has evolved into a popular measure of investors' forecast of future volatility, as well as a gauge of "fear" in the stock market. Implied S&P500 volatility (as measured by VIX) exposure is tradable in many forms; through S&P500 options, over-the-counter variance swaps, VIX futures and options and ETPs based on VIX futures indexes. Different trading vehicles of implied volatility have very different return features because of their distinct characteristics. In this section, I attempt to differentiate among the diverse alternatives that investors have nowadays in order to achieve volatility exposure, focusing though on VIX futures and VIX-related ETPs.

VIX derivatives

In 2004, the CBOE Futures Exchange (CFE) launched futures contracts with VIX as the underlying asset, while the respective options were listed in the CBOE in 2006. Since their launch VIX futures have been actively promoted as having unique characteristics and advantages; in particular, they offer investors opportunities for speculation, diversification, vega hedging and arbitrage. VIX future

[2] See Alexander and Korovilas (2012) and the references cited therein.

contracts provide a better alternative for achieving volatility exposure compared to traditional delta-neutral combinations of options (such as straddles and strangles).

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

Futures and spot returns on the same underlying often deviate. This divergence is known as the futures roll yield and its cumulative impact can be quite significant, as in some instances it may even offset the entire investor's holding period return. Nevertheless, despite its importance in futures related products, there are noticeable misconceptions regarding its nature, measurement and impact. In the case of VIX futures market, the roll yield is the difference between the spot VIX and the respective futures price. Practitioners call it a yield because this difference results in a small amount being made or paid every day as the two prices (futures and the spot VIX) converge. The roll yield is positive when the VIX futures term structure is in contango and negative when it is in backwardation. The important question is if the spot VIX converges to the futures price or if the futures price converges to the spot VIX. For example, if the cash VIX index lies at 16% and the futures price is at 19%, every day as expiration approaches the two prices should converge. If we assume that the spot price will remain constant, then the futures price will drop gradually every day and thus an investor with a short position in the futures contract will gain a small amount every day. In the completely opposite scenario, the futures price will remain at the same level, while the spot price will gradually increase. In this case even though the roll yield still exists, the short position doesn't profit since the futures price stays at 19%. Of course in reality the most likely outcome will be something between the two extremes. The spot price rises while the futures price falls, in order to converge on each other

somewhere in the mid-range. If, for example, the cash VIX rises to 18% and the thus the futures price falls to the same level by expiration, the short futures position does not pocket the whole roll yield but only a part of it; the respective difference will be the volatility risk premium. It should be noted that even at the expiration date, VIX future prices do not converge exactly to VIX index due to the procedure that determines the settlement price of the futures contract[3].

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

Another trading alternative are VIX options, which have as an underlying the expected value of VIX at expiration, rather than the current VIX value, and thus, their price movements can be unrelated to the spot VIX index[4]. The inferiority of VIX futures and options in tracking the VIX index in the medium/ long term partially explains the popularity of VIX futures ETPs in the past few years. Exchange Traded Products (ETPs) have made volatility trading accessible to the investors without the need to access futures markets.

VIX Futures Index Series

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

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

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

Respectively, the S&P 500 VIX Medium-Term Futures Index Total Returns tracks the daily returns of a long position in a VIX futures contract with a maturity of approximately six months, by holding exposure to the fourth, fifth, sixth and seventh month VIX futures contracts. Every day the index rolls over from the fourth-month contract into the seventh-month contract, while keeping fixed the positions in the other two series (the fifth-month and sixth-month contracts). Both indices include interest accrual based on the 91-day US Treasury Bills rate (Deng et al, 2012). The respective VIX futures indices have a comparable correlation to the S&P 500 as the spot VIX has; Liu and Dash (2012) report correlations of the futures indices to the S&P 500 ranging from -76.59% to -79.17% and correlation of the spot VIX to the S&P 500 at approximately -75%. They also report that futures indices have a positive return 95% of the time the S&P 500 index has a loss greater than 1%.

Futures contract-based volatility indices have three separate sources of return: namely price, roll and collateral return. Price return arises from changes in the underlying future prices, while roll return arises from rolling long future positions forward through time. Roll return is usually negative for VIX related indices since the VIX futures term structure is almost always in contango[5]. The most plausible explanation of the contango dominance is the positive skewness observed in the distributions of both the VIX index and realized S&P500 volatility. The highest levels of both implied and realized volatility have been significantly higher that their average/ median values and since market participants cannot accurately predict when realized volatility will actually increase, they price VIX futures with longer expiration dates higher in order to price in the higher probability of a significant surge in volatility (Hill, 2012). Finally, collateral return assumes the notional value of the underlying are reinvested at the risk-free interest rate. This is equivalent to assuming an investor posts 100% margin with Treasury bills (Georgiev, 2001).

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

Volatility ETPs

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

Exchange-Traded Products (ETPs) are best defined as open-ended securities listed on a stock exchange, which aim to track the performance of an underlying asset. The term Exchange-Traded Products includes, among others, investment vehicles such as Exchange-Traded Funds (ETFs), Exchange-Traded Notes (ETNs) and US Grantor and other statutory trusts. ETFs are structured and regulated as mutual funds (or collective investment schemes) and are registered under the Investment Company Act of 1940. ETNs are generally senior, unsecured, unsubordinated debt listed on a stock exchange; they are not collateralized, thus ETN investors have full exposure to the issuer's credit risk. Finally, US Grantor and Statutory Trusts are frequently referred to as ETFs, but are not registered under the Investment Company Act of 1940. A Grantor trust usually holds physically a defined set of assets, whereas Statutory trusts and other partnership structures may open derivative positions and are recognized under federal law as Commodity Pools. Volatility related products are structured as ETNs and Commodity Pools (See Table 1).

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

VIX ETF on the market and hence I will concisely describe its portfolio construction as an indicative paradigm[6].

VXX tracks the performance of the first two front series of VIX futures. The actual dollar weight of each month held by VXX changes each day as iPath continuously rolls its portfolio in order to maintain a constant maturity weighted average futures maturity of one month. Summarizing the roll process as described comprehensively in iPath's VXX prospectus: at the beginning of the roll period all the weight is allocated to the first month contract, then on each subsequent business day a fraction of the first month VIX futures holding is sold and an equal notional amount of the second month VIX future contract is bought. This fraction is proportional to the number of first month VIX futures contracts as of the previous index roll day, and inversely proportional to the length of the current roll period (usually around 21 days). In this way the initial position in the first month contract is gradually rolled over to the second month contract, until the following roll period starts (when the old second month VIX futures contract becomes the new first month VIX futures contract). The roll process has a measurable effect on the price of the ETP (in this case VXX) depending on the shape of VIX futures term structure. When the term structure is in contango, at the end of each day iPath must sell a quantity of 1st month contracts and buy a respective quantity of 2nd month contracts at a higher price resulting in a negative roll yield for the fund. Conversely, when the term structure is in backwardation, at the end of each day iPath must sell the 1st month and buy the 2nd one at a lower value, resulting in a positive roll yield for the fund. The exact level of the roll yield depends first on the difference between and 1st and 2nd month series and second on the number of days in the roll period (more days result in a smaller roll yield).

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

[6] For a thorough description of the Volatility Exchange-Traded Products see Alexander and Korovilas (2013), Goltz and Stoyanov (2013) and Liu and Dash (2012).

magnified daily exposure to VIX-related indices as well. Exposure to the VIX is no longer just limited to the traditional sub-sets of long, inverse or leveraged Exchange traded products (see Table 2 for a graphical taxonomy of available volatility ETPs). For example, Citigroup calculates a volatility index that combines a daily rolling long exposure to the third- and fourth-month futures contracts on the VIX Index with a dynamic short exposure to the S&P 500 Total Return Index. This volatility index serves as a benchmark index for the C-Tracks ETN Citi Volatility Index Total Return (CVOL). Furthermore, two other large financial institutions have recently introduced products that attempt to exploit the nuances of volatility futures markets. In particular, UBS recently launched the E-TRACS Daily Long-Short VIX ETN (XVIX), a product that follows a strategy involving a 100% long position in the S&P 500 VIX Mid-Term Futures Index Excess Return with a short 50% position in the S&P 500 VIX Short-Term Futures Index Excess Return, with a daily rebalancing of the long/ short positions. Separately, Barclays bank introduced the iPath S&P 500 Dynamic VIX ETN (XVZ), which is also designed to invest on the S&P 500 VIX Short-Term Futures Index Excess Return and the S&P 500 VIX Mid-Term Futures Index Excess Return. The particular product follows a dynamic allocation strategy between the two indices by monitoring the steepness of the implied volatility curve. These two ETPs attempt to exploit potential inefficiencies in the VIX futures market, as they try to capture the risk premium of the near-term VIX futures contracts relative to the mid-term VIX contracts by holding a consistent long-short exposure ratio between the two series.

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

Volatility Hedged Large Cap ETF (SPXH) and the VelocityShares Tail Risk Hedged Large Cap ETF (TRSK) - which track proprietary indices that also offer exposure to the S&P500 combined with a dynamic volatility hedge.

According to Alexander and Korovilas (2013), the Exchange Traded Products (ETPs) that track constant-maturity VIX futures and trade on the New York Stock Exchange (NYSE) have some adverse features not shared by futures: first, they retain the credit risk of the issuer (which has been relatively high since the credit crisis); second, since the issuer of these products will only redeem the shares early in large lots, a small investor may be trapped into an illiquid investment; lastly, many of these products have a callable feature whereby the issuer can call back the shares at any time, with a short call notice period. On the other hand, ETPs have significantly lower fees and costs compared with other VIX related instruments (e.g. variance swaps).

VIX ETP PERFORMANCE

Data

Table 1 summarizes selected attributes of all seventeen volatility related ETPs in the U.S. as of September 1, 2014 (ranked by the Assets under Management). Data for VIX ETPs were gathered from ETF Data Base (i.e., http://etfdb.com/etfdb-category/volatility/) and Yahoo Finance. All of the ETPs listed in Table 1 are benchmarked to S&P 500 VIX futures indices. The difference between the total return and excess return index benchmarks is subtle, but important and it is explained in Whaley (2013). The only ETP that tracks a difference index (Citi Volatility Index Total Return) is the C-Tracks ETN Citi Volatility Index Total Return (CVOL). The particular table does not include hybrid products (which combine equity and volatility exposure) such as the PowerShares S&P 500 Downside Hedged Portfolio (PHDG) or the Barclays ETN S&P VEQTOR ETN (VQT). While the total number of ETPs related to the Chicago Board Options Exchange's Market Volatility Index (VIX) has increased significantly since 2009, when the first relevant products were launched, during the last couple of years their popularity – as expressed by the total number of offered products and their AuM

– has declined. For example, UBS ETRACS closed several VIX ETPs on September 12, 2012, while Barclays also redeemed a couple of VIX ETNs in 2011[7].

The first volatility products were offered by iPath on January 29th, 2009 (the iPath S&P 500 VIX Short-Term Futures ETN and the iPath S&P 500 VIX Mid-Term Futures ETN) and the most recent additions are the ProShares Ultra VIX Short-Term Futures ETF (UVXY) and the ProShares Short VIX Short-Term Futures ETF (SVXY) which were launched on October 4th, 2011. This study does not encompass inverse funds, which allow investors to profit from a decline in volatility, and leveraged funds, which allow investors to amplify the returns of the underlying volatility index. Furthermore, two ETPs were also excluded: the iPath S&P500 Dynamic VIX ETN (XVZ) since it was introduced in August 2011 and the VelocityShares VIX MT ETN (VIIZ) which had no substantial volume before May 2013. Therefore, the empirical study includes totally seven volatility related ETPs and the VIX futures.

The data set of the current analysis consists of the daily/ weekly/ monthly returns of the seven ETPs under review and the VIX futures and the daily/ weekly/ monthly returns of the cash CBOE Volatility index, the VIX. The particular frequencies are chosen because, according to Alexander and Korovilas (2012), the average holding time of a VIX futures contract has fallen, but still remains between one week and a month. The period under review is from January 5, 2011 until March 31, 2014. The ETPs returns are calculated based on the closing prices in the stock exchange, rather that the official daily Net Asset Value (NAV). All funds under review do not distribute any form of dividend/ income.

The futures returns are calculated based on the settlement prices of the nearest-to-deliver VIX futures contract. In order to calculate the daily futures returns, the timing of the rollover in the dataset is based on the trading volume and open interest of the respective contracts; when the second shorter maturity contract surpasses in terms of daily volume and open interest the first (shortest maturity contract) we rollover into the next contract. Regarding the weekly and monthly returns, we can

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

reasonable assume that an investor interested in opening a new position will choose the nearest to maturity contract that would not expire during the holding period (week or months), in order to avoid the rollover yield. For example, if an investor wants to have a one month exposure to VIX for example at the beginning of May 2012, she will open a position in the June 2012 contract and not in the May 2012 contract, which expires in between (so in that way there is no need to roll-over and thus the investor will avoid a potential roll yield).

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

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

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

Methodology

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

The simplest way to measure tracking error is to calculate the difference in returns between the fund/ product and the benchmark index at the end of a certain period. Nevertheless, since the objective of these volatility-related products is to provide exposure as accurately as possible to volatility as measured by the VIX, and not just match the value at the end of the holding period, this

would not be sufficient. Another method involves calculating and comparing the standard deviations of returns. According to Aber *et al* (2009), if an ETP tracks accurately an underlying index, they should also have equivalent standard deviations. Therefore, the hypothesis that the daily/ weekly/ monthly standard deviations of VIX and the respective ETP are equal is tested using an F-test.

In addition, the three most popular tracking error methodologies are followed in this study[8]. The first one involves calculating the standard deviation of the difference in returns between the ETP (and the futures contract) and the VIX index return ($e_{ETPt} = R_{ETPt} - R_{VIXt}$):

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

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

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

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

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

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

In theory, if the ETP mimics its benchmark exactly, the estimated intercept coefficient (α) should not be statistically different from zero and the estimated slope coefficient (β) should not to be statistically different from unity. If beta exceeds one, the ETP moves more aggressively with respect to the underlying index and if beta is smaller than one, the ETP exhibits lower riskiness. In practice, however the intercept should be less than zero due to trading costs and fees[9] and the slope estimate maybe different from one due to tracking error. Finally, the R-squared of the above specification

[8] See Frino and Gallagher (2001) for additional information.
[9] According to Whaley (2013) the intercept coefficient may also incorporate an interest component.

reflects the proportion of the variance of the VIX ETP's return that is explained by the VIX return and can be considered as an alternative tracking error measure.

Empirical Results

Descriptive Statistics

Table 3 includes the descriptive statistics of the seven ETPs under review, the VIX futures and the spot VIX index returns. All ETPs and VIX futures have negative mean returns in all frequencies. The most plausible explanation is the negative roll yield. Since the VIX futures term structure is usually in contango (i.e. the futures price curve slopes upward), at each rebalancing there is almost always a negative roll cost (usually small) created by selling the lower price shorter-term contract and buying the higher price longer-term contract. This minor daily roll-cost builds up to a highly negative long-run return for investors in VIX futures tracker ETPs.

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

In order to test the statistical significance of the standard deviation differences F-tests are conducted. The null hypothesis is that the standard deviation of the VIX index's returns and the ETP's returns are the same. The results are included in Table 4. The null hypothesis cannot be accepted at the five per cent significance level for all but one case (the C-Tracks ETN Citi Volatility Index TR) concerning daily and weekly returns. Regarding monthly returns, the tests provide a mixed picture regarding the volatility of the ETPs under review compared with VIX index; nevertheless, in no case

the volatility (as measured by the standard deviation of returns) of a VIX related instrument exceeds the volatility of the spot index.

As a preliminary analysis tool the correlation estimates of daily/ weekly/ monthly returns are calculated (Table 5). In general, almost all correlation coefficients are statistical significant at 99% confidence interval and decrease as the frequency of returns increases (from daily to monthly). Regarding daily returns, VIX futures exhibit a robust correlation of 90% with spot VIX and three ETPs that track the S&P 500 VIX Short-Term Futures Index (namely VXX, VIXY and VIIX) also have high correlations (slightly lower than 90%). Interestingly, VIX futures weekly and monthly returns are not correlated with the respective spot VIX returns. The three aforementioned ETPs also have the highest correlation with weekly and monthly VIX returns. Finally, the only ETP that exhibits a statistical significant negative correlation with spot VIX is the UBS E-TRACS Daily Long-Short VIX ETN (XVIX). This latter finding is consistent with Alexander and Korovilas (2013) who find that XVIX offers an almost uncorrelated exposure to VIX.

Tracking errors

Table 6 includes the three separate tracking error (TE) estimates and their average for each product. All tracking errors (for all products under review and under all methodologies) are statistically different from zero at the 1% level. The first method (TE_1) – which estimates the tracking error as the standard deviation of the return differences – results in the highest errors for all funds, while the third one (TE_3) – which estimates the tracking error as the standard errors of the returns regression (4) – yields the lowest estimates. According to Pope and Yadav (1994), TE_3 and TE_1 should give the same result if the beta of regression (4) is exactly equal to unity. If this is not the case, then the regression residuals will differ from TE_1. If betas are substantially below one – which is the case in our regressions – then the residual risk will be downward biased compared with what would be expected if β was equal to one. Because of these potential estimation issues, the average tracking error is computed in order to obtain more justified tracking error estimates.

The tracking errors increase significantly for all products as the tracking period under review is extended. The average daily tracking error ranges between 2.355% and 6.483%, while the weekly

average ranges between 5.887% and 13.159% and monthly one ranges between 11.415% and 23.792%. Regarding the magnitude of tracking error among the various instruments, the lowest tracking error in daily returns is observed in the case of VIX futures. This can be attributed to the fact that over short periods of time, spot and futures returns tend to move together closely. For example, the one-day price change of the most active VIX futures contract will typically have the same sign and similar magnitude to the price change of the VIX spot index; their correlation exceeds 90%. Regarding the tracking error of the ETPs, the lowest tracking error – following VIX futures – is observed in the case of three products that track the short-term end of the VIX futures term structure; namely the iPath S&P 500 VIX Short-Term Futures ETN (VXX), the ProShares VIX Short-Term Futures ETF (VIXY) and the VelocityShares VIX Short-Term ETN (VIIX). The dynamic allocation strategy based UBS E-TRACS Daily Long-Short VIX ETN (XVIX) exhibits the highest average tracking error in daily returns.

The empirical findings regarding longer holding periods portray a different picture. Conversely to tracking errors for daily returns, VIX futures have by far the highest tracking error for both weekly and monthly returns. This finding can basically be attributed to the volatility mean reversion property, which is already reflected into VIX futures prices. More specifically, regarding weekly returns, VXX, VIXY and VIIX exhibit the lower tracking errors compared to spot VIX. It should be noted that these three ETPs are also the runner-ups (after VIX futures) based on the daily tracking errors. Regarding monthly returns, it is challenging to determine statistically which ETP has the best tracking performance. Interestingly, based on the calculated monthly tracking errors, the ETPs that track the longer end of the VIX futures term structure or follow a dynamic allocation do not track spot VIX more effectively (compared to the ETPs that track the VIX Short-Term Futures Index). In theory, since the magnitude of the roll yield depends on the slope of the VIX futures term structure, longer-maturity VIX futures tracker ETPs should not suffer relatively so much from the negative roll yield. This is true because the difference in roll costs between the two serial VIX futures contracts is smaller at the medium/long-end compared to the short-end of the futures term structure. The empirical

findings of the current study though do not support the notion that medium-term ETPs are better trackers of the spot VIX index.

Regression Analysis

In this section the results of the returns regression (4) between volatility ETPs and VIX futures and the spot VIX index are analyzed (reported in Table 7). Ideally, we would expect insignificant alphas (α) and betas (β) hovering more or less around one, but the empirical findings do not confirm our expectations. In general, the performance regression results are consistent with the tracking errors estimates suggesting the limited tracking ability of all the products under review. For the most part, the intercept terms are negative and significantly different from zero and the slope coefficients are all less than one, with the respective deviations being significant in size. Interestingly, the lower the frequency of returns is, the higher the beta of the ETPs to the VIX.

In particular, VIX futures prices are more sensitive to daily swings in the VIX than the respective ETPs, while conversely their sensitivity in weekly or monthly VIX moves is statistically insignificant. Additionally, the three products that track the short-term end of the VIX futures term structure (that is the iPath VXX, the ProShares VIXY and the VelocityShares VIIX) have a beta to the VIX that is twice as large as the two products that track the mid-term end of the VIX futures curve – namely the iPath S&P 500 VIX Mid-Term Futures ETN (VXZ) and the ProShares VIX Mid-Term Futures ETF (VIXM); this is evidence of their greater sensitivity, as for a 1 percent daily move in the VIX, the short-term ETPs tend to move around 0.5 percent and the mid-term ETPs tend to move around 0.2 percent. Interestingly, the C-Tracks ETN Citi Volatility Index Total Return (CVOL) has the highest beta to VIX in all frequencies and the UBS E-TRACS Daily Long-Short VIX ETN (XVIX) has a beta to the cash VIX that is very close to zero (for daily, weekly and monthly returns) confirming the non-correlation with the volatility index.

Finally, the aforementioned conclusions are generally confirmed by the R-squared of each respective regression. The adjusted R-squared figures reflect the proportion of the variance of the VIX ETPs return that is explained by the spot VIX return; for example VIX futures daily returns regression

has an adjusted R-squared of 0.813, which means it tracks the VIX more accurately than the respective volatility ETPs.

CONCLUSION

Volatility has become a widely accepted asset class over the past decade. The financial turmoil caused by the burst of the internet bubble at the turn of the millennium and the great recession caused by the 2008 credit crisis has resulted in an insatiate investor demand for volatility exposure. Prior to 2004, the only way to take a position on the VIX was through portfolios of S&P500 options or through the use of over-the-counter instruments, such as variance swaps. Futures contracts on the S&P500 Volatility Index (VIX) began trading on the CBOE Futures Exchange (CFE) in March 2004. Today, investors have a variety of instruments linked to the S&P 500 VIX index - VIX options, futures, ETPs based on VIX futures indexes. Exchange Traded Products (ETPs) are best defined as open-ended securities that are listed on a stock exchange and aim to track the performance of an underlying asset. VIX-related ETPs are equity-like securities designed to provide exposure not to current implied volatility of the S&P500 (as measured by the spot VIX), but to the forward level of VIX. The first such product, iPath VXX, was offered on January 29th, 2009 and its substantial and rapid success very quickly gathered significant competition from other ETPs' managers. Their success can be partly attributed to the easy and inexpensive exposure to volatility they offer to investors.

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

For those investors who, despite the current findings, consider VIX ETPs and VIX futures as short-term directional investments in order to gain exposure to volatility, we offer three suggestions.

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

In concluding, it should be noted that the empirical findings of the particular study show that even though several volatility products exist nowadays, there is potential room for additional VIX-related ETPs that would attempt to track the actual spot VIX (and not VIX futures based indices) following either a physical (e.g. through investing in S&P500 options) or a synthetic (e.g. through opening position in variance swaps) replication method.

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APPENDIX

Table 1 – The profiles of volatility Exchange Traded Products (ETPs)

Product name	Ticker Symbol	Benchmark index	Structure	**AuM**[1]	**Avg Volume**[2]	**Inception date**	**Expense Ratio**
iPath S&P 500 VIX Short-Term Futures ETN	VXX	S&P 500 VIX Short-Term Futures Index Total Return	ETN	$1,021	33,815,938	29-Jan-09	0.89%
VelocityShares Daily Inverse VIX Short-Term ETN	XIV	S&P 500 VIX Short-Term Futures Index Excess Return (-100%)	ETN	$691	9,705,984	29-Nov-10	1.35%
ProShares Ultra VIX Short-Term Futures ETF	UVXY	S&P 500 VIX Short-Term Futures Index (200%)	Commodity Pool	$339	7,999,800	04-Oct-11	0.95%
ProShares Short VIX Short-Term Futures ETF	SVXY	S&P 500 VIX Short-Term Futures Index (-100%)	Commodity Pool	$271	846,553	04-Oct-11	0.95%
VelocityShares Daily 2x VIX Short-Term ETN	TVIX	S&P 500 VIX Short-Term Futures Index Excess Return (200%)	ETN	$192	12,786,162	29-Nov-10	1.65%
VelocityShares Daily Inverse VIX Medium-Term ETN	ZIV	S&P 500 VIX Mid-Term Futures Index Excess Return (-100%)	ETN	$137	85,958	29-Nov-10	1.35%
ProShares VIX Short-Term Futures ETF	VIXY	S&P 500 VIX Short-Term Futures Index	Commodity Pool	$110	1,052,523	03-Jan-11	0.85%
iPath S&P 500 VIX Mid-Term Futures ETN	VXZ	S&P 500 VIX Mid-Term Futures Index Total Return	ETN	$56	1,136,889	29-Jan-09	0.89%
ProShares VIX Mid-Term Futures ETF	VIXM	S&P 500 VIX Mid-Term Futures Index	Commodity Pool	$42	78,956	03-Jan-11	0.85%
iPath S&P500 Dynamic VIX ETN	XVZ	S&P 500 Dynamic VIX Futures Total Return Index	ETN	$27	12,661	17-Aug-11	0.95%
UBS E-TRACS Daily Long-Short VIX ETN	XVIX	S&P 500 VIX Futures Term-Structure Index Excess Return	ETN	$12	5,587	01-Dec-10	0.85%
VelocityShares VIX Short-Term ETN	VIIX	S&P 500 VIX Short-Term Futures Index Excess Return	ETN	$7	51,905	29-Nov-10	0.89%
C-Tracks ETN Citi Volatility Index Total Return	CVOL	Citi Volatility Index Total Return	ETN	$4.5	76,009	12-Nov-10	1.15%
Barclays ETN Inverse S&P 500 VIX Short-Term Futures ETN	XXV	S&P 500 VIX Short-Term Futures Index Excess Return (-100%)	ETN	$3.8	926	16-Jul-10	0.89%
iPath Inverse S&P 500 VIX Short-Term Futures ETN	IVOP	S&P 500 VIX Short-Term Futures Index Excess Return (-100%)	ETN	$1.9	12,827	19-Sep-11	0.89%
VelocityShares VIX Medium-Term ETN	VIIZ	S&P 500 VIX Mid-Term Futures Index Excess Return	ETN	$1.5	2,378	29-Nov-10	0.89%
VelocityShares Daily 2x VIX Medium-Term ETN	TVIZ	S&P 500 VIX Mid-Term Futures Index Excess Return (200%)	ETN	$0.84	6,134	29-Nov-10	1.65%

[1] Assets Under Management (AuM) as of Sep 01, 2014 in millions
[2] Average daily volume (number of shares) for May-Aug 2014

Table 2 – A graphical taxonomy of volatility ETPs

+2x	ProShares Ultra VIX ST Futures ETF (UVXY) VelocityShares Daily 2x VIX ST ETN (TVIX)				VelocityShares Daily 2x VIX MT ETN (TVIZ)
+1x	iPath S&P500 VIX ST Futures ETN (VXX)		C-Tracks ETN Citi Volatility Index Total Return (CVOL)		iPath S&P 500 VIX MT Futures ETN (VXZ)
	ProShares VIX ST Futures (VIXY)		E-TRACS Daily Long-Short VIX ETN (XVIX)		ProShares VIX MT Futures ETF (VIXM)
	VelocityShares Daily Long VIX ST ETN (VIIX)		iPath S&P500 Dynamic VIX ETN (XVZ)		VelocityShares VIX MT ETN (VIIZ)
	1 month	**2 months**	**3 months**	**4 months**	**5 months**
-1x	iPath Inverse S&P 500 VIX ST Futures ETN (XXV) iPath Inverse S&P 500 VIX ST Futures ETN II (IVOP) ProShares Short VIX ST Futures ETF (SVXY) VelocityShares Daily Inverse VIX ST ETN (XIV)				VelocityShares Daily Inverse VIX MT ETN (ZIV)
-2x					

Table 3 – Summary Statistics on the returns of ETPs, VIX futures and VIX index

	VIX	VIX Futures	VXX	VIXY	VXZ	VIXM	XVIX	VIXX	CVOL
Panel A: Daily Returns									
Mean	0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.001	-0.002	-0.005
Median	-0.004	-0.007	-0.005	-0.005	-0.003	-0.003	0.000	-0.005	-0.009
Maximum	0.500	0.258	0.207	0.207	0.103	0.102	0.032	0.208	0.363
Minimum	-0.270	-0.210	-0.133	-0.131	-0.082	-0.089	-0.030	-0.134	-0.252
Std. Dev.	0.074	0.047	0.040	0.040	0.020	0.020	0.008	0.040	0.066
Skewness	1.35	0.91	0.81	0.80	0.62	0.61	0.08	0.79	0.90
Kurtosis	8.98	6.97	5.88	5.81	5.77	5.84	4.16	5.96	7.03
# Obs.	813	813	813	813	813	813	813	813	813
Panel B: Weekly Returns									
Mean	0.007	-0.010	-0.012	-0.012	-0.008	-0.008	-0.002	-0.011	-0.023
Median	-0.001	-0.024	-0.016	-0.017	-0.003	-0.004	-0.003	-0.017	-0.023
Maximum	0.441	0.768	0.294	0.296	0.130	0.127	0.054	0.296	0.518
Minimum	-0.366	-0.229	-0.222	-0.221	-0.119	-0.121	-0.065	-0.225	-0.342
Std. Dev.	0.133	0.108	0.086	0.086	0.042	0.042	0.0185	0.086	0.136
Skewness	0.428	2.54	0.607	0.604	0.179	0.160	-0.084	0.607	0.776
Kurtosis	3.44	1.83	4.42	4.45	3.75	3.69	3.16	4.45	5.16
# Obs.	169	169	169	169	169	169	169	169	169
Panel C: Monthly Returns									
Mean	0.008	-0.046	-0.047	-0.048	-0.030	-0.031	-0.009	-0.047	-0.096
Median	-0.024	-0.106	-0.063	-0.062	-0.037	-0.038	-0.012	-0.071	-0.138
Maximum	0.528	0.558	0.664	0.657	0.287	0.290	0.050	0.672	0.630
Minimum	-0.303	-0.377	-0.316	-0.318	-0.182	-0.180	-0.089	-0.315	-0.531
Std. Dev.	0.198	0.193	0.189	0.188	0.094	0.093	0.039	0.189	0.256
Skewness	0.689	1.50	1.59	1.56	1.02	1.08	-0.264	1.61	1.14
Kurtosis	2.93	5.26	6.71	6.60	4.98	5.20	2.27	6.85	4.44
# Obs.	39	39	39	39	39	39	39	39	39

Table 4 – Variance comparison tests (F-tests)

ETP	Daily returns	Weekly returns	Monthly returns
VIX Futures	Rejected	Rejected	Accepted
VXX	Rejected	Rejected	Accepted
VIXY	Rejected	Rejected	Accepted
VXZ	Rejected	Rejected	Rejected
VIXM	Rejected	Rejected	Rejected
XVIX	Rejected	Rejected	Rejected
VIIX	Rejected	Rejected	Accepted
CVOL	Rejected	Accepted	Accepted

Note: The null hypothesis is that the standard deviation of the fund is equal to that of its benchmark index.

Table 5 – Correlation estimates of the returns of ETPs and VIX index

	Daily returns	Weekly returns	Monthly returns
VIX Futures	0.902**	0.086	-0.161
VXX	0.890**	0.851**	0.789**
VIXY	0.892**	0.852**	0.791**
VXZ	0.808**	0.718**	0.654**
VIXM	0.802**	0.719**	0.643**
XVIX	-0.208**	-0.324**	-0.332**
VIIX	0.875**	0.852**	0.787**
CVOL	0.835**	0.796**	0.794**

** Identifies coefficient significant at the 1% level

Table 6 – The Tracking Errors of ETPs and VIX futures

ETP	Standard Deviation of Returns Difference (TE_1)	Mean Absolute Return Difference (TE_2)	Standard Errors of Regression (4) (TE_3)	Average TE
Panel A: Daily Returns				
VIX Futures	3.748	2.656	2.053	**2.355**
VXX	4.245	2.941	1.837	**3.008**
VIXY	4.231	2.925	1.828	**2.995**
VXZ	5.932	4.146	1.168	**3.749**
VIXM	5.954	4.158	1.177	**3.763**
XVIX	7.614	5.351	0.757	**6.483**
VIIX	4.352	3.007	1.947	**3.102**
CVOL	4.104	3.048	3.630	**3.594**
Panel B: Weekly Returns				
VIX Futures	16.427	12.258	10.792	**13.159**
VXX	7.536	5.610	4.514	**5.887**
VIXY	7.517	5.603	4.512	**5.877**
VXZ	10.708	8.238	2.968	**7.305**
VIXM	10.735	8.280	2.923	**7.313**
XVIX	14.055	11.017	1.756	**8.943**
VIIX	7.511	5.618	4.507	**5.879**
CVOL	8.587	6.984	8.222	**7.931**
Panel C: Monthly Returns				
VIX Futures	29.782	22.363	19.230	**23.792**
VXX	12.590	10.075	11.757	**11.474**
VIXY	12.530	10.032	11.683	**11.415**
VXZ	15.388	11.753	7.234	**11.458**
VIXM	15.543	11.879	7.250	**11.557**
XVIX	21.407	16.673	3.711	**13.930**
VIIX	12.666	10.233	11.839	**11.579**
CVOL	15.556	15.197	15.757	**15.503**

Note: TE_1 is the standard deviation of the return difference between ETP and VIX index. TE_2 is the average of the absolute return difference between ETP and VIX index and TE_3 is the standard errors of regression (4). All numbers in percentages.

Table 7 – Performance Regression of ETPs

This Table presents the results of ETPs' performance regression. Particularly, the following single market model is used: $R_{it} = \alpha_i + \beta_i R_{VIXt} + \varepsilon_{it}$

in which: R_{it} indicates the daily/ weekly/ monthly return of ETP i, R_{VIXt} denotes the daily/ weekly/ monthly return of VIX index and ε_{it} is the residual error.

The hypotheses are tested by conducting a Wald-test. The first hypothesis regarding alpha evaluates the statistical difference of the estimates from zero (H_0: α=0) and the second hypothesis regarding beta evaluates the statistical difference of the estimates from unity (H_0: β=1).

					Hypothesis Testing	
	α	**β**	**Adj. R^2**	**# obs**	**H_0: α=0**	**H_0: β=1**
Panel A: Daily Returns						
VIX Futures	-0.003**	0.577**	81.28%	813	Rejected	Rejected
	(0.001)	(0.017)				
VXX	-0.004**	0.484**	79.23%	813	Rejected	Rejected
	(0.001)	(0.017)				
VIXY	-0.004**	0.485**	79.48%	813	Rejected	Rejected
	(0.001)	(0.018)				
VXZ	-0.002**	0.216**	65.20%	813	Rejected	Rejected
	(0.000)	(0.009)				
VIXM	-0.002**	0.213**	64.26%	813	Rejected	Rejected
	(0.000)	(0.009)				
XVIX	-0.000	-0.022**	41.95%	813	Accepted	Rejected
	(0.000)	(0.005)				
VIIX	-0.004**	0.475**	76.59%	813	Rejected	Rejected
	(0.001)	(0.008)				
CVOL	-0.006**	0.741**	69.62%	813	Rejected	Rejected
	(0.001)	(0.033)				
Panel B: Weekly Returns						
VIX Futures	-0.011	0.070	1.51%	169	Accepted	Rejected
	(0.008)	(0.051)				
VXX	-0.016**	0.547**	72.30%	169	Rejected	Rejected
	(0.004)	(0.037)				
VIXY	-0.016**	0.549**	72.44%	169	Rejected	Rejected
	(0.003)	(0.039)				
VXZ	-0.009**	0.229**	51.29%	169	Rejected	Rejected
	(0.002)	(0.023)				
VIXM	-0.009**	0.226**	51.39%	169	Rejected	Rejected
	(0.002)	(0.023)				
XVIX	-0.002	-0.045**	9.99%	169	Accepted	Rejected
	(0.001)	(0.009)				
VIIX	-0.016**	0.549**	72.50%	169	Rejected	Rejected
	(0.003)	(0.026)				
CVOL	-0.029**	0.809**	63.18%	169	Rejected	Rejected
	(0.006)	(0.068)				
Panel C: Monthly Returns						
VIX Futures	-0.044	-0.156	0.00%	39	Accepted	Rejected
	(0.031)	(0.158)				
VXX	-0.054**	0.753**	61.27%	39	Rejected	Rejected
	(0.019)	(0.096)				
VIXY	-0.054**	0.752**	61.52%	39	Rejected	Rejected
	(0.019)	(0.096)				
VXZ	-0.033**	0.311**	41.21%	39	Rejected	Rejected
	(0.012)	(0.059)				
VIXM	-0.033**	0.303**	39.73%	39	Rejected	Rejected
	(0.059)	(0.059)				
XVIX	-0.008	-0.065*	8.63%	39	Accepted	Rejected
	(0.006)	(0.030)				
VIIX	-0.053**	0.753**	60.93%	39	Rejected	Rejected
	(0.019)	(0.097)				
CVOL	-0.104**	1.024*	61.98%	39	Rejected	Accepted
	(0.024)	(0.197)				

Newey-West Standard errors in parentheses

** Identifies coefficient significant at the 1% level

* Identifies coefficient significant at the 5% level