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Does the Tail Wag the Dog? Evidence from Fund Flow to VIX ETFs and ETNs

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Abstract: This paper investigates if and how the fund flows to VIX exchange-traded funds (ETFs) and VIX exchange-traded notes (ETNs) impact the underlying volatility VIX index. The VIX ETFs and ETNs are divided into four groups depending on their investment strategy. We found that each group has a very distinctive fund flow pattern, reflecting the mean-reverting character of the VIX. We found that generally higher fund flows to VIX exchange-traded funds and notes which apply a normal tracking strategy tend to increase the value of the VIX, while higher fund flows to VIX exchange-traded funds and notes which apply an inverse tracking strategy decrease the value of the VIX. Moreover, we show that money flows to VIX exchange-traded products is insufficient to contribute to market instability during market downturns. The results of this study provide arguments for discussion on impact of exchange trade products on their underlying products (see SEC's File No. S7-11-15).

Keywords: VIX, Exchange-traded fund, Exchange-traded note, Fund flow, VIX future price, VIX future price term structure

JEL Classifications: G11, G23

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1. Introduction

The need to employ variance-related instruments in investment portfolios for diversification purposes has been emphasized since the onset of the global financial crisis (Chen, Chung and Ho [2010]; Santon [2011]; Whaley [2013]; DeLisle, Doran and Krieger [2014]). Investors prefer to include volatility products in their portfolios to enjoy diversification benefits during periods of turmoil. Among those variance-related products, instruments whose performance is linked to the Volatility Index (VIX) level have become most popular. VIX is a measure of the implied volatility of S&P 500 index options. VIX as a market volatility index represents the market's expectation of stock market volatility over the next 30-day period. In recent years, it has become a commonly accepted "fear gauge" for many investors.

The characteristics of the CBOE's VIX index do not allow market participants to invest directly in it. However, volatility trading is not restricted to VIX investing; a few approaches are available, such as combinations of static positions in options with dynamic trading in the underlying or straddle, strangle combinations[1] (Neuberger [1990]; Dupire [1997]; Carr and Madan [1998]). Such trading requires a high level of engagement from investors, as option positions need to be monitored and rebalanced frequently. On top of that, the trading of options portfolios is much more complex than any buy-and-hold strategy commonly used in the case of exchange-traded fund (ETF) and exchange-traded note (ETN) investments.

The CBOE Futures Exchange (CFE) responded to the growing demand for simplified volatility trading. On March 26, 2004, the first-ever trading in futures on the VIX began on the CFE, making it possible for investors to directly trade in volatility. Since February 24, 2006, VIX option contracts are available to trade, providing investors more flexibility in volatility investing. VIX options and futures shortly became actively traded contracts at the CFE. The average daily trading volume of VIX options increased its size from 0.13 million contracts in 2009 to 0.57 million contracts in 2015. At the

[1]A long position in a straddle-and-strangle could benefit from a rise in volatility; while delta-hedging an option position provides exposure to the difference between the realized volatility and the anticipated volatility used in pricing and hedging the option.

same time, the daily trading volume of all S&P 500 index option groups[2] is 0.97 million contracts[3]. The average trading volume in VIX futures climbed from 4.5 thousand contracts in 2009 to 205 thousand contracts in 2015[4], dwarfing nearly all other futures trading on the CFE.

Despite their popularity, VIX futures and options contracts are complex investments, particularly for individual investors. While sophisticated investors can trade VIX futures and options for speculation, directional exposure, arbitrage, diversification and hedging, it is not so easy and cost effective for unsophisticated investors to trade them to get exposure to market volatility. The need to provide volatility-related exchange-traded products to a wide variety of investors has been increasingly emphasized. Commenting on the issuance of VIX exchange-traded products, Coleman [2009] states that "Barring some unforeseen complication, individual investors and their professional advisors should soon be able to do much the same in a seemingly less complicated and affordable manner."

Indeed, in February 2009, Barclays iPath launched S&P 500 VIX Short-Term Futures Exchange-Traded Notes (NYSE: VXX) and S&P 500 VIX Mid-Term Futures Exchange-Traded Notes (NYSE: VXZ), representing the emergence of VIX futures-based exchange-traded products. Those exchange-traded products invest in VIX futures indexes, thereby providing investors with exposure to market volatility. For instance, the VXX ETN tracks the S&P VIX Short Term Futures Index Total Return. The index itself is designed to follow the changes in the value of short-term VIX futures contracts. According to its prospectus, the VXX ETN is designed to provide investors with exposure to one or more maturities of futures contracts on the VIX index. These VIX ETNs quickly became the most popular variance instruments among investors because of their low costs, tax efficiency and stock-like features. In 2010, just one year after their issuance, the average daily trading volume of VXX ETNs reached around 19 million shares and they have been growing fast. After the successful introduction of VXX and VXZ, other VIX-related ETNs and ETFs have been launched. These

[2] The S&P 500 option groups include SPX Options Traditional, SPX Options Non-Traditional, SPX Options - Mini and SPY Options, covering seven types of SPX options.
[3] The data were retrieved from CBOE Historical Options Data: http://www.cboe.com/data/putcallratio.aspx.
[4] The data were retrieved from the website http://cfe.cboe.com/data/historicaldata.aspx.

instruments track different VIX index futures and VIX-related indices and thereby provide investors with a wide variety of investment choices. Currently, there are more than 20 VIX-related exchange-traded products, making easy for global investors to get exposure to market volatility in a cost-efficient manner. For the sake of simplicity, we refer to VIX ETNs and ETFs as VIX exchange-traded products (ETPs).

The increase in investors' interest in volatility-linked products has been accompanied by an increase in academic output on the topic. The literature on the VIX index has evolved into several streams. The first one focuses on the pricing and modeling of the VIX index, VIX futures and VIX options. Zhang and Zhu [2006] posit a stochastic variance model of VIX evolution over time and develop a model for VIX futures. They find free parameters estimated from different periods over-price VIX future contracts on different levels. This topic has also been examined by Lin [2007] and Brenner, Shu and Zhang [2008]. Lin [2013] applies CBOE exponential and hump volatility functions with one- to three-factor models of the VIX evolution to examine the pricing for VIX options. He finds that hump volatility functions provide efficient out-of-sample valuation for most VIX put options, while exponential volatility functions present an effective choice as pricing models for VIX call options.

Another stream in the relevant literature examines the interaction between the VIX and VIX-related products. Shu and Zhang [2012] apply a modified Baek and Brock nonlinear Granger test and report evidence that both spot and futures prices react simultaneously to new information, supporting the information and price efficiency in the VIX futures market. Konstantinidi, Skiadopoulos and Tzagkaraki [2008] investigate whether the behavior of the implied volatility indices are predictable, and their results show that no models outperform the random walk model in an out-of-sample setting and that no economically significant profits can be attained. Nossman and Wilhelmson [2009] focus on testing the efficiency of the VIX futures market, and they point out that the risk premium adjusted futures price forecasts the movement direction for the VIX index well. Kanniainen, Lin and Yang [2014] use information on the VIX to improve the empirical performance of GARCH models for pricing options on the S&P 500 and find supporting evidence that non-affine models outperform affine models. Frijns, Tourani-Rad and Webb [2016] investigate the relation of causality between the VIX and its futures and find evidence of causality from VIX futures to the VIX index. Daigler,

Dupoyet and Patterson [2014] examine the concavity adjustment for VIX futures. They demonstrate that the implied variance of VIX futures is strongly correlated with both market volatility and VIX futures time to expiration.

The literature on VIX ETPs has been somewhat piecemeal. Husson and McCann [2012] assess the risks associated with VXX ETNs, and show that the return to the VXX ETNs depends in large part on movements in the futures markets. Stanton [2011] and Deng, MacCann and Wang [2012] investigate how effectively VIX ETPs can hedge a portfolio of US large-cap stocks and find that VIX ETPs can hardly be applied as an effective hedging instrument. Alexander and Korovilas [2012] study the return of VIX ETNs and argue that the ETN market could lead VIX futures despite the fact that they are supposed to track. They document that the large-scale hedging activities of ETN issuers on the CBOE market could affect the prices of VIX futures. The VIX ETN issuers who have a short position in volatility need to hedge it with a long position in volatility-linked products such as VIX futures. The popularity of ETNs leads to an increased need for hedging, which may result in upward pressure on VIX futures. The pressure may even be amplified by the fact that speculative traders can predict ETNs hedging activity and front-run them by taking a long position on CBOE VIX futures. A similar topic has been examined by Eraker and Wu [2014], who propose an equilibrium model to explain the negative expected return to VIX futures and ETNs. Clowers and Jones [2016] investigate eight VIX ETPs that include ETNs and ETFs. They compare the performance and returns of those VIX instruments with that of the VIX index and report that VIX ETPs do not correlate well with the VIX index. They further suggest that VIX ETPs are not suitable for a buy-and-hold investment strategy, as those ETPs are exposed to a declining value, due to the large degree of contango in VIX futures applied by these ETPs.

So far, few attempts have been made to examine the flows to VIX ETPs and the possible impact of the fund flows on the VIX index. The literature, however, has documented that fund flow matters to other investment vehicles, such as mutual funds (Edelen and Warner [2001]; Boyer and Zheng [2009]; Ben-Rephael, Kandel and Wohl [2011]; Christoffersen, Musto and Wermers [2014]) and hedge funds (Brown, Goetzmann, Liang and Schwarz [2008]; Boyson, Stahel and Stulz [2010]; Dichev and Yu [2011]; Li, Zhang and Zhao [2011]; Horst and Salganik [2014]). The impacts of fund flow have also

been examined in the context of ETFs. Kalaycıoğlu [2004] investigates the flow-return relationship in ETFs at individual and aggregate levels and finds significant negative correlation between ETF flows and market returns. Staer [2014] explores the relation between ETF flows and their underlying securities' returns and reports a positive relation between daily contemporaneous ETF flows and the underlying stocks' returns, which is also supported by Change and Ke [2014].Clifford, Fulkerson and Jordan [2014] investigate the drivers of equity ETF flows and find that higher volume, smaller spreads and higher price to net asset value ratios will increase ETF flows.

Taking into account the previously reported relationships between fund flow and performance, one may expect that the money flow to VIX ETPs can impact the performance of the underlying VIX index. In the aftermath of the collapse of VelocityShares Daily 2x VIX Short-Term ETN (TVIX),[5] the Security and Exchange Commission (SEC) decided to look into the trading of it, and the financial media started to ask questions about whether extensive money flows to ETFs and ETNs may have an impact on the underlying itself.

An article published in the *Financial Times* raises concerns that distorted messages about future expectations of market behavior may be sent by the VIX futures markets due to the popularity of ETPs (Kaminska and Makan [2012]). At the same time, the *Wall Street Journal* asked to what degree money flow into VIX products more broadly affects the VIX itself (Lauricella [2012]). These concerns are shared by Alexander and Korovilas [2012] and Asensio [2013], who suggest that as VIX futures have become more accessible to general investors, the inflows can create distortions in VIX futures markets, especially for short-dated tenors, which are most actively used for the management of VIX ETPs.

On June 12, 2015, SEC filed an official document No. S7-11-15, to seek public comment on topics related to the listing and trading of exchange-traded products on national securities exchanges and sales of these products by broker-dealers. In that file

[5]On February 21, 2012, Credit Suisse stopped issuing new shares in VelocityShares Daily 2x VIX Short Term ETN (TVIX) due to internal limits on the size of ETNs; as a result, the share price of the ETN increased to $14.43, 89% higher than its $7.62 net asset in one month. Next it immediately plunged 29% after Credit Suisse reopened issuance and then dropped another 30% on the next day (see Russolillo [2012]; Lauricella, Eagkesham and Dieterich [2012]; Dieterich and Kiernan [2012]).

comments were requested on the nature, extent, and potential causes of premiums and discounts across the wide range of ETP strategies and holdings. Furthermore, the item 17 in the file precisely raise the question: "To what extent, if any, does trading activity in ETP Securities affect price discovery, price correlation, liquidity, or volatility in the ETP's underlying or reference assets?" which confirms the concerns about the relationship between ETPs and underlying index.[6]

This study focuses on examination of fund flows to VIX ETPs and their effect on the VIX index. In addition, our study answers Question 17 in SEC's File No. S7-11-15, on how the ETP can affect the underlying using results obtained for VIX ETPs market. The contribution of the study is twofold. Firstly, reported results help to understand the dynamics of fund flow to different VIX ETP groups as a function of market performance. Secondly, our findings show that while the aggregated flow has marginal effects on the VIX index, fund flow to a few specific groups of those VIX ETFs and ETNs have significant impacts on the VIX index. Moreover, we show that there is no extra impact of flow on VIX during a bear market, suggesting that trading in VIX ETPs during a bearish period do not destabilize the underlying market.

The remainder of this paper is organized as follows. Section 2 discusses technical details concerning VIX ETFs and ETNs. Section 3 reviews the related literature and outlines the hypotheses. Section 4 presents the data and methodology. Section 5 presents the results of the empirical analysis on fund flow to VIX ETPs. Section 6 summarises the findings and concludes.

2. VIX ETFs and ETNs

VIX futures are cash-settled futures contracts on the VIX index. On the settlement date, investors with an open position in VIX futures will be credited or debited the difference

[6] The CME Group released a statement that stock index futures market are more liquid than ETP markets, and therefore stock index futures market functions as the leading price indicator. On the other hand, BlackRock commented that more ETFs are becoming the true market and the underlying assets may eventually catch up with any gap between the two. Though it is not agreed precisely on which product is leading prices, the statements show the nature of derivative products has changed and they could pose risks to the underlying securities.

between their purchase (or sale) price and the settlement price. Unlike other financial futures, VIX futures price is not given by a cost-of-carry model (Grunbichler and Longstaff [1996]), as VIX is not an asset and there is no "carry" arbitrage between VIX futures and VIX.[7] Instead, the fair price of VIX futures is calculated by pricing the forward 30-day variance that underlies the settlement price of VIX futures. The exchange may list VIX futures for trading up to nine near-term serial months, and VIX futures expire on the third Wednesday of each calendar month.

The CBOE VIX index cannot be invested in directly; however, investors can trade other VIX-related indices. Among those VIX-related products, the most traded and tracked by VIX ETFs and ETNs are the S&P 500 Short-Term VIX Futures Index and the S&P 500 Mid-Term VIX Futures Index. The S&P 500 Short-Term VIX Futures Index offers exposure to a daily rolling long position in the next two near-term VIX futures contracts expiring in the first and second front months, while the S&P 500 Mid-Term VIX Futures Index offers exposure to a daily rolling long position in four-, five-, six- and seven-month VIX future contracts. Both of these indices roll positions in relevant-month VIX futures to provide exposure to the VIX index. For instance, the S&P 500 Short-Term VIX Futures Index rolls from the nearest-month VIX futures to the next month on a daily basis in equal fractional amounts, while the S&P 500 Mid-Term VIX Futures Index rolls along position in four-, five-, six- and seven-month VIX futures daily.

Both VIX ETFs and ETNs are instruments traded on the exchanges and enable investors to gain exposure to equity market volatility. VIX ETFs and ETNs generally track a VIX-related index,[8] and the most tracked indices are the S&P 500 Short-Term VIX Futures Index and the S&P 500 Mid-Term VIX Futures Index. In order to follow the performance of those VIX futures indices, VIX ETPs also need to roll the relevant positions in the VIX futures market. For instance, a VIX ETF which tracks the performance of the S&P 500 VIX Short-Term Futures Index, rolls the first front-month VIX futures to the second front month on a daily basis in equal fractional amounts, which means the VIX ETF shorts the nearest-month VIX futures and longs the next-month VIX futures. In a normal situation (in terms of volatility level), the VIX future

[7] Investors cannot create a position equivalent to one in VIX futures by buying VIX and holding the position to the futures expiration date while financing the transaction.
[8] Most VIX ETFs and ETNs are traded on the Bats Global Markets (BATS) exchanges.

price term structure is in contango, when the shorter-term VIX future contracts are trading at a lower price than the longer-term future contracts. Consequently, costs are accrued each time when the VIX ETFs/ETNs roll their positions in corresponding VIX futures. The opposite case is that if a VIX ETF tracks the inverse performance of S&P 500 VIX Short-Term Futures Index, it rolls its daily positions by longing the nearest-month VIX futures and shorting the next-month VIX futures. In a contango situation, such rolling by this inverse VIX ETF/ETN actually incurs an inflow.

Although both VIX ETFs and ETNs are designed to provide investors with exposure to VIX-related indices, the way VIX ETFs and ETNs get the exposure could be quite different, even as they track the same VIX-related index. For instance, VIX ETFs which track the performance of the S&P 500 Short-Term VIX Futures Index need to hold actual positions in VIX futures contracts comprising the underlying index. More specifically, as the S&P 500 Short-Term VIX Futures Index comprises VIX futures expiring in first and second front months, those VIX ETFs need to get long or short positions in VIX future contracts maturing in first- and second-front months, depending on the tracking strategies. VIX ETNs in contrast to VIX ETFs do not necessarily have holding positions, as an arrangement may be made with the issuing bank or an independent swap counterparty. Thus, VIX ETNs become more flexible as long as they manage to provide investors the exposure to the underlying indices.

3. Hypothesis

The following section summarizes our hypothesis on the fund flows to different VIX ETPs and how the flows impact on the VIX index. We also elaborate on other factors, such as VIX futures prices and VIX futures price term structure, and discuss their possible effects on the VIX index.

3.1 Fund flow to VIX ETPs

As VIX ETPs are structured to generate returns when equity volatility changes, investors tend to include more VIX ETPs in their portfolios to hedge against market volatility, especially when the stock market performs poorly. Kaminska and Makan

[2012] argue that with the increased popularity of VIX ETPs, a greater amount of money flows into those volatility-related investment vehicles. In order to accommodate the increased money flows and provide investors with more exposure to market volatility, VIX ETPs tend to open more positions in the VIX futures market to track the performance of the underlying VIX futures indices. These trades in the VIX futures market by VIX ETPs are generally large; therefore, they might distort the price of VIX futures. The imbalance in VIX futures could then seep into the underlying S&P options market and affect the VIX index. On the other hand, the VIX ETPs provide different tracking strategies (normal or inverse),[9] and thereby can generate quite different returns, depending on the prevailing market conditions. For instance, when equity market volatility increases, a VIX ETP which applies the normal tracking strategy generates a positive return, while a VIX ETP applying inverse tracking strategy loses money. On the contrary, when stock market volatility decreases, a VIX ETP applying normal tracking strategy suffers a loss, whereas a VIX ETP applying inverse tracking strategy gains profit. As funds could flow into VIX ETPs which employ different tracking strategies under different market conditions, the impacts of fund flows to normal and inverse tracking strategy VIX ETPs may offset each other. Thus, it is not clear if the aggregated fund flows to all VIX ETPs has any statistically significant overall impacts on the VIX index.

As discussed above, investors have various incentives to invest in VIX ETPs which employ different tracking strategies. In order to isolate the impacts of fund flows to different categories of VIX ETPs, we divide VIX ETPs into separate groups depending on their tracking strategies (normal and inverse) and the horizon of their underlying future indices (short-term and mid-term).This allows us to test the impacts of fund flows to different VIX ETP groups, namely normal-short, normal-mid and inverse-short. When there are increasing fund flows to VIX ETPs in normal-short and normal-mid groups, those VIX ETPs tend to get more long positions in relevant VIX futures, lifting up the prices of VIX futures. An increase in VIX futures prices will imply a higher expected value of the VIX index. Therefore, we hypothesize that the fund flows in VIX ETPs in normal-short and normal-mid groups have positive impacts on the VIX index.

[9] A VIX ETP which applies a normal strategy provides exposure to the performance of its underlying index, while a VIX ETP which applies an inverse strategy provides exposure to the inverse performance of its underlying index.

Analogously, higher fund flow to VIX ETPs in inverse groups leads those VIX ETPs to short more relevant VIX futures, pulling down the VIX future prices and the expectation for market volatility in the future. We put forward the hypothesis that fund flows to inverse VIX ETP groups have negative impacts on the VIX index.

In addition, taking into account the mean-reverse property of the VIX index (Dueker [1997]; Whaley [2008]; Leung, Li, Li and Wang [2016]), it is likely that investors get more incentives to trade VIX ETPs during time periods when equity market volatility is very extreme (high or low). More specifically, investors are motivated to take long positions in VIX ETPs in normal (inverse) groups when the VIX index is extremely low (high). On the other hand, the collapse of equity markets' value is generally accompanied by important market events, which might outperform VIX ETPs as a driver of investors' perception of the market. In that case, the VIX index is more likely influenced by the market trends. Thus, the impacts of fund flow to VIX ETPs during such periods might have an unclear pattern. We expect investors have more incentives and are more likely to take more speculative positions when the VIX is high. Therefore, we hypothesize that during the period when equity market volatility is extreme, the impact of fund flow to VIX ETPs' inverse and normal groups on the VIX index is stronger.

3.2 VIX futures price and VIX futures price term structure

Previous literature has widely investigated the relationship between the VIX index and VIX futures. Some studies report the information and price efficiency in the VIX futures market (Konstantinidi, Skiadopoulos and Tzagkaraki [2008]; Shu and Zhang [2012]). On the other hand, there are studies showing VIX futures prices can forecast the movement direction of the VIX index (Nossman and Wilhelmson [2009]; Frijns, Tourani-Rad and Webb [2016]). In line with the previous studies, we include lagged VIX futures price in our model to account for the potential predictable effect of VIX futures on the VIX index and, in addition, control for the autocorrelation effects in the VIX index. Accordingly, the lagged VIX futures price is expected to have a positive impact on the VIX index.

The term structure of VIX futures is typically in contango (upward sloping) and changes into backwardation [10] (downward sloping) when the equity market moves into excessively volatile periods (Alexander and Korovilas [2012]). A contango (backwardation) term structure refers to a market condition where the longer-term futures contract is trading at a higher (lower) price than the nearer-term futures contract, therefore reflecting the market expectation for a future spot price (Gorton and Rouwenhorst [2005]). We include a VIX futures term structure in the model to capture the market's expectation of the VIX index. Accordingly, a backwardation term structure is expected to have a negative effect on the level of the VIX index.

4. Data and Method

4.1. Data

Our sample includes 1387 daily observations of VIX ETFs and ETNs traded on U.S. exchanges. The sample period spans from 28 January 2009, when the first VIX ETP was issued, to 31 December 2015. The daily closing data for the S&P 500 index, the VIX index, VIX futures term structure and fund flows to VIX ETPs were collected from the Bloomberg database. Our sample covers close to 100% of total market capitalization of all VIX-related ETPs. The descriptive information for those VIX ETPs is presented in Exhibit 1.

EXHIBIT 1 HERE

As presented in Exhibit 1, there are 18 VIX ETFs and ETNs, and 13 of them track the S&P 500 short-term or mid-term VIX futures indices. Among those 13 VIX ETPs, there are 4 VIX ETFs issued by Proshares, while the other 9 are VIX ETNs.

4.2. Method

To examine the effect of fund flows on the VIX index, the following model was estimated:

[10] Normal backwardation is the case when the short-term VIX futures prices are higher than those of long-term VIX futures. For instance, the price of next-term VIX futures is higher than the second front-month VIX futures, while the price of second front-month VIX futures is higher than those of third front-month VIX futures, etc.

$$R_t^{VIX} = \beta_0 + \sum_{i=1}^{k} \varphi_i Flow_{i,t-1} + \sum_{i=1}^{k} \theta_i Flow_{i,t-1} \cdot D_t + \beta_1 R_{t-1}^{VF} + \beta_2 D_t + \beta_3 \Delta CB17_t + \varepsilon_{i,t},$$

where:

R_t^{VIX} is the percentage change in the daily closing price of the underlying VIX index at the end of day *t*.

$Flow_{i,t-1}$ is the lagged net fund flow to group *i* (*i*=1,.., *k*).

k indicates the number of VIX ETP groups examined in each model specification.

R_{t-1}^{VF} is the lagged percentage change in the daily price of VIX futures.

$CB17_t$ is the VIX futures term structure proxy, which is calculated as the price difference between the first front month and the seventh front month VIX futures divided by the first front-month VIX future price[11].

$\Delta CB17_t$ is the change in VIX futures term structure calculated as the difference between $CB17_t$ and $CB17_{t-1}$[12].

D_t is the time dummy, which equals to one when the daily return of the S&P 500 index is lower than its fifth percentile level observed during the study period. Both the first and fifth percentile are in line with the method to estimate Value at Risk (see Jorion [2007]). However, selection of the first percentile results in a low number of trading days.

$Flow_{i,t-1} \cdot D_t$ is the interaction of the lagged fund flow and the time dummy, which captures the impact of the fund flow to VIX ETPs during market turmoil periods.

$\varepsilon_{i,t}$ is the error term. For the sake of completeness, we include definitions and the

[11] The other term structure measure designed to capture the backwardation effect was considered. The results were robust for selection of the backwardation proxy. When we consider the proxy for backwardation in the VIX futures price term structure, there is a tradeoff between measure length, which captures the number of future months in term structure, and data availability, as there are periods when the price of VIX futures for longer than eight months is not available. Hence, CB17 is applied as the proxy for backwardation and it measures a relatively long period (seven months) in term structure, and thus provides data consistency. In the robustness test, we also apply different length measures, such as CB15, which is the ratio calculated with the first and fifth front-month VIX future prices in term structure, and we get similar findings.

[12] $\Delta CB17_t$ is defined as: $\Delta CB17_t = \frac{\left(P_{1,t} - P_{7,t}\right)}{P_{1,t}} - \frac{\left(P_{1,t-1} - P_{7,t-1}\right)}{P_{1,t-1}} = \frac{P_{7,t-1}}{P_{1,t-1}} - \frac{P_{7,t}}{P_{1,t}}$, where $P_{i,t}$ is the price of *i*th front month VIX future at time *t*. A high positive value of $\Delta CB17_t$ indicates that VIX future term structure changes from strong contango to deep backwardation.

descriptive statistics of all variables employed in the paper (see Exhibit 2).

EXHIBIT 2 HERE

5. Empirical Results

5.1. Descriptive statistics

In this section, we first examine the changes in net fund flows to VIX ETPs during the study period. S&P 500 index returns are employed to proxy for various market conditions. We categorize S&P 500 index returns into deciles and record the statistics of the net fund flow to each of the four examined VIX ETP groups in each decile. Exhibit 3 presents the mean and standard deviation of net fund flows to normal-short, normal-mid, inverse-short and inverse-mid VIX ETPs across the range of S&P 500 index returns observed during the study period.

EXHIBIT 3 HERE

As depicted in Panel A, on average, there are positive fund inflows to all four VIX ETP groups. The normal-short group received the highest daily average flow of $6.14 million, whereas the inverse-mid group, being a newly established, experienced the smallest daily average fund inflow of $0.07 million. The net fund flow into the normal-short group peaked at normal market conditions, with the daily average reaching $17.8 million when S&P 500 index returns hovered around its fifth decile. In contrast, the fund flow to the inverse-short group reached its highest levels over the periods when S&P 500 index experienced extreme returns, with the daily average flow of $14.4 million recorded in the lowest decile and $12.5 million in the highest decile of S&P 500 index returns.

As presented in Panel B of Exhibit 3, the fund flow to the normal-short group was more volatile than those of other groups, as evidenced by a higher standard deviation. It is noteworthy that the fund flow to inverse-short group is characterized by the highest variability when the S&P 500 index experienced extremely negative returns.

Exhibit 4 features the 25th percentile, 75th percentile, mean and median of the fund flows for three large groups (normal-short, normal-mid, inverse-short) across the range of S&P 500 index returns. The observed flows for normal-short and inverse-short VIX ETPs follow distinct patterns, and are consistent with the statistics presented in Panel A of Exhibit 3.

EXHIBIT 4 HERE

An interesting question is how the net fund flow to VIX ETP groups changed over the periods of market turmoil. We define market turmoil as the periods when S&P 500 index returns fell below its fifth percentile level observed during the study period.

Exhibit 5 depicts the changes in the average net flows to the four VIX ETP groups for 10 days prior to and after day "0", marked as when the S&P 500 index fell below its fifth percentile level of -1.5%. There are 78 days with such extremely negative returns during the study period.

EXHIBIT 5 HERE

As shown in Exhibit 5, a high net fund flow to inverse-short group was accompanied with an outflow of money from normal-short group. The pattern suggests that in time when equity market experienced extremely negative returns, investors bet that observed high volatility will go down. In such a case, it's likely that normal-short VIX ETPs will make loss while inverse-short ETPs will generate positive returns. This pattern supports the argument that market participants expect the VIX index to move in a mean-reverse way (Whaley [2008]; Leung, Li, Li and Wang [2016]).

Exhibit 6 shows the changes in the average net flows to the four ETP groups for 10 days before and after the days when the S&P 500 index recorded a higher return than its 95^{th} percentile level of 1.5%. There are 72 days with such extremely positive returns during the study period

EXHIBIT 6 HERE

As presented in Exhibit 6, there was a large inflow to the inverse-short group and a substantial outflow from the normal-short group prior to day “0”. A reverse pattern is observed for both groups following day “0”. That’s to say, when the market performs well the patterns of fund flow to inverse-short and normal-short groups indicate that the investors expect a higher volatility. We conjecture that investors anticipate an increase in VIX as a result of a market correction following a surge of more than 1.5 percent. However, the patterns observed in Exhibit 6 are not as striking as those featured in Exhibit 5.

As a robustness check, we use VIX index value as an alternative proxy for market performance. Exhibit 7 presents the summary statistics of the net fund flows to the four VIX ETP groups across different deciles of VIX index values.

EXHIBIT 7 HERE

Panel A presents the means of net fund flows and Panel B presents the standard deviation of net fund flows for the four VIX ETP groups. As seen in Panel A, the normal-short group experienced the largest inflow of $28.9 million when the VIX index was in its lowest decile, and saw the largest outflow of $15.48 million when the VIX index reached its highest decile level. In contrast, the net fund flow to the inverse-short group saw a deep inflow of $24.7 million when the VIX index recorded its highest decile level, and experienced the largest outflow of $10.1 million when the VIX index plunged to its lowest decile level. As shown in Panel B of Exhibit 7, the inverse-short group has the most volatile net fund flow and it occurred when the VIX index peaked at its top decile.

Overall, the above findings suggest that investors tend to take long positions in normal (inverse) VIX ETP groups over normal (volatile) market conditions. The observed patterns were more pronounced during the 10-day window surrounding the days with extreme returns.

5.2. Estimation model

In order to address the concern that some of our independent variables may be correlated, we present the matrix in Exhibit 8.

EXHIBIT 8 HERE

To examine the effects of fund flows to VIX ETPs on the VIX index value, we run three sets of models, each with different specifications. First, we analyze the aggregated fund flow to all VIX ETPs; the results are presented in Exhibit 9. We then categorize VIX ETPs into two groups based on their tracking strategies (normal or short) and conduct a similar analysis. The results are presented in Panel A of Exhibit 10. We further categorize VIX ETPs into three groups based on both the tracking strategies (normal or short) and the horizon of their underlying indices (short-term or mid-term). The results are presented in Panel B of Exhibit 10. In all analyses, the parameters estimation is reported with Newey-West standard errors.

EXHIBIT 9 HERE

The results in Exhibit 9 indicate that the aggregated fund flow to all VIX ETPs has no statistically significant impacts on the VIX index, even during market turmoil periods. On the other hand, the time dummy, which captures periods with extremely negative returns, and the shift in VIX future price term structure, exhibit significant positive effects on the VIX index. A higher $\Delta CB17_t$ is associated with a more pronounced shift in VIX futures term structure from contango to backwardation. The results suggest that a higher VIX index value is more likely to occur when the equity market plunges to its lowest 5% based on the data over the study period and when the VIX futures term structure changes to backwardation from contango. The lagged VIX futures price has significant negative impacts on VIX index change.

EXHIBIT 10 HERE

Panel A of Exhibit 10 presents the results of the models with VIX ETPs categorized into two groups, namely normal and inverse, which are based on their strategies. The

results in Panel A of Exhibit 10 are consistent with our hypothesis. The fund flow to the normal (inverse) VIX ETP group has a statistically significantly positive (negative) impact on the VIX index. However, the interaction terms are not significant, which is in contrast to our hypothesis that the effect of fund flow to the inverse VIX ETP group is more pronounced during market turmoil periods. Other variables retain the same sign as in the aggregate model discussed above (see Exhibit 9). The time dummy and the shift in the VIX futures term structure factor have significant positive impacts, while the lagged VIX futures price impose a significant negative effect on VIX index change.

Panel B of Exhibit 10 presents the results of the models with VIX ETPs categorized into three groups, namely normal-short, normal-mid and inverse-short.[13] In line with our hypothesis, the fund flow to the normal-short (inverse short) group has a statistically significant positive (negative) impact on the daily change of the VIX index. The fund flow to the normal-mid group is no longer significant when the interaction terms, the time dummy and the shift in the VIX futures term structure entered the model. The effects of other variables are consistent with the results featured in Panel A of Exhibit 10.

6. Conclusion

This study examines the fund flows to VIX exchange-traded products (ETPs) and focuses on their effects on the underlying volatility index during the period January 2009–December 2015. Our empirical findings suggest that investors have more incentives to take long positions in VIX ETP groups which apply normal tracking strategies when the equity market is calm. Analogously, when the equity market is highly volatile, investors tend to be long in VIX ETP groups which apply inverse tracking strategies. These findings provide supportive evidence that market participants expect the VIX index to move in a mean-reverse way (Whaley [2008]; Leung, Li, Li and Wang [2016]).

The important contribution of this paper is the fact that it provides arguments for discussion on the implication of the rapid growth of VIX-linked exchange-traded

[13] Due to limited observations, the inverse-mid group is excluded from the sample used to run the models, with results featured in Panel B of Exhibit 10.

products. Market regulators and financial media are concerned that financial innovations such as VIX ETFs and ETNs may cause instability on the equity and derivatives market during crisis periods. In 2015, the Security and Exchange Commission was concerned how the ETP can affect underlying market (see SEC's File No. S7-11-15 including the question 17). Our results indicate that the fund flows into different VIX ETP groups have statistically significant impacts on the VIX index. More specifically, the fund flow to the normal (inverse) VIX ETP groups has a significant positive (negative) effect on the VIX index. However, in contrast to expectations formulated by financial press, we find that that the funds flow to VIX ETPs do not have additional statistically significant impact on level of VIX index during high volatility times.

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Exhibit 1 Characteristics of ETFs and ETNs

This table presents an overview of the prevailing VIX exchange-traded funds and VIX exchange-traded notes (sourced from Bloomberg on 31 December 2015).

Name	Ticker	Market Cap (in millions)	Tracking Strategy	Fund Type	Inception Date	Underlying Index	Price	Expense Ratio	Turnover (in millions)
AccuShares Spot CBOE VIX Down Shares	VXDN	3.50	Inverse	ETF	5/19/2015	CBOE Volatility Index (VIX)	15.00	0.95%	0.009
AccuShares Spot CBOE VIX Up Shares	VXUP	2.77	Normal	ETF	5/19/2015	CBOE Volatility Index (VIX)	12.30	0.95%	0.018
ETRACS Daily Long-Short VIX ETN	XVIX	11.96	Normal	ETN	11/30/2012	S&P 500 Index VIX Term-Structure Excess Return	15.60	0.85%	0.028
First Trust CBOE S&P 500 VIX Tail Hedge Fund	VIXH	3.63	Normal	ETF	8/30/2012	CBOE VIX Tail Hedge Index	21.77	0.60%	0.018
iPath Inverse S&P 500 VIX Short-Term Futures ETN	XXV	0.75	Inverse	ETN	7/16/2010	S&P 500 VIX Short-Term Future Index	38.04	0.89%	0.008
The iPath S&P 500 Dynamic VIX ETN	XVZ	9.16	Normal	ETN	8/17/2011	S&P 500 Dynamic VIX Futures TR Index	27.27	0.95%	0.074
iPATH S&P 500 VIX Mid-Term Futures ETN	VXZ	38.43	Normal	ETN	1/29/2009	S&P 500 Mid-Term VIX Futures TR Index	13.04	0.89%	13.966
iPath S&P 500 VIX Short-Term Futures ETN	VXX	760.71	Normal	ETN	1/29/2009	S&P 500 Short-Term VIX Futures TR Index	27.52	0.89%	2945.351
ProShares Short VIX Short-Term Futures	SVXY	628.10	Inverse	ETF	10/4/2011	S&P 500 Short-Term VIX Futures Index	33.92	0.95%	384.764
ProShares Ultra VIX Short-Term Futures	UVXY	565.67	Twice	ETF	10/2/2011	S&P 500 Short-Term VIX Futures Index	49.63	0.95%	1543.228
ProShares VIX Mid-Term Futures ETF	VIXM	27.66	Normal	ETF	1/4/2011	S&P 500 Mid-Term VIX Futures Index	63.34	0.85%	1.475
ProShares VIX Short-Term Futures ETF	VIXY	105.97	Normal	ETF	1/4/2011	S&P 500 Short-Term VIX Futures Index	18.24	0.85%	72.812
VelocityShares Daily 2x VIX Medium Term ETN	TVIZ	1.53	Twice	ETN	11/29/2010	S&P 500 Mid-Term VIX Futures Index	18.81	1.65%	0.006
VelocityShares Daily 2x VIX Short Term ETN	TVIX	299.24	Twice	ETN	11/29/2010	S&P 500 Short-Term VIX Futures Index	10.89	1.65%	431.748
VelocityShares Daily Inverse VIX Medium Term ETN	ZIV	103.81	Inverse	ETN	11/29/2010	S&P 500 Mid-Term VIX Futures Index	34.53	1.35%	1.541
VelocityShares Daily Inverse VIX Short-Term ETN	XIV	1012.11	Inverse	ETN	11/29/2010	S&P 500 Short-Term VIX Futures Index	17.37	1.35%	658.270
VelocityShares VIX Medium Term ETN	VIIZ	0.62	Normal	ETN	11/29/2010	S&P 500 Mid-Term VIX Futures Index	17.81	0.89%	0.007
VelocityShares VIX Short Term ETN	VIIX	9.38	Normal	ETN	11/29/2010	S&P 500 Short-Term VIX Futures Index	37.26	0.89%	11.148

The *tracking strategy* indicates how exchange-traded products provide investors with a cash payment at the scheduled maturity or early redemption. For instance, a *Twice* tracking strategy indicates that the exchange-traded fund (note) will provide its investors with a cash payment at the scheduled maturity or early redemption based on 2X the performance of its underlying index. *Turnover* is defined as Turnover / Traded Value according to Bloomberg, which represents the sum of all trade prices, multiplied by the number of shares related to each price.

Exhibit 2 Summary statistics for models' variables

This table presents the definition and statistical summary of the variables employed in the models. The most traded VIX ETF groups are the normal-short and inverse-shot groups, which have the highest market capitalization and high net fund flows.

Variables	Definition	Obs	Mean	Std. Dev.	Min	Max	Median	10% Percentile	90% Percentile
ChgVIX	Daily percentage change of VIX Index	1926	0.0025	0.0755	-0.2957	0.5000	-0.0063	-0.0760	0.0898
ΔVFX	Daily percentage change of generic 1st VIX future	1926	0.0012	0.0532	-0.2081	0.3098	-0.0067	-0.0539	0.0672
netfflow	Aggregated net fund flow of all VIX ETFs	1672	7.0900	72.5425	-552.2840	611.3002	0.5452	-59.5922	81.5903
inverse_etf_flow	Aggregated net fund flow of all inverse VIX ETFs	1672	0.2548	33.3681	-269.4550	449.1380	0.0000	-17.5230	17.0538
normal_etf_flow	Aggregated net fund flow of all normal VIX ETFs	1672	6.7279	70.3366	-552.2840	424.5397	1.5200	-59.7276	79.3109
normal_short	Aggregated net fund flow of all normal-short VIX ETFs	1672	6.4116	66.9742	-362.5740	418.8950	0.3515	-56.7439	74.9697
normal_mid	Aggregated net fund flow of all normal-mid VIX ETFs	1672	0.3163	18.9778	-375.0530	150.1380	0.0000	-3.4139	5.7396
inverse_short	Aggregated net fund flow of all inverse-short VIX ETFs	1388	0.2712	37.7301	-269.4550	449.1380	0.0000	-25.6501	22.9747
inverse_mid	Aggregated net fund flow of all inverse-mid VIX ETFs	960	0.0751	1.2349	-12.7828	13.6158	0.0000	0.0000	0.0000
CB17	Term structure factor calculated as the ratio of price difference between first front month and 7th front month VIX future over the first front month VIX future price $(Price_1-Price_7)/Price_1$	1913	-0.1763	0.1951	-0.8055	0.5121	-0.2055	-0.3925	0.0954
ΔCB17	Change in term structure factor, calculated as $CB17_t-CB17_{t-1}$	1913	-.0001	0.0493	-0.2414	0.3501	-0.0054	-0.0492	0.0545
Ddown	Time Dummy equals to one when the return of S&P 500 index is lower than its fifth percentile level during the study period	1927	0.0503	0.218697	0	1	0	0	0

Exhibit 3 Return of S&P 500 and net fund flow to VIX ETPs

Exhibit 3 presents the summary statistics for net fund flows to four exchange-traded funds and notes groups: normal-short group, normal-mid group, inverse-short group and inverse-mid group. The net fund flows are summarized based on the different deciles of S&P 500 index returns, Panel A presents the means of net fund flows and Panel B presents the standard deviation of net fund flows for four VIX ETF/ETN groups. Panel A shows the net fund flow into the normal-short group peaked at the fifth decile of S&P 500 index returns, while the fund flow to inverse-short group achieved its highest levels over the periods when the S&P 500 index experienced extreme returns. In Panel B, higher standard deviation levels can be observed over the periods when the S&P 500 index experienced extreme returns for both normal and inverse VIX ETF groups.

Panel A (Mean)

Groups	Mean	1-10th (Low)	11-20th	21-30th	31-40th	41-50th	51-60th	61-70th	71-80th	81-90th	91-100th (High)
Normal Short	6.144	2.9608	-7.2581	3.3666	8.5051	17.8095	16.6448	14.6465	9.6549	-3.6180	-9.3570
Normal Mid	0.303	-0.7874	0.7841	0.3631	1.1774	0.5076	-0.6478	1.4473	0.5959	-1.2884	0.4106
Inverse Short	0.259	14.4328	7.0322	-0.4519	-4.2615	-6.1165	-4.1646	-0.9423	0.2431	0.6202	12.5098
Inverse Mid	0.071	-0.3180	-0.2568	0.1122	-0.0366	0.0956	0.1454	0.2082	0.1133	0.4690	-0.2360

Panel B (Std. Dev.)

Groups	Std Dev.	1-10th (Low)	11-20th	21-30th	31-40th	41-50th	51-60th	61-70th	71-80th	81-90th	91-100th (High)
Normal Short	65.589	71.9578	63.6202	69.6233	64.9948	67.8106	67.5709	53.1456	59.1076	69.5805	77.7791
Normal Mid	18.582	23.1616	17.2052	8.0741	6.8775	31.4368	29.4577	13.1752	7.7786	21.8894	12.1082
Inverse Short	36.904	63.7158	40.0727	24.7741	34.5564	41.8283	29.1457	18.0659	38.0640	41.8319	34.7234
Inverse Mid	1.205	1.3906	1.5245	0.9973	1.2775	0.8434	1.3527	1.4125	0.3725	1.7388	1.0949

Exhibit 4 Net Fund Flows to VIX ETP groups and Equity Market Performance

Exhibit 4 presents the 25th percentile (p25), 75th percentile (p75), mean and median of the fund flows at different deciles of the daily returns of the S&P 500 index. The horizontal axis indicates the level of the daily returns of the S&P 500 index from decile 1 to decile 10.

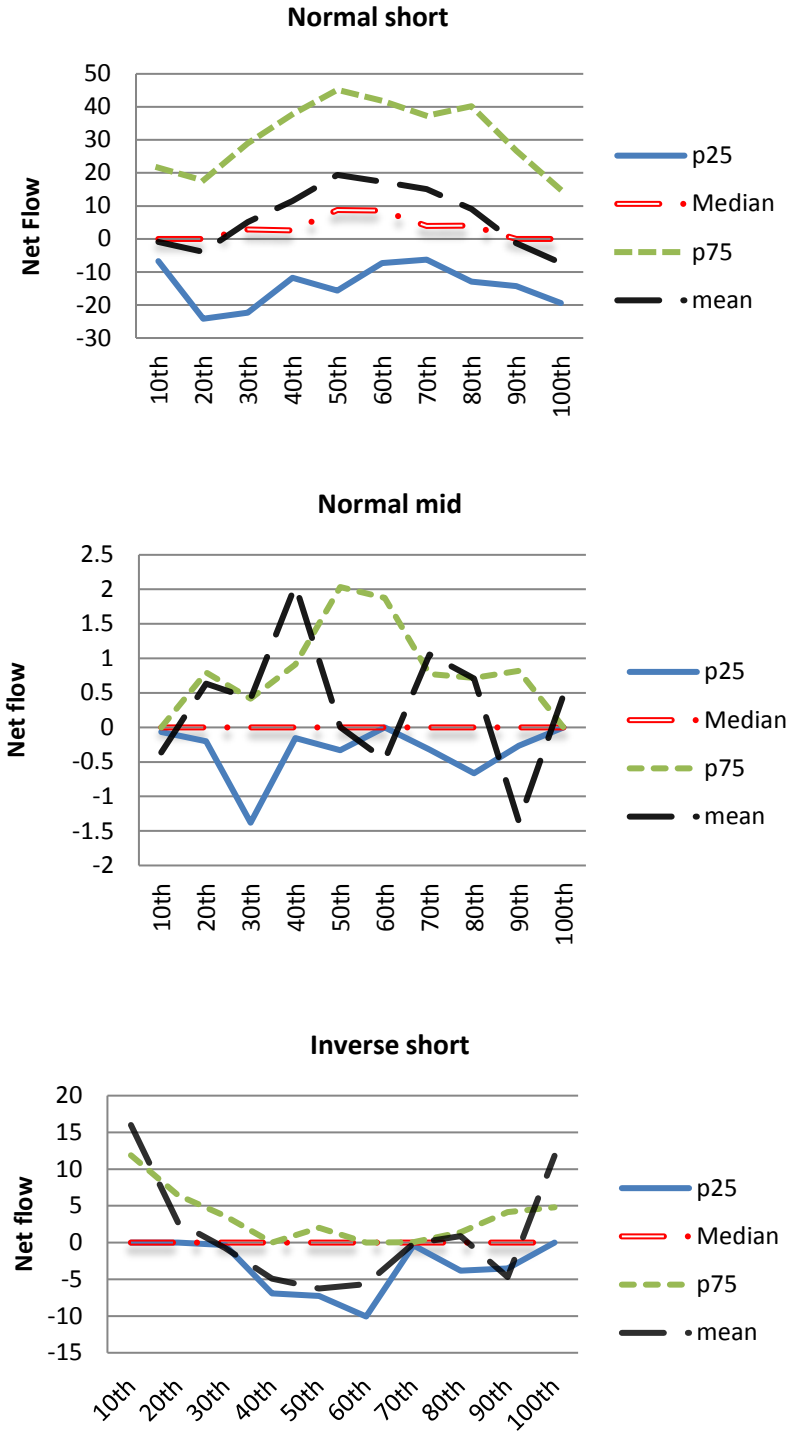

Exhibit 5 Changes in Average Net Fund Flows before and after Market Downturns

Exhibit 5 presents the changes in the average net flows to the four VIX ETF/ETN groups for 10 days before and after the days when the daily return of the S&P 500 index fell lower than -1.5%, which is around the fifth percentile level of the S&P 500 index daily returns observed during the study period. Axis X presents the event days where day "0" is the day when the S&P 500 index fell below -1.5%. There are 78 days with extremely negative returns as defined above.

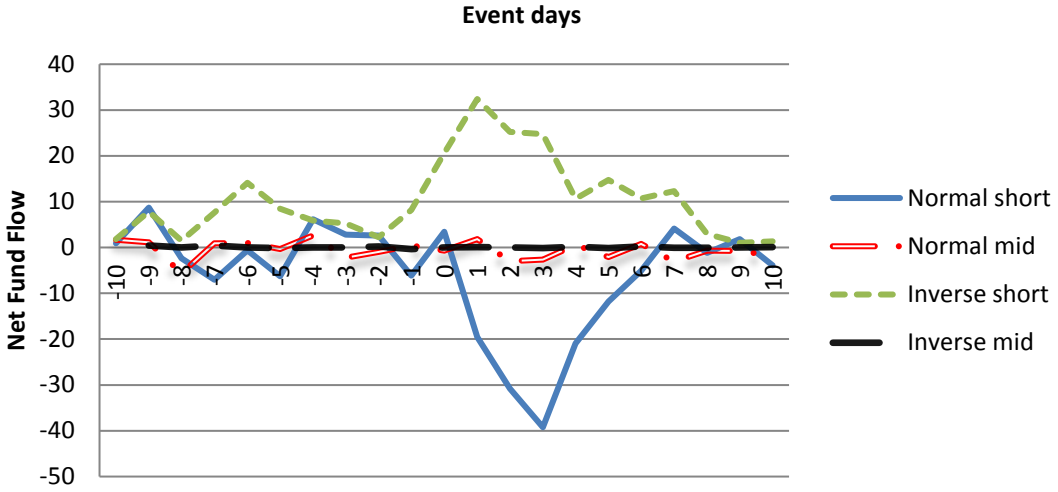

Exhibit 6 Changes in Average Net Fund Flows before and after Market Upturns

Exhibit 6 presents the changes in the net flows to the four VIX ETF/ETN groups for 10 days before and after the days when the daily return of the S&P 500 index was higher than 1.5 percent, which is around the 95th percentile level of the S&P 500 index daily returns observed during the study period. Axis X presents the event days where day "0" is the day when S&P 500 index rose above 1.5 percent. There are 72 days of extremely positive returns as defined above.

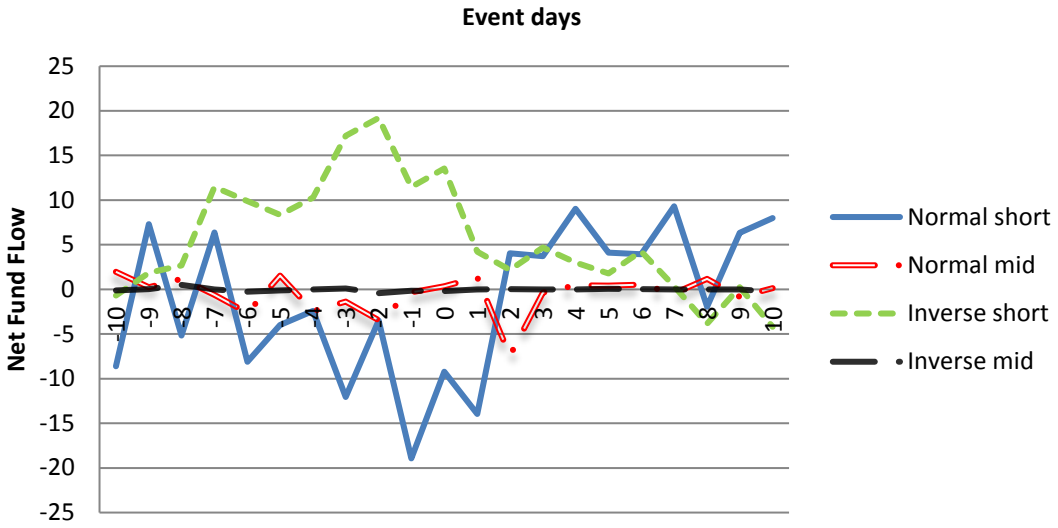

Exhibit 7 VIX Index and net fund flow to VIX ETPs

Exhibit 7 presents the summary statistics for net fund flows to four exchange-traded funds and notes groups: normal-short group, normal-mid group, inverse-short group and inverse-mid group. The net fund flows are summarized based on the different deciles of VIX index. Panel A presents the means of net fund flows and Panel B presents the standard deviation of net fund flows for four VIX ETF/ETN groups. Panel A indicates that the net fund flow to the normal-short group gets its highest positive level when the VIX index is low and the heaviest outflow appears when the VIX index is high, while the net fund flow to inverse-short group shows an opposite trend – deep inflow (outflow) when the VIX index value is high(low). In Panel B, standard deviation of fund flows is found to be higher at the two ends of the distribution for the inverse-short VIX ETF group.

Panel A (Mean)

Groups	Mean	1-10th (Low)	11-20th	21-30th	31-40th	41-50th	51-60th	61-70th	71-80th	81-90th	91-100th (High)
Normal Short	6.144	20.8711	23.8792	16.5448	-5.7747	6.4720	0.7122	7.3500	-1.4035	-3.6672	-15.4757
Normal Mid	0.303	0.0598	0.0690	1.9308	1.4822	-0.9409	2.3011	3.0507	-2.6055	-2.7668	0.4309
Inverse Short	0.259	-10.1255	-12.2512	-1.9216	5.0251	3.4684	8.4641	3.8806	12.3259	8.1191	24.6975
Inverse Mid	0.071	0.2060	0.1960	0.1626	-0.1040	0.0231	-0.1390	-0.2741	0.0000	0.0000	0.0000

Panel B (Std. Dev.)

Groups	Std Dev.	1-10th (Low)	11-20th	21-30th	31-40th	41-50th	51-60th	61-70th	71-80th	81-90th	91-100th (High)
Normal Short	65.589	55.7746	65.5432	78.2627	56.7149	78.8435	72.5231	57.8501	48.7249	63.2013	77.3060
Normal Mid	18.582	3.5386	5.8124	10.9495	15.3976	32.0663	11.8551	17.4937	22.9096	33.8211	6.3830
Inverse Short	36.904	36.9685	42.4271	37.1539	31.6322	22.6499	21.7533	23.4654	46.7610	35.8846	97.0481
Inverse Mid	1.205	1.6817	1.1825	1.3257	0.7952	0.2543	1.0269	1.7397	0.0000	0.0000	0.0000

Exhibit 8 Correlation matrix for model variables

Exhibit 8 presents the correlation between the independent variables employed in the estimation models.

	$ChgVIX_t$	ΔVFX_{t-1}	$Ddown_t$	$\Delta CB17_t$	$normal\_short_{t-1}$	$normal\_mid_{t-1}$	$inverse\_short_{t-1}$	$inverse\_mid_{t-1}$
$ChgVIX_t$	1.0000							
ΔVFX_{t-1}	-0.0650**	1.0000						
$Ddown_t$	0.5153***	0.0221	1.0000					
$\Delta CB17_t$	0.7056***	-0.0254	0.3490***	1.0000				
$normal\_short_{t-1}$	0.0402	0.0390	-0.0452*	0.0125	1.0000			
$normal\_mid_{t-1}$	0.0312	-0.0315	0.0110	0.0290	0.0108	1.0000		
$inverse\_short_{t-1}$	-0.0675**	0.0455*	0.0631**	-0.0137	-0.2182***	0.0089	1.0000	
$inverse\_mid_{t-1}$	-0.0163	-0.0379	-0.0640**	-0.0132	0.0143	0.0359	0.0227	1.0000

*,**,*** corresponds to statistically significance at the 10 percent, 5 percent and 1percent level, respectively.

Exhibit 9 The impact of aggregated money flow to VIX ETPs on the VIX index

	(1)	(2)	(3)	(4)
Aggr Fund Flow$_{t-1}$	0.0135	0.0212	0.0014	0.0096
	(0.43)	(0.78)	(0.07)	(0.51)
Ddown$_t$* Aggr Fund Flow $_{t-1}$		-0.0572	0.0891	-0.0006
		(-0.23)	(0.25)	(-0.00)
ΔVFX$_{t-1}$	-0.0938*	-0.1110***	-0.0669*	-0.0816**
	(-1.79)	(-2.74)	(-1.76)	(-2.54)
Ddown$_t$		0.1817***		0.1082***
		(12.30)		(8.69)
ΔCB17 $_t$			1.0630***	0.9002***
			(12.93)	(12.33)
Adj R-squared	0.003	0.2698	0.5827	0.5824
Observations	1387	1387	1387	1387

The dependent variable is the daily percentage change of the VIX index value. The main explanatory variable is aggregated fund flow of all VIX-related exchange-traded funds and notes. ΔVFX_{t-1} is the percentage change in the daily price of VIX futures with a one-day lag; $CB17_t$ is the VIX futures term structure item, calculated as the ratio of price difference between the first front-month and seventh front-month VIX future over the first front-month VIX future price; $\Delta CB17$ is defined as the change in VIX futures term structure item, calculated as the difference between $CB17_t$ and $CB17_{t-1}$; $Ddown_t$ is the time dummy, which equals to one when the return of the S&P 500 index is lower than its fifth percentile level during the study period. The columns in Exhibit 9 report the findings with different controls. *t*-statistics are reported in brackets. *,**,*** corresponds to statistically significance at the 10%, 5% and 1% level, respectively.

Exhibit 10 The impact of money flow to VIX ETPs on the VIX index

Panel A	(1)	(2)	(3)
Normal Fund Flow $_{t-1}$	0.0369	0.0537**	0.0400**
	(1.17)	(1.98)	(2.42)
Inverse Fund Flow $_{t-1}$	-0.1134*	-0.1697***	-0.1582***
	(-1.76)	(-3.45)	(-3.93)
Ddown $_t$ * Normal Fund Flow $_{t-1}$			-0.0731
			(-0.26)
Ddown $_t$ * Inverse Fund Flow $_{t-1}$			0.3470
			(0.80)
ΔVFX_{t-1}	-0.0910*	-0.1064***	-0.0821***
	(-1.70)	(-2.58)	(-2.62)
Ddown $_t$		0.1840***	0.1067***
		(12.19)	(8.14)
$\Delta CB17_t$			0.8932***
			(12.24)
Observations	1387	1387	1387
Adj R-squared	0.0075	0.2813	0.5907
Panel B	(4)	(5)	(6)
Normal Short Flow $_{t-1}$	0.0315	0.0503*	0.0386**
	(0.96)	(1.79)	(2.24)
Normal Mid Flow $_{t-1}$	0.1512*	0.1199	0.0641
	(1.69)	(1.42)	(1.07)
Inverse Short Flow $_{t-1}$	-0.1154*	-0.1721***	-0.1601***
	(-1.77)	(-3.46)	(-3.94)
Ddown $_t$ * Normal Short Flow $_{t-1}$			-0.0418
			(-0.14)
Ddown $_t$ * Normal Mid Flow $_{t-1}$			-1.3581
			(-1.01)
Ddown $_t$ * Inverse Short Flow $_{t-1}$			0.3671
			(0.85)
ΔVFX_{t-1}	-0.0895*	-0.1055**	-0.0799***
	(-1.66)	(-2.54)	(-2.61)
Ddown $_t$		0.1839***	0.1078***
		(12.17)	(8.07)
$\Delta CB17_t$			0.8927***
			(12.25)
Observations	1387	1387	1387
Adj R-squared	0.0073	0.2810	0.5910

The dependent variable is the daily percentage change of the VIX index value.$\Delta VFX_{t-1}$is the percentage change in the daily price of VIX futures with a one-day lag; $CB17_t$ is the VIX futures term structure item, calculated as the ratio of price difference between the first front-month and seventh front-month VIX future over the first front-month VIX future price; $\Delta CB17$ is defined as the change in VIX futures term structure item, calculated as the difference between $CB17_t$ and $CB17_{t-1}$; $Ddown_t$ is the time dummy, which equals to one when the return of the S&P500 index is lower than its fifth percentile level during the study period. By dividing all VIX ETFs and ETNs into different groups according to their different tracking strategies, Column (1), (2) and (3) present the results of Newey West tests based on two VIX ETF groups: the normal and inverse groups, while columns (4), (5) and (6) present the results of Newey West test

based on three[14] VIX ETF groups: the normal-short, normal-mid and inverse-short groups. *t*-statistics are reported in brackets.*,**,*** corresponds to statistically significance at the 10%, 5% and 1% level, respectively.

[14]According to different tracking strategies, there are four VTX ETF groups: normal-short, normal-mid, inverse-short and inverse-mid. The inverse-mid group is not reported in Exhibit 10 as there is only one VIX ETF in that group, which was issued much later than others and traded at a low level with a small size. Considering the data availability and group size affect, it is not reported in column (4), (5), (6); however, it is included in the "inverse group" reported in column (1), (2), (3).