Retail investors and product confusion: The case of VIX investments

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Preliminary draft

Abstract

VIX exchange-traded products (VIX ETPs) are complex financial products, yet popular among retail investors. This study examines whether retail investors understand VIX ETPs and benefit from using them. I find that retail investors in aggregate lose money and display poor selection and market timing when trading VIX ETPs. Retail trading patterns indicate the mistaken belief that VIX ETPs can be used to trade the VIX index. This highlights product confusion as an important and novel factor underlying retail investors' performance in markets characterized by financial innovation and complexity.

Keywords: Retail investors; Product confusion; Investor sophistication; VIX ETPs; VIX index

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1 Introduction

Since financial investments are an important source of lifetime income, researchers have sought to understand retail investors' investment decisions and performance. The somewhat discouraging results of many studies is that these investments reduce the wealth of retail investors (see, e.g., Barber & Odean (2000, 2001), Barber et al. (2009, 2024) for evidence on stocks and Bauer et al. (2009), Bryzgalova et al. (2023), de Silva et al. (2022) on options). The losses of investors have been linked to a wide range of factors, including overconfidence and high levels of trading (Odean 1999, Barber & Odean 2000, 2001, Grinblatt & Keloharju 2009), investors being sensation seeking (Grinblatt & Keloharju 2009, Barber et al. 2009), issuers' overpricing (Henderson & Pearson 2011, Célérier & Vallée 2017, Vokata 2021), and search costs (Egan 2019, Dorn 2010). There is also some evidence that retail investors are not able to fully exploit the benefits brought about by certain financial innovations. For example, retail investors struggle to exploit the low-cost diversification benefits of passive ETFs (Bhattacharya et al. 2017) and fail to choose the cheapest among S&P 500 index funds (Elton et al. 2004).

The introduction of VIX exchange-traded products (VIX ETPs) constitute another event of financial innovation. Prior to the introduction, retail investors did not have access to the VIX futures market (Whaley 2013, Alexander et al. 2015). From a theoretical perspective, investors would benefit from an increase in the set of possible investments. Empirically, Chen et al. (2011) show that VIX futures contracts result in a significant enlargement of the investment opportunity set emphasizing the diversification benefits of VIX-related instruments. To enhance diversification, investors search for financial instruments that display a low or negative correlation. However, stock correlations are timevarying and tend to increase during market turmoil (Longin & Solnik 2001, Ang & Chen 2002). In this light, VIX ETPs are interesting as they potentially enhance diversification or serve as hedging instruments at times where other asset classes turn out to be more highly correlated.[1] Hence, VIX ETPs are expected to be attractive to retail investors.

While the first VIX ETPs were introduced in 2009 and therefore are still fairly new, they are also complex instruments built on different derivative products and financial indices including the VIX index (see Figure 2). Because of this connection to VIX, investors may perceive VIX ETPs as direct investments in the non-tradable VIX index (such speculations have previously been put forward by, e.g.,

[1] Bangsgaard & Kokholm (2024) show that the negative correlation between SPX futures and VIX futures tends to be more pronounced during periods characterized by a high level of the VIX index.

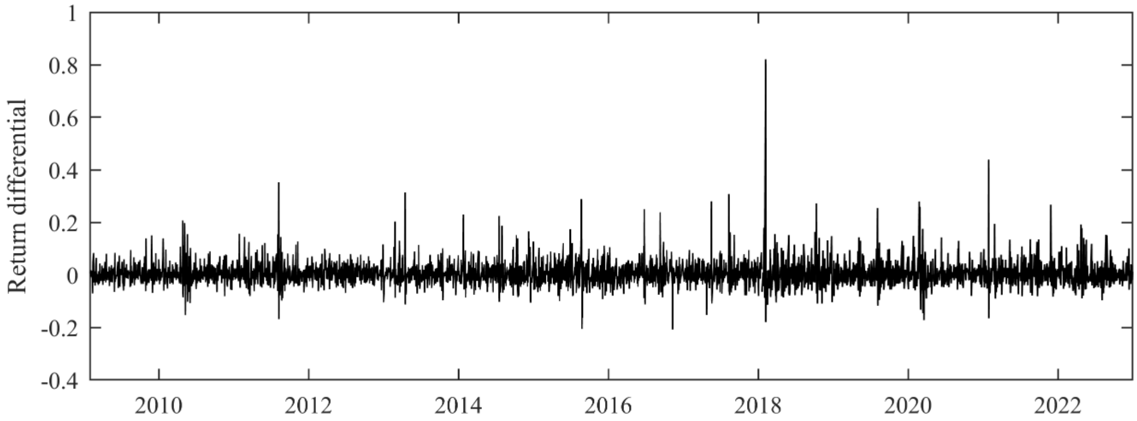

Figure 1: Return differential between the VIX index return and the return on VXX.
The figure shows the daily difference in the return on the VIX index and the return on the VIX ETP called VXX that track the short-term VIX futures index. Technically, the end of the sample shows the return differential for VXXB which is a VIX ETP essentially identical to VXX introduced to replace VXX after its termination.

Whaley (2013)). Instead, the products are more closely linked to the price of VIX futures contracts through a VIX futures index. This is important since the behavior of the VIX futures price and the VIX index therefore differs. Figure 1 illustrates the difference in the daily return on the VIX index and the return on a particular VIX ETP called VXX. As shown, the return differential can be anywhere between -20 and 80 percentage points and on half of the sample days it is at least 2 percentage points in absolute value. The return differential may be better understood by considering the VIX futures settlement. Since a VIX futures contract is settled based on the VIX index, its price largely reflects the expected future value of the VIX index at the expiration of the futures contract. As a consequence, the two may respond differently to the same news depending on whether the news is important for the current level of VIX or the expected future level of VIX. In many cases, new information would be more important for the current level of VIX because the uncertainty causing a high VIX is expected to resolve over time. Thus, the same news leads to a smaller relative increase in the VIX futures price than in the VIX index. At the time where uncertainty is resolved, VIX decreases, but since uncertainty resolution was expected by the market, this new lower level of VIX is already priced in the VIX futures market. Hence, the VIX index displays mean-reversion (Zhang et al. 2010) but the VIX futures price and the VIX ETP prices do not. Given that any anticipated future change in VIX is already reflected in the VIX futures price, and thereby the VIX ETP price, attempts to trade on these predictable patterns of the VIX index via VIX ETPs are not expected to be profitable.

Since VIX ETPs are complex instruments, retail investors could have many flawed beliefs about the nature of these products. In addition to the underlying connection between VIX ETPs and VIX via the settlement of VIX futures contracts, another reason that investors might specifically conflate VIX ETPs with the VIX index is the extensive media attention on the VIX index relative to VIX futures contracts or VIX futures indices. Consequently, heightened investor awareness of VIX increases the likelihood that investors will seek ways to trade it. Along these lines, Barber & Odean (2008) show that attention influences which stocks investors buy, and the findings of Grullon et al. (2004) suggest that firms' advertising attracts investors. The tickers of some of the VIX ETPs are VXX, VIXY, VIIX, TVIX, UVXY, XIV, and SVIX which have similarities with the VIX futures ticker, VX, but could also create associations with the VIX index and enhance the misconception that ETPs actually allow for trading VIX. A related mechanism is studied by Rashes (2001) who shows that stocks with similar tickers display strong return comovement and attributes this to retail investors unintentionally using the incorrect ticker symbol. Reddit posts also indicate that investors suffer from some degree of confusion regarding VIX ETPs. For instance, some investors ask for advice on VIX ETPs that track the VIX index which directly reflect the flawed belief that VIX ETPs can be used to buy and sell the VIX index. While this only serves as anecdotal evidence that retail investors confuse VIX ETPs with the VIX index, this study explores whether product confusion applies more broadly to retail investors in VIX ETPs.

In the context of VIX ETPs, product confusion arises when investors erroneously believe that VIX ETPs are investments in the VIX index. I will refer to an investor with this belief as a naïve investor. The naïve investor's expected profit from trading a VIX ETP is the leverage-scaled VIX index change (the naïve profit) and the expected return is the leverage-scaled return on the VIX index (the naïve return).[2] Through the analysis of retail investors in the VIX ETP market, this study introduces and adds product confusion to the list of factors that can adversely influence the investment performance of retail investors. The notion of product confusion is not restricted to VIX ETPs but could be applicable to other financial instruments particularly when these are complex or new to investors.

Using the methodology of Boehmer et al. (2021), I identify retail investor activity back to the introduction of the first VIX ETPs in early 2009 to December 2022. I find that retail investors in aggregate lose money when trading VIX ETPs. The estimates of retail investor profit show that investors lose both

[2] A VIX ETP is characterized by its leverage ratio which indicates that its daily return is approximately equal to the leverage ratio times the return on the given VIX futures index. Common values of the leverage ratio is one (normal), two (leveraged), or minus one (inverse). The product VXX from Figure 1 is a normal VIX ETP meaning that its naïve return is simply the return on the VIX index.

on the day of trading and with longer holding periods. Over the full sample, the magnitude of aggregate retail loss is $193 million on the day of trading corresponding to an annualized return of -11.09%. With a holding period of one month, losses are nearly $1.5 billion. Losses are not driven by a single event but accumulate over the full sample period. Trades in products from all three leverage categories contribute to the loss for holding periods up to five days but for longer investment horizons the profit from trading inverse products is positive. By regressing the VIX ETP return on the past retail order imbalance, I also show that retail trades are characterized by poor selection and market timing ability.

In contrast to this, the aggregate profit changes sign from negative to positive when computed based on the movements of the VIX index rather than the VIX ETP prices. Since the VIX index is non-tradable, there is no financial instrument available that would allow investors to generate the naïve profit. Likewise, replacing the actual VIX ETP return with the naïve return there are no signs of poor selection and market timing but instead a weak tendency for investors to display some skill in selection and market timing. Hence, the VIX ETP trades of retail investors would have been successful if the products were, in fact, investments in the VIX index. Given the different behavior of VIX futures prices and the VIX index, the actual investment performance which is based on the VIX ETP prices turns out to be highly different from the naïve VIX-based version. Generally speaking, unexpected changes in VIX would lead to a change in both the VIX index and the VIX ETP price. Hence, if the positive naïve profit results from investors predicting changes in VIX that follow from new information, the actual profit is expected to also be positive. Contrarily, if the positive naïve profit results from investors trading ahead of predictable VIX changes, such as those associated with mean-reversion, the actual profit does not have to be positive as the VIX ETP price already incorporates these future movements. For this reason, the positive naïve profit and negative actual profit indicate that investors believe they trade the leverage-scaled VIX index when trading VIX ETPs.

Patterns in aggregate retail order imbalances also indicate that retail investor trading is driven by beliefs of mean-reversion in the VIX ETP price since the order imbalance of normal and leveraged products is lower on days with a greater increase in the VIX index. The opposite applies to inverse products, and the results hold when controlling for both sentiment and a proxy for ambiguity about volatility. Possibly, retail investors want to buy VIX when it has decreased and sell it after an increase because they expect that it will soon revert. This trading pattern is consistent with an anticipated mean-reversion of the VIX index for investors who believe that buying normal and leveraged products is equivalent to buying VIX and buying inverse products is equivalent to selling VIX.

Despite the negative profit, retail investors could still be in the market for VIX ETPs for other reasons. Specifically, if they want to limit the risk of a negative shock to portfolio value in response to spikes in market volatility or stock market crashes, it may be rational ex-ante to pay a premium to insure against such market movements. The insurance is provided through normal and leveraged products, and its cost is reflected by the negative average return on the products.[3] If these products allow for hedging the downside risk of a diversified stock portfolio, risk averse investors would be able to better manage portfolio risk and match their risk tolerance. This can be important since risk aversion influences financial risk-taking (see, e.g., Guiso et al. (2018)). From this perspective, VIX ETPs may have a positive impact on portfolio performance and stock market participation. In order to understand whether the insurance-like characteristic can explain the realized losses, I compute the risk-adjusted return for the portfolio of VIX ETPs traded by retail investors. For retail investor trades in normal and leveraged products, the negative risk-adjusted return suggests that the trading patterns of retail investors generates a VIX ETP loss that is larger than what can be justified by the implicit cost of portfolio protection.

Additional analysis reveals that the results on retail investor performance are not driven by trading costs in the form of the bid-ask spread or driven by the fees charged by VIX ETP issuers. Unlike retail trades, I find that the trades that are not classified as retail trades do not lead to a negative profit, are not subject to poor selection and market timing, and do not generate a negative risk-adjusted return. Accordingly, while retail investors appear unsuccessful in the VIX ETP market, other investors seem to experience different outcomes.

Overall, the empirical evidence of this study points in the direction that retail investors do not capture the potential benefits of VIX ETPs. Conversely, they lose money when trading VIX ETPs. These findings contribute to the discussion of retail investor sophistication and performance in a market for complex financial instruments. The topic is of importance to regulators who have expressed concerns about retail investors' use of VIX ETPs (Financial Industry Regulatory Authority 2017, U.S. Securities and Exchange Commission 2020).

[3] Several studies have documented a negative average return from investing in VIX futures (Szado 2009, Chen et al. 2011, Eraker & Wu 2017). Likewise, substantial negative returns have been documented for normal and leveraged VIX ETPs (Whaley 2013, Eraker & Wu 2017, Christensen et al. 2020). The negative returns on investments with a long volatility exposure reflects a premium for insuring against surges in market volatility (Carr & Wu 2009).

The concept of product confusion differs from what is already described in the literature. When retail investors trade ETFs and try to time the market (Bhattacharya et al. 2017), it does not imply that they do not understand what an ETF is or how it works. They may deliberately pursue market timing although the products were not intended for this. When retail investors accidentally type in the wrong ticker (Rashes 2001), it does not reflect a lack of sophistication but a simple mistake in submitting the order. Likewise, when suboptimally choosing between many close to identical instruments (Dorn 2010), there is not necessarily a link to confusion. Investors may fully understand what the instrument is doing but search costs prevents the investor from choosing the cheapest version of it. All these situations clearly contain some aspect of investment mistakes but they do not arise because retail investors confuse a financial instrument with another instrument or index.

The paper is structured as follows. Section 2 describes VIX-related indices and instruments, including VIX ETPs. In Section 3, I introduce the data used for the empirical analysis. The performance of retail investors in VIX ETPs is analyzed in Section 4. Specifically, Section 4.4 focuses on the product confusion hypothesis. Finally, Section 5 concludes.

2 VIX derivatives and exchange-traded products

In order to understand the VIX ETP market, this section first introduces the VIX index and the VIX futures contracts in Section 2.1 while proceeding to VIX ETPs in Section 2.2. Section 2.3 shows how VIX ETP prices and related indices evolve over the sample period.

2.1 The VIX index and VIX futures

Introduced in 1993 by the Chicago Board Options Exchange (Cboe), the VIX index is a measure of market participants' risk-neutral expectation of the volatility of the S&P 500 index returns over the next 30 calendar days. The index is computed from S&P 500 index options in a model-free manner. The options included in the VIX calculation varies over time to interpolate a volatility measure with a 30 day horizon and to ensure that only out-of-the-money (OTM) options are used. Since the options included and their weighting changes over time, replication of the VIX index is extremely complex to achieve in practice, rendering trading of the VIX index infeasible. As a consequence, the usual cost-of-carry relation between the futures contract and the spot does not exist in the case of VIX futures (Grünbichler

& Longstaff 1996, Zhang et al. 2010). VIX futures contracts were introduced in March 2004 and VIX options in February 2006. They are cash-settled using the value of the VIX index computed from S&P 500 index options during a special opening auction. Let VIX_t denote the time t level of the VIX index and VX_t^i the time t VIX futures price of the ith contract month maturing at T_i. If the contract had been a forward rather than a futures, the payoff from a long position in a VIX futures contract entered at time t with $t \leq T_i$ is $VIX_{T_i} - VX_t^i$ times the notional.

2.2 VIX ETPs

The launch of the first VIX ETPs took place on January 29, 2009, where Barclays introduced VXX and VXZ tracking short-term and mid-term VIX futures indices, respectively. Up to this point, trading of VIX-related instruments was limited to a smaller set of market participants since institutional investors are prohibited from trading directly in VIX futures and options, and most retail investors lack both the size and sophistication to participate directly in the derivatives market (Whaley 2013, Alexander et al. 2015). Thus, the introduction of VIX ETPs made it feasible for retail investors to trade VIX-related instruments.

VIX ETPs are designed to provide investors with a daily return that, before fees, matches the return on a specific VIX futures index. The short-term and mid-term VIX futures indices have a target maturity of one month and five months, respectively. When the VIX ETP is directly tracking the VIX futures index, it has a leverage ratio of 1 (normal VIX ETP), while VIX ETPs with leverage ratios above one, mostly equal to 2, means that they are tracking two times the return on the specified index (leveraged VIX ETP). Finally, a negative leverage ratio, most commonly at -1, implies that the goal is to track the negative of the index return (inverse VIX ETP).

Figure 2 provides an overview of the financial instruments and indices that the VIX ETPs are created from. They are related to the stocks included in the S&P 500 index and a set of additional indices in the following manner: Options are written on the S&P 500 index, which in turn are used to construct another index, the VIX index. As described in Section 2.1, a VIX futures contract is settled based on the VIX index. At a given point in time, VIX futures contracts with different expirations exists. Fixing a target maturity, a weighting of selected VIX futures contracts can be used to create a VIX futures index. To maintain a constant maturity, there is a daily roll from VIX futures contracts of shorter maturities

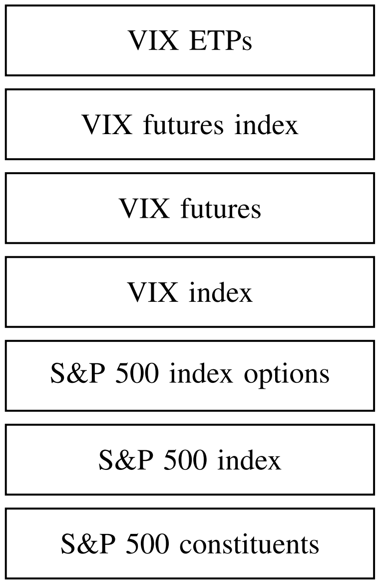

Figure 2: The financial instruments and indices behind VIX ETPs.

to contracts of longer maturities. On each day, the return on the index is computed from the change in the relevant VIX futures prices. Before fees, the VIX ETP issuer aims at generating a daily return that matches the leverage-scaled return on the index.

2.3 The behavior of VIX ETP prices and related indices

To illustrate the relation between VIX ETPs and the VIX index, Figure 3 plots the time series of the VIX index, one-month VIX futures price, short-term VIX futures index, and the price of VXX, which is a short-term VIX ETP with a leverage ratio of one. The one-month VIX futures is not a traded contract but a price series constructed from a weighting of the front-month and second-month VIX futures prices using the same weights as for the VIX futures index ensuring a constant maturity of 30 days (see S&P Dow Jones Indices (2022)). The VIX index and one-month VIX futures price display similar paths. The series appear to exhibit mean-reversion as they revert to lower levels following a spike in volatility. The short-term VIX futures index and price of VXX also increase at times of spikes in volatility, but over long horizons they both exhibit a fairly steep decline in value. It is evident that over longer horizons the evolution of the VIX index and constant maturity VIX futures price is very different from that of the VIX futures index and price of VXX.

Table 1 presents summary statistics for the return on the series displayed in Figure 3. The table

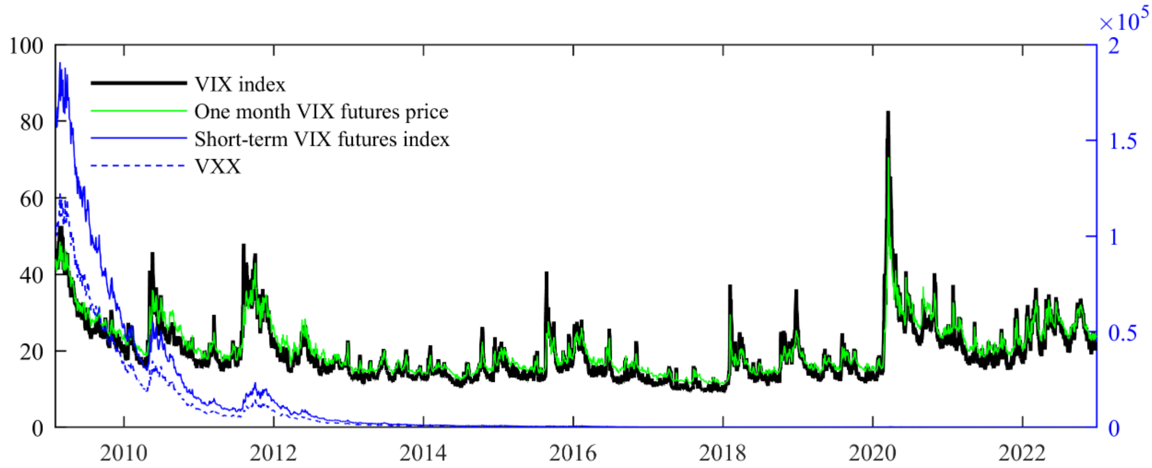

Figure 3: VIX index, one-month VIX futures price, short-term VIX futures index (SPVIXSTR), and the price of VXX.

The one-month VIX futures is not a traded contract but a series constructed from a weighting of the front-month and second-month VIX futures prices using the same weights as for the VIX futures index ensuring a constant maturity of 30 days (see S&P Dow Jones Indices (2022)).

confirms the negative average return on the short-term VIX futures index over the period from January 2009 to December 2022. In contrast, the average return is positive for the VIX index and one-month VIX futures. Table 1 also reports summary statistics for the return on the VIX ETPs confirming the negative average returns for normal and leveraged products and positive average returns for inverse products. For VXX, which has a leverage ratio of one, the daily average return is -23.6 bps, corresponding to an annualized average return of -59.5% ($-0.236\% * 252$). The leveraged product UVXY has a return of -40.4 bps per day or -101.8% annually. For any leverage category, the magnitude of the average return is less severe for the mid-term products. Furthermore, skewness is positive for the normal and leveraged products and negative for the inverse products. Exceptions to these patterns are products which exist for only a short period.

The correlation between the different VIX ETP returns is shown in Table 2. As expected, the correlation of returns for products with the same leverage ratio is close to one and positive across normal and leveraged products, which again are both negatively correlated with the return on inverse products. Correlations across short-term and mid-term products are generally weaker.

Returning to Table 1, it also shows that the return distribution of the VIX index is wider than that of the constant maturity VIX futures contract with more extreme returns at both ends of the distribution. Since the one-month VIX futures price reflects expectations of future spot volatility, it incorporates the

Table 1: Summary statistics on daily returns on VIX ETPs, VIX index, one-month VIX futures, and the short-term VIX futures index.
Returns are in percentages.

Ticker	Mean	Std. dev.	Min	Q1	Med	Q3	Max	Skew	Kurt
VXX	-0.236	3.969	-14.256	-2.436	-0.588	1.441	33.475	1.207	8.529
VXXB	-0.053	4.840	-15.711	-2.700	-0.777	1.708	37.060	1.943	12.099
VIXY	-0.169	4.398	-15.674	-2.554	-0.654	1.553	39.099	1.610	10.810
VIIX	-0.151	4.389	-16.281	-2.501	-0.574	1.479	37.905	1.663	11.498
VMAX	-0.330	4.732	-15.864	-2.631	-0.672	0.980	40.845	2.909	22.766
UVXY	-0.404	7.713	-33.450	-4.538	-1.176	2.581	66.206	1.401	10.101
TVIX	-0.363	8.451	-40.794	-4.716	-1.219	2.649	76.282	1.713	12.847
UVIX	-0.217	7.907	-18.938	-4.784	-2.102	3.361	37.463	1.511	6.975
IVO	-0.247	4.263	-21.469	-1.322	0.229	1.630	12.243	-1.208	8.432
IVOP	0.235	3.698	-18.430	-0.183	0.020	1.014	24.715	0.229	16.896
SVXY	0.131	3.787	-82.957	-1.140	0.465	1.883	13.361	-4.723	89.566
XIV	0.147	4.544	-92.576	-1.537	0.510	2.365	13.178	-5.361	99.783
VMIN	-0.026	5.404	-69.161	-1.177	0.426	2.120	14.212	-5.226	54.311
SVIX	0.073	3.881	-16.519	-1.688	0.874	2.340	9.532	-1.257	5.656
VXZ	-0.099	1.940	-8.212	-1.188	-0.212	0.834	16.215	0.868	7.834
VXZB	0.058	2.316	-15.288	-1.014	0.000	0.719	22.890	2.355	23.062
VIXM	-0.057	2.061	-14.041	-1.201	-0.200	0.844	18.215	1.296	12.516
VIIZ	-0.109	1.839	-5.993	-1.191	-0.186	0.744	12.620	0.953	7.245
TVIZ	-0.253	3.816	-17.273	-2.487	-0.498	1.649	25.392	0.796	7.244
ZIV	0.042	2.124	-18.413	-0.880	0.194	1.164	14.053	-1.390	12.937
VIX index	0.288	8.183	-29.573	-4.263	-0.721	3.537	115.598	2.197	19.852
One-month futures	0.084	4.619	-26.418	-2.291	-0.354	1.916	94.148	3.331	56.538
Short-term index	-0.185	4.710	-25.952	-2.589	-0.708	1.599	96.115	3.498	57.733

Table 2: Correlation of VIX ETP returns.
Correlations are based on daily returns and reported only for the products included in the panel regressions (see Section 3.1).

	VXX	VXXB	VIXY	VIIX	UVXY	TVIX	SVXY	XIV	VXZ	VIXM	ZIV
VXX	1.000										
VXXB	0.971	1.000									
VIXY	0.999	0.975	1.000								
VIIX	0.998	0.988	0.998	1.000							
UVXY	0.990	0.964	0.985	0.986	1.000						
TVIX	0.980	0.976	0.985	0.983	0.977	1.000					
SVXY	-0.870	-0.715	-0.855	-0.858	-0.855	-0.797	1.000				
XIV	-0.860	-0.199	-0.857	-0.857	-0.796	-0.788	0.987	1.000			
VXZ	0.922	0.899	0.923	0.920	0.916	0.909	-0.795	-0.786	1.000		
VIXM	0.922	0.879	0.910	0.913	0.897	0.902	-0.784	-0.802	0.987	1.000	
ZIV	-0.903	-0.887	-0.901	-0.900	-0.881	-0.882	0.809	0.834	-0.959	-0.974	1.000

Table 3: Summary statistics on the daily return differential between leverage-scaled VIX index returns (naïve returns) and VIX ETP returns.

For each product, the difference in returns is computed as $L_i \cdot r_t^{VIX} - r_{i,t}$ and shown in percentages. The column Sign shows the proportion of days where the two returns are of the same sign, and the column Corr shows the correlation between the two returns.

Ticker	Mean	Std. dev.	Min	Q1	Med	Q3	Max	Sign	Corr
VXX	0.500	0.049	-20.780	-2.212	0.023	2.623	82.123	0.833	0.886
VXXB	0.472	0.055	-17.970	-2.571	-0.024	2.577	82.082	0.833	0.881
VIXY	0.498	0.049	-20.914	-2.252	0.031	2.564	81.361	0.846	0.894
VIIX	0.483	0.051	-20.874	-2.358	0.036	2.635	81.545	0.841	0.886
VMAX	0.666	0.060	-20.911	-2.074	0.280	2.998	74.753	0.773	0.851
UVXY	0.920	0.089	-41.486	-3.882	0.078	4.594	164.989	0.844	0.887
TVIX	1.042	0.104	-41.370	-4.801	0.075	5.526	163.196	0.834	0.875
UVIX	0.653	0.064	-14.282	-3.777	-0.424	3.826	25.883	0.858	0.933
IVO	-0.559	0.064	-37.505	-3.168	0.584	3.117	16.151	0.858	0.802
IVOP	-0.304	0.065	-31.972	-2.504	0.184	3.278	19.564	0.696	0.501
SVXY	-0.352	0.045	-83.609	-1.914	-0.007	1.580	102.625	0.842	0.778
XIV	-0.449	0.059	-101.275	-2.646	-0.071	2.185	112.243	0.831	0.716
VMIN	-0.380	0.075	-79.329	-2.904	-0.121	2.315	88.829	0.759	0.606
SVIX	-0.291	0.034	-16.460	-1.930	0.145	2.007	7.715	0.842	0.912
VXZ	0.409	0.068	-23.895	-3.292	-0.219	3.218	99.383	0.764	0.781
VXZB	0.356	0.082	-45.758	-4.002	-0.680	3.149	115.598	0.685	0.571
VIXM	0.385	0.070	-23.519	-3.538	-0.347	3.203	102.130	0.780	0.764
VIIZ	0.376	0.074	-23.567	-3.303	-0.200	3.210	102.978	0.718	0.688
TVIZ	0.858	0.143	-47.255	-7.125	-0.544	6.983	205.804	0.739	0.724
ZIV	-0.417	0.072	-102.871	-3.290	0.224	3.535	28.095	0.765	0.736

anticipated mean-reversion of volatility and, therefore, its movements will generally be less extreme compared to the VIX index. Since the underlying driver of VIX ETP prices is the VIX futures price, this pattern carries over to VIX ETPs. This is confirmed in Table A.1 showing the slope coefficient estimates from regressing the VIX ETP return on the leverage-scaled VIX index return (naïve return). Across all ETPs, the coefficient estimates do not exceed 0.565. For mid-term products, the coefficients are even lower not exceeding 0.187. The fact that the estimates are below one stress the importance of understanding the differences between VIX and VIX ETPs. VIX futures prices largely reflect the expected future level of VIX. When significant news hit the market, VIX may spike but if the news is not expected to have a lasting impact on the level of VIX, the VIX futures price and the VIX ETP price will move less in response to this.

To further examine the difference in the actual VIX ETP return and the leverage-scaled VIX index return (naïve return), Table 3 reports summary statistics on the difference between the naïve and the actual return on each VIX ETP. The lower and upper quartile reveals that for half of the days the majority of the ETPs are characterized by an absolute return differential which is larger than 2-3 percentage points. The maximum values further show that these return differences can be close to 100 percentage points or even greater for several of the ETPs. A positive return differential could represent a situation where VIX increases and the uncertainty that causes a high VIX is expected to be resolved over time. With a quick expected uncertainty resolution, the expected future level of VIX changes much less than the current VIX. As a result, the news that triggered the increase in VIX causes a relatively smaller change in the VIX ETP price. Similarly, a negative return differential could appear at the time the uncertainty is resolved. Since it was expected that the uncertainty would eventually be resolved, the point where uncertainty is resolved, and VIX thus decreases, there is no or only a modest change in the VIX ETP price.

While Figure 3 shows that the long-run behavior of VIX is very different from that of the short-term VIX futures index and the price of the ETP VXX, the daily return differential reveals that the actual and naïve returns vary considerably even at the daily level. Thereby product confusion, i.e. conflating VIX ETPs with the VIX index, can give rise to distinct investment outcomes also at shorter horizons.

3 Data

Section 3.1 and 3.2 introduce the data used for the empirical analysis, while Section 3.3 describes the methodology used for identifying and signing retail trades. In Section 3.4 limitations and advantages of the data are discussed. Finally, summary statistics on retail activity are presented in Section 3.5.

3.1 TAQ data

Trades and quotes are collected from the NYSE Trade and Quote (TAQ) database. The sample period begins with the introduction of the first VIX ETPs on January 29, 2009 and ends on December 30, 2022 covering a total of 3506 trading days. The set of VIX ETPs included is listed in Table 4.[4] For each VIX ETP, I keep the trade data for a given day when it has at least 500 trades. This means that some VIX ETPs will not enter the sample immediately after their introduction but are included at a

[4] Since the tickers of some products change over time, each product does not have a unique ticker. Hence, the initial ticker of a product is reported in Table 4 and used throughout the paper when referring to that product.

Table 4: VIX exchanged-traded products.
Horizon refers to the target maturity of the VIX futures index tracked by the ETP, which is either short-term (ST) or mid-term (MT). Horizon refers to the target maturity of the VIX futures index tracked by the ETP, which is either short-term (ST) or mid-term (MT). Horizon refers to the target maturity of the VIX futures index tracked by the ETP, which is either short-term (ST) or mid-term (MT).

Ticker	Name	Issuer	Type	Horizon	Leverage ratio	First day of trading	Last day of trading
VXX	iPath Series S&P 500 VIX Short Term Futures ETN	Barclays Bank	ETN	ST	1	20090130	20190129
VXXB[a]	iPath Series B S&P 500 VIX Short Term Futures ETN	Barclays Bank	ETN	ST	1	20180118	
VIXY	ProShares VIX Short-Term Futures ETF	ProShares	ETF	ST	1	20110104	
VIIX	VelocityShares Daily Long VIX Short-Term ETN	Credit Suisse	ETN	ST	1	20101130	20200702
VMAX	REX VolMAXX Long VIX Futures Strategy ETF	REX Shares	ETF	ST	1	20160503	20180724
UVXY	ProShares Ultra VIX Short-Term Futures ETF	ProShares	ETF	ST	2[b]	20111004	
TVIX	VelocityShares Daily 2x VIX Short-Term ETN	Credit Suisse	ETN	ST	2	20101130	20200702
UVIX	2x Long VIX Futures ETF	Volatility Shares	ETF	ST	2	20220330	
IVO	iPath Inverse S&P 500 VIX Short-Term Futures ETN	Barclays Bank	ETN	ST	-1	20110114	20110916
IVOP	iPath Inverse S&P 500 VIX Short Term Futures ETN	Barclays Bank	ETN	ST	-1	20110919	20180323
SVXY	ProShares Short VIX Short-Term Futures ETF	ProShares	ETF	ST	-1[b]	20111004	
XIV	VelocityShares Daily Inverse VIX Short-Term ETN	Credit Suisse	ETN	ST	-1	20101130	20180215
VMIN	REX VolMAXX Short VIX Futures Strategy ETF	REX Shares	ETF	ST	-1	20160503	20181126
SVIX	-1x Short VIX Futures ETF	Volatility Shares	ETF	ST	-1	20220330	
VXZ	iPath Series S&P 500 VIX Mid-Term Futures ETN	Barclays Bank	ETN	MT	1	20090130	20190129
VXZB[a]	iPath Series B S&P 500 VIX Mid-Term Futures ETN	Barclays Bank	ETN	MT	1	20180118	
VIXM	ProShares VIX Mid-Term Futures ETF	ProShares	ETF	MT	1	20110104	
VIIZ	VelocityShares Daily Long VIX Medium-Term ETN	Credit Suisse	ETN	MT	1	20101130	20180814
TVIZ	VelocityShares Daily 2x VIX Medium Term ETN	Credit Suisse	ETN	MT	2	20101130	20180814
ZIV	VelocityShares Daily Inverse VIX Medium-Term ETN	Credit Suisse	ETN	MT	-1	20101130	20200702

[a] As of May 2, 2019, VXXB took over the ticker VXX, and VXZB took over the ticker VXZ.
[b] As of February 28, 2018, the target leverage of UVXY was changed from 2 to 1.5 and for SVXY from -1 to -0.5.

later point in time where they have gained a sufficient amount of trading activity. For those days with a sufficient amount of trading, the TAQ data is cleaned according to the procedure outlined in Appendix A.1.1. When constructing the different variables, only data from 9:30am to 4:00pm is used.

For some VIX ETPs, especially those that exist for only a short period of time and the mid-term products, there are generally less days satisfying the condition of a minimum of 500 trades. When there is less than 250 days over the full sample with a sufficient amount of trading, the ticker is excluded completely from all the panel regressions but still included in the rest of the empirical analysis. This results in a smaller sample of 11 tickers with eight short-term products (VXX, VXXB, VIXY, VIIX, UVXY, TVIX, SVXY, XIV) and three mid-term products (VXZ, VIXM, ZIV) giving 20,746 product trading days. This smaller sample consists of both normal, leveraged, and inverse products, thus, representing the entire VIX ETP market. Requiring a minimum of 250 sample days for a given ticker to be included means that a total of only 574 product trading days are removed across all the nine excluded tickers.

3.2 Other data

Daily VIX ETP closing prices and closing midquotes are from Bloomberg. The values of the S&P 500 index and short-term VIX futures index (SPVIXSTR) and mid-term VIX futures index (SPVIXMTR) is also obtained from Bloomberg. The VIX index, VVIX index, and VIX futures prices are retrieved from the Cboe webpage. From Kenneth French's webpage, I collect daily data on the factors of the Fama/French 3-factor model.[5] I also obtain daily values of the US economic policy uncertainty index (EPU) (Baker et al. 2016).[6]

3.3 Identifying marketable retail orders

In many cases, only proprietary data allows for identification of retail orders. Researchers have attempted to overcome the identification issue by often equating small trade size with retail investor activity (see, e.g., Barber et al. (2008)). Later, decimalization and algorithmic trading have changed the financial markets, rendering identification based on trade size less reliable (Boehmer et al. 2021). In the absence of proprietary data, the approach suggested by Boehmer et al. (2021) (BJZZ algorithm) opens up the possibility for classifying marketable orders submitted by retail investors directly from TAQ data.

[5] https://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html
[6] https://www.policyuncertainty.com/index.html

The reasoning behind the BJZZ algorithm is as follows (for further details, see e.g. Boehmer et al. (2021) and Barardehi et al. (2021)). The execution of retail orders typically involves a retail broker where the retail order is placed and a wholesaler, a type of over-the-counter (OTC) market maker, to whom the retail broker typically routes the order. Nearly all retail orders are non-directed, meaning that the retail broker can choose where to execute the order, for instance, by routing it to a wholesaler. When the order is executed or internalized by the wholesaler, it must be reported and displayed in TAQ data with the exchange code "D". Furthermore, retail brokers are required to execute retail orders at the best available price. Wholesalers providing the execution service to retail brokers therefore compete for orders by offering small price improvements relative to the national best bid or offer (NBBO). In contrast to retail orders, institutional orders are usually executed on exchanges or dark pools rather than being internalized and do not receive subpenny price improvements. This implies that marketable retail orders share the unique feature of having exchange code "D" and a price that trades away from a round penny. These are the two features used in the identification strategy of the BJZZ algorithm.

Formally, each retail order is associated with a variable $Z_{i,t,k} = 100 \cdot \text{mod}(P_{i,t,k}, 0.01)$ where $P_{i,t,k}$ denotes the price of the kth retail order of product i recorded on day t, such that $Z_{i,t,k} \in [0,1)$ measures the fraction of a penny for the price. When determining the direction of the trade, buyer-initiated (seller-initiated) retail trades are expected to have a price just below (above) a round penny. The trade is therefore labelled as seller-initiated when $Z_{i,t,k} \in (0,0.4)$ and as buyer-initiated when $Z_{i,t,k} \in (0.6,1)$.

As in Boehmer et al. (2021), the direction of retail investor trading in VIX ETP i during day t is measured relative to the total marketable retail investor activity as

$$mroibvol_{i,t} = \frac{mrbvol_{i,t} - mrsvol_{i,t}}{mrbvol_{i,t} + mrsvol_{i,t}}, \tag{1}$$

$$mroibtrd_{i,t} = \frac{mrbtrd_{i,t} - mrstrd_{i,t}}{mrbtrd_{i,t} + mrstrd_{i,t}} \tag{2}$$

using trading volume and number of trades, respectively. Here $mrbvol_{i,t}$ ($mrsvol_{i,t}$) is the sum of the trading volume associated with buyer-initiated (seller-initiated) retail trades on day t for product i and likewise for $mrbtrd_{i,t}$ and $mrstrd_{i,t}$ when the summation is based on the number of trades. The proportion of retail activity relative to the total activity is defined as

$$mrpvol_{i,t} = \frac{mrbvol_{i,t} + mrsvol_{i,t}}{vol_{i,t}}, \tag{3}$$

$$mrptrd_{i,t} = \frac{mrbtrd_{i,t} + mrstrd_{i,t}}{trd_{i,t}} \tag{4}$$

where $vol_{i,t}$ and $trd_{i,t}$ denotes the total trading volume and total number of trades, respectively, including trades that are not marketable retail orders.

3.4 Discussion of the data

The BJZZ algorithm proposes a solution to an important barrier in analyzing retail investor behavior as it suggests a method for the identification of retail trades from data which is available to most researchers. With fragmented markets, one of the advantages of TAQ data is that it contains all retail trades as opposed to proprietary data which is typically available only from a single retail broker and thereby contain only a subset of the retail investors trading VIX ETPs. In addition, TAQ data contains information on all trades, not just retail trades.

Although it is possible to identify retail trades with the BJZZ algorithm, an important limitation of TAQ data is that we do not observe which retail investors are involved in which trades. In principle, a single retail investor could be responsible for all trades. Hence, we do not know how many different retail investors engage in trading VIX ETPs, how often each investor trades, when they close their positions, etc. Since the individual investors cannot be identified, the results of this study reflect the aggregate behavior and performance of retail investors. Large differences can exist within this group. Some retail investors could be sophisticated and profit from their trades while others are less skilled and incur losses. Such heterogeneity is found among retail investors in the equity market (Ivković et al. 2008, Jones et al. 2025, Coval et al. 2021, Barber et al. 2024) and in the option market where Bauer et al. (2009) show that a subset of retail investors consistently outperform the market and other retail investors.

The rest of the retail investor's portfolio is also not revealed by the data. Therefore, we cannot observe whether retail investors use VIX ETPs in combination with well-diversified portfolios or what impact VIX ETPs potentially have on the portfolio composition, performance, and risk taking. For this reason, only the direct impact of VIX ETP trading can be analyzed while any indirect effect that the products may have at the portfolio level cannot be identified. However, retail investors have a tendency to hold under-diversified portfolios (Goetzmann & Kumar 2008), have a preference for realizing winners rather than losers (disposition effect) (Odean 1998, Grinblatt & Keloharju 2001), and suffer from mental accounting (Thaler 1999). Hence, they often struggle to evaluate investment decisions from a portfolio perspective. If VIX ETPs are traded by investors who also hold, e.g., a portfolio of stocks, the indirect effect from using VIX ETPs becomes more important to assess the overall benefits of using the products. On the other hand, measuring only the direct effect is less critical when investors, in addition to the VIX ETPs, hold few or no other financial instruments.

Another potential drawback of relying on TAQ data for the relevant products is that it contains information only on investors who actually trade the given product. Not every retail investor will trade VIX ETPs, so the results apply only to the group of investors who choose to do so. Thus, it is also not possible to compare investors who trade VIX ETPs with investors who refrain from trading the products. Since the BJZZ algorithm identifies retail investors through trading, the investors who trade more (either through high volumes or number of trades depending on which measure of order imbalance or proportion of retail activity is used) automatically have a greater influence on the results. Trading activity has been shown to vary across investors with overconfident and sensation-seeking investors trading more (Odean 1999, Grinblatt & Keloharju 2009). If these results extend to investors in VIX ETPs, the data is more likely to reflect the behavior of investors with these characteristics.

3.5 Summary statistics on retail activity

Figure 4 shows that on the majority of the sample dates, retail orders make up between 10-15% of the total dollar trading volume in the VIX ETP market. At the beginning of the sample, the share of retail activity is very low but quickly picks up to a level of about 10% by the beginning of 2010. On most days, retail investors' share of dollar volume ranges between 10-20%. For each VIX ETP, Table A.2 shows summary statistics for the share of trading activity coming from retail orders. Together these results reveal that VIX ETPs are not only populated by retail investors and thereby highlight the importance of directly measuring retail activity rather than proxying it by aggregate measures of order imbalance or fund flow.

When focusing on the retail dollar volume, Figure 5 shows the share of retail investor dollar volume

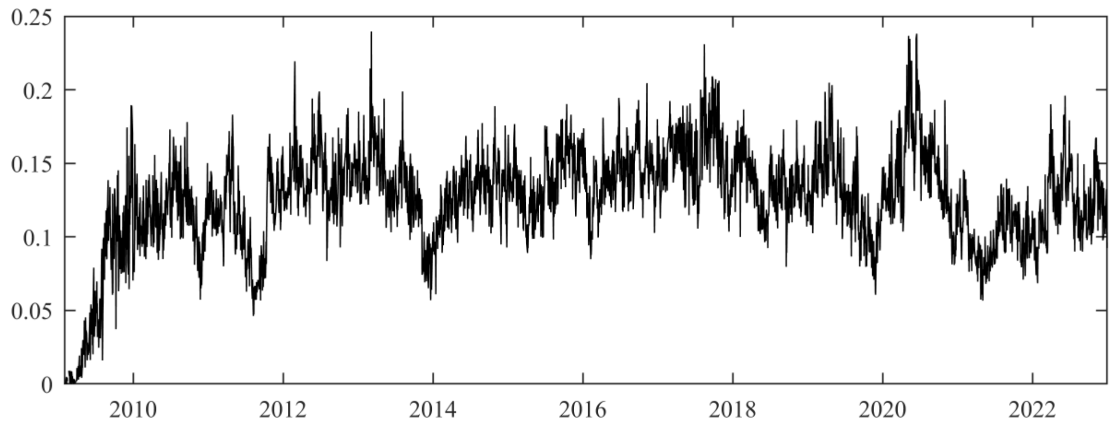

Figure 4: Retail investor share of total dollar volume in VIX ETPs.

split by leverage category.[7] With the VIX ETP market being dominated by normal VIX ETPs in the beginning of the sample, all retail activity stems from this category. From 2011, leveraged and inverse products begin to constitute an increasing share of the total activity, while the share attributed to normal products is reduced to approximately 25% by the beginning of 2018. Particularly, retail investors are active in the inverse products, which is responsible for about half of the retail dollar volume. However, in early 2018, there is a sudden drop to the share of activity in inverse products, which remains relatively constant at a level around 10% throughout the rest of the sample. Instead, retail activity in leveraged products dominates ranging between 40-80%. These patterns indicate that the extreme movements in the VIX index on February 5, 2018, which has later been called Volmageddon, changed retail investors' behavior in the VIX ETP market. OVer the full sample period, it appears that retail investors have become relatively less active in the somewhat simpler products with a direct tracking of VIX futures indices, and that the popularity of the inverse products shifts to the leveraged products following Volmageddon.

4 Retail investor performance

This section analyzes whether retail investors benefit from trading in VIX ETPs and subsequently explores whether investors suffer from product confusion. Section 4.1 quantifies the retail investor profit while selection and market timing is analyzed in Section 4.2 and 4.3. Product confusion is the focus of Section 4.4, while Section 4.5 delves further into the patterns of retail order imbalance. Section 4.6

[7] A plot similar to Figure 5 but split on VIX ETPs with different index horizon reveals that mid-term VIX ETPs make up a very small share of the total retail dollar volume over the sample.

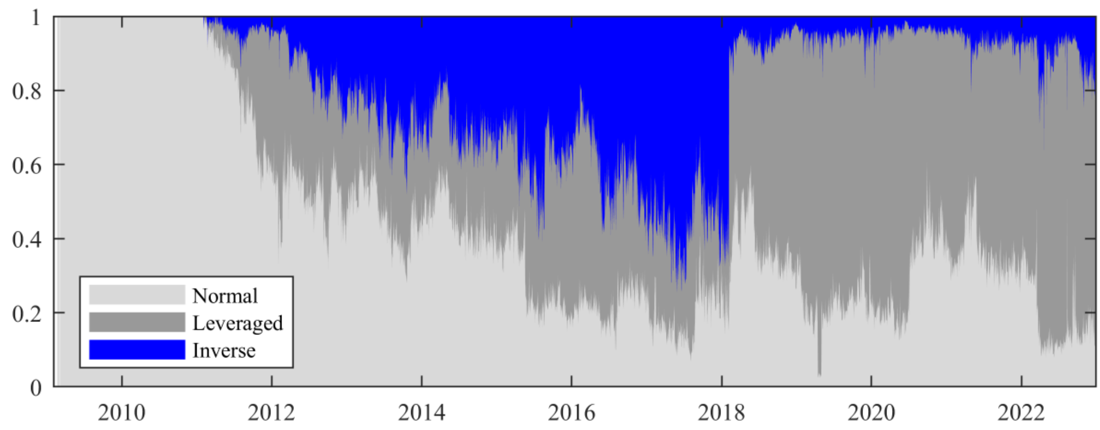

Figure 5: Share of retail investor dollar volume in VIX ETPs with different leverage ratios.

examines the risk-adjusted return of retail investors and a set of robustness checks are performed in Section 4.7.

4.1 Retail investor profit

Analyzing the profitability of trading would often require more detailed data, which allows for identification of the individual investors and their holding periods of the relevant instruments. Despite the limitations of the available data, this section approaches the question of the aggregate profitability of retail investors' trades by focusing on the raw dollar profits from trading over a fixed holding period. The dollar profit of retail investors in the ith VIX ETP based on their trades on day t when the positions are held until the market close h days later is computed as

$$profit^{\$}_{i,t,t+h} = \sum_{k=1}^{K_{i,t}} mrvol_{i,t,k}(P_{i,t+h} - P_{i,t,k})(I^{b}_{i,t,k} - I^{s}_{i,t,k}) \tag{5}$$

where the retail investor of the kth retail order trades a volume equal to $mrvol_{i,t,k}$ at the price, $P_{i,t,k}$, and where $P_{i,t+h}$ denotes the closing price of product i on day $t+h$. $K_{i,t}$ denotes the total number of retail orders of the ith product on day t. The indicator function $I^{b}_{i,t,k}$ ($I^{s}_{i,t,k}$) equals one when the kth trade is classified as a buy (sell) and is zero otherwise. On a given day, the aggregate dollar profit of retail investors across all M VIX ETPs is then given by $\sum_{i=1}^{M} profit^{\$}_{i,t,t+h}$.

Table 5 reports the resulting aggregate retail profit over the full sample period for the day-of-trading and horizons of 1, 5, 10, and 21 days. As shown in Panel A, the day-of-trading profit across all VIX ETPs is negative at a level of $193 million. If the positions are held until the end of the next trading day, retail

Table 5: Aggregate dollar profit of retail investors in VIX ETPs over the sample period.
The column t shows the day-of-trading profit (using trade prices and the closing price on day t), while the column $t+h$ aggregates profit h days ahead (using the closing price on day $t+h$) based on the retail order imbalances of day t. Panel A shows profit across all products, Panel B for products within each leverage category, and Panel C for products tracking an index with the same target maturity. The left part of the table reports the raw dollar profit accumulated over the sample period. The right part of the table shows the equivalent return given by the ratio of the accumulated dollar profit over one half times the difference between total retail dollar volume and total profit.

	Dollar profit (mm$)					Return (%)				
Horizon	t	$t+1$	$t+5$	$t+10$	$t+21$	t	$t+1$	$t+5$	$t+10$	$t+21$
Panel A: All										
	-192.59	-287.89	-594.53	-1106.73	-1484.11	-0.044	-0.066	-0.136	-0.253	-0.339
Panel B: Leverage ratio										
Normal	-53.59	-64.50	-155.46	-329.24	-677.62	-0.038	-0.046	-0.111	-0.235	-0.484
Leveraged	-133.19	-206.89	-425.68	-813.14	-923.54	-0.070	-0.109	-0.224	-0.428	-0.486
Inverse	-5.82	-16.49	-13.39	35.64	117.06	-0.005	-0.015	-0.012	0.033	0.109
Panel C: Index horizon										
Short-term	-191.97	-288.38	-594.45	-1107.44	-1488.79	-0.044	-0.066	-0.136	-0.254	-0.341
Mid-term	-0.63	0.49	-0.08	0.71	4.68	-0.055	0.043	-0.007	0.063	0.411

investors, in aggregate, suffer additional losses of approximately \$95 million ($-\$287.89-(-\$192.59)$). Profit continues to stay negative and grow in magnitude to roughly -\$1.48 billion as the holding period increases to one month. Overall, the results suggest that in aggregate retail investors lose when trading VIX ETPs. These results are not unique for VIX ETPs. Barber et al. (2024) show that, on average, retail investors do not profit from their stock trading and perform poorly on the day of trading.

To gauge the magnitude of the retail profit it is scaled by a measure of the size of the initial investment in order to convert it into a return. Specifically, profit is scaled by the difference of the total retail dollar volume and the profit divided by two.[8] The right part of Table 5 shows the resulting numbers. For the day of trading, the return of -4.4 bps per day is equivalent to an annual loss of 11.09% ($-0.044\% * 252$).

Turning to the split on leverage ratios in Panel B, we see that trades in normal and leveraged products are characterized by losses. For any horizon, it is clear that the aggregate dollar losses are largest for the class of leveraged VIX ETPs. Here, the day-of-trading loss amounts to \$133 million, which is close

[8] As an example, consider a retail investor buying a product at a price of \$120 and later selling it at \$150. The return from the trade is 25% and the profit is \$30. The two trades involved in opening and closing the position both contribute to the total retail dollar trading volume with a total of \$270. Knowing only the dollar trading volume and the dollar profit, it is possible to compute the return as $\$30/((\$270-\$30)/2) = \$30/\$120 = 0.25$.

to 70% of the total day-of-trading loss across all ETPs. Assuming a one month horizon, the number increases to $924 million. Even though losses are smaller in magnitude for inverse products ($5.82 million on the day of trading), the fact that they also lose money on products within this class indicates that even retail investors with more speculative trading motives incur a loss. However, this result only holds for holding periods up to five days. For 10 and 21 days, the profit in inverse products is $36 and $117, respectively. Still, the main result of the table is that retail investors lose when trading VIX ETPs. First, the positive profit in inverse products at longer horizons is small relative to the losses in the other two leverage categories. Second, although the two longer holding periods might match the holding period of some investors, the day-of-trading profit is a more suitable benchmark since it reveals whether retail investors would have been better or worse of by trading at the same day market close instead of the time of the day where their trade execution took place.

When grouping all short-term products, Panel C reveals that most of the total loss can be attributed to retail investors in this set of VIX ETPs which also have a much larger trading activity than mid-term products. The profit for mid-term products is negative for the day of trading but positive for horizons of one, 10, and 21 days. The magnitude of the profit is much smaller compared to short-term products but not in terms of the resulting return on the day of trading which is -5.5 bps relative to -4.4 bps for the short-term products.

Comparing the losses for different leverage ratios and index horizons, it is worth noticing that the magnitude of the raw dollar profits should be seen in the light of the amount of retail investor activity for that subset of VIX ETPs. In order to account for differences in retail activity across the different groupings of the VIX ETPs, the return displayed in the right part of the table is again useful. A comparison of the resulting numbers across leverage ratios shows the same pattern as the return is lowest for leveraged products and highest for inverse products.

Figure 6 reveals how profit accumulates over time by showing the cumulative day-of-trading dollar profit. For VIX ETPs in each leverage category, investors gradually incur losses. Profit remains close to zero in the first part of the sample, where only few products exist, and retail dollar volume is smaller. Although losses are not driven exclusively by a few events, some extreme periods stand out. For instance, retail investors in the inverse VIX ETPs suffered large losses during Volmageddon. Hereafter, retail activity in inverse products was heavily reduced and small relative to the activity in normal and leveraged products, as shown in Figure 5. This can help explain the minimal change in cumulative profit beyond

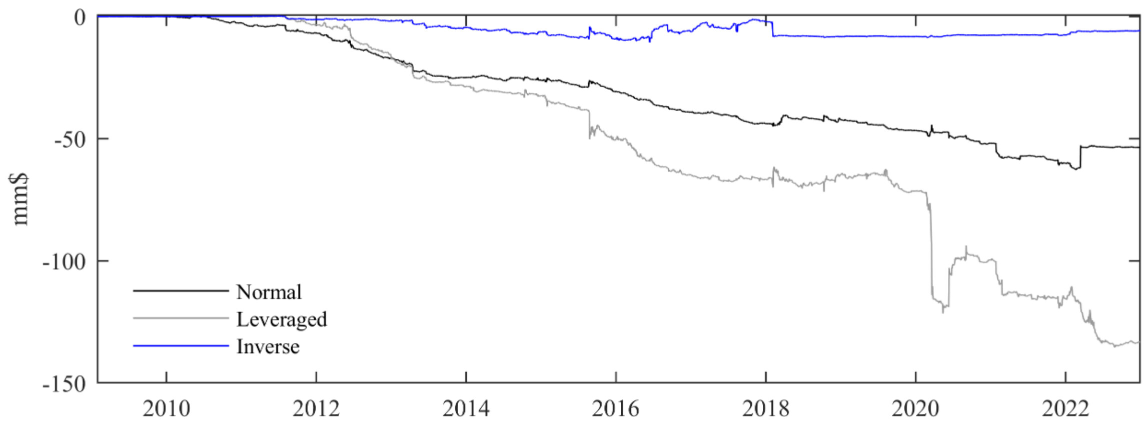

Figure 6: Cumulative day-of-trading dollar profit of retail investors in VIX ETPs.

this point. At the aggregate level, retail investors in leveraged products also suffered large day-of-trading losses in March 2020 with the outbreak of the COVID-19 pandemic. These fluctuations across time underscore the importance of effectively timing investments in the products.

4.2 Selection

Given the set of available VIX ETPs, do retail investors systematically select the better or worse performing products? Using the following panel regression, I focus on this question by analyzing whether the future VIX ETP returns are higher or lower for products which are more heavily bought by retail investors on a given day

$$r_{i,t+h} = \gamma_{t+h} + b \cdot mroib_{i,t} + e_{i,t+h}. \tag{6}$$

With $h = 1$, the model shows the relation between the return on VIX ETP i on day $t+1$, $r_{i,t+1}$, and the retail order imbalance of the VIX ETP measured over day t, $mroib_{i,t}$. A positive value of b implies that on average the next-day return tends to be higher for products where retail order imbalance is high relative to the order imbalance of other products. To assess the selection ability of retail investors, the panel data regression model is estimated using day fixed effects, γ_{t+h}. Standard errors are clustered by product, thereby assuming that observations may be correlated across time within a given product but are independent across products.[9] The same specifications are used for all other panel data regressions

[9] This choice is based on Thompson (2011), who argues that double-clustering is not needed with highly unbalanced panels and that clustering along the dimension with fewer observations should be given higher priority. In my case, the panel data set is highly unbalanced, with the product dimension being much smaller than the time

Table 6: Selection. Relation between retail order imbalance and future VIX ETP returns.
The table reports the estimation results from the model in (6) where the VIX ETP return on day $t+h$ is regressed on the retail order imbalance of day t. Each row of the table shows the estimated coefficient on $mroib_{i,t}$ while changing the dependent variable as indicated by the row names. The coefficient on $mroib_{i,t}$ is shown where it is the only explanatory variable (column (1) and (3)) and when controlling for the lagged VIX ETP return (column (2) and (4)). In column (1) and (2), the retail order imbalance is measured in terms of trading volume, while in column (3) and (4), it is measured using the number of trades. $^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$.

	mroibvol		mroibtrd	
	(1)	(2)	(3)	(4)
$r_{i,t+1}$	-0.0020^{*}	-0.0021^{*}	-0.0037^{***}	-0.0041^{***}
	(-1.7903)	(-1.8983)	(-2.6502)	(-2.9435)
$r_{i,t+2}$	-0.0006	0.0002	-0.0039^{***}	-0.0021
	(-0.5233)	(0.1760)	(-2.8304)	(-1.5440)
$r_{i,t+3}$	-0.0008	-0.0005	-0.0024^{*}	-0.0017
	(-0.7445)	(-0.4817)	(-1.7274)	(-1.2617)
$r_{i,t+4}$	-0.0012	-0.0015	-0.0033^{**}	-0.0040^{***}
	(-1.1369)	(-1.3411)	(-2.4170)	(-2.9054)
$r_{i,t+5}$	-0.0001	-0.0002	-0.0006	-0.0007
	(-0.1284)	(-0.1658)	(-0.4135)	(-0.5035)

of the paper.

The results of the relation between the next-day return and the retail order imbalance are shown in the first row of Table 6. The coefficient on *mroib* is negative in all cases but only significant at a 10% significance level when the volume-based imbalance measure is used. For the trade-based imbalance measure, the coefficient is significant at the 1% level, irrespective of whether we control for lagged VIX ETP returns or not. The negative coefficient on *mroib* indicates that retail investors systematically make mistakes when trading VIX ETPs. At a given point in time, the order imbalance tends to be lower (higher) for the products with higher (lower) returns on the following day. The negative coefficient does not necessarily lead to the conclusion that retail investors lose from their VIX ETP trading but indicates that their selection among the available VIX ETPs is poor.

The magnitude of the coefficient on the trade-based order imbalance is roughly twice that of the volume-based imbalance. The trade-based measure assigns the same weight to all retail trades irrespective of the volume of the trade. Wealthier investors may trade larger volumes per trade and, therefore, have a greater influence on the volume-based relative to the trade-based order imbalance. The smaller magnitude and weaker significance of the coefficient on *mroibvol* would then be consistent with the lit-

dimension.

erature documenting how affluent retail investors are more sophisticated (see, e.g., Calvet et al. (2009)). Furthermore, Grinblatt et al. (2012) show that higher IQ of retail investors is associated with better financial outcomes. If IQ and wealth is positively correlated for retail investors in VIX ETPs, these effects can spill over to the results, with *mroibvol* giving a higher weight to wealthy, high-IQ investors, resulting in a coefficient estimate closer to zero.

The adjusted R-squared for the regression involving the next-day return is far below zero at a level of -0.20. Relative to stocks, the time fixed effects are less likely to result in the same improvements to R-squared for VIX ETPs. Whereas stocks return generally comove somewhat on a given day, the sample of VIX ETPs includes both products with a long and short volatility exposure that, by construction, generate returns that are strongly negatively correlated (see Table 2). For this reason, day fixed effects are unlikely to capture much of the cross-sectional variation in VIX ETP returns. Additionally, the highly unbalanced panel of VIX ETPs means that the number of time fixed effects is high relative to the number of product trading days. Taken together, these factors most likely contribute to the low level of the adjusted R-squared.

Instead of focusing exclusively on the next-day return, Table 6 also shows the estimation results describing the relation between retail order imbalance and the VIX ETP return up to five days ahead. The negative relation persists for some days for the trade-based order imbalance before the coefficient on $mroib_{i,t}$ becomes insignificant. When using the volume-based order imbalance, the coefficient is insignificant when considering returns beyond the next day.

4.3 Market timing

The market timing ability of retail trades is another important dimension of understanding retail investors' performance. For a given product, do retail investors systematically buy relatively more the day before high returns are realized and vice versa? This question can be analyzed using a regression model similar to the on in (6) but including product fixed effects, γ_i, rather than time fixed effects. The regression model is given by

$$r_{i,t+h} = \gamma_i + b \cdot mroib_{i,t} + e_{i,t+h}. \tag{7}$$

Table 7: Market timing. Relation between retail order imbalance and future VIX ETP returns. The table reports the estimation results from the model in (7) where the VIX ETP return on day $t+h$ is regressed on the retail order imbalance of day t. Each row of the table shows the coefficient on $mroib_{i,t}$ while changing the dependent variable as indicated by the row names. The coefficient on $mroib_{i,t}$ is shown where it is the only explanatory variable (column (1) and (3)) and when controlling for the lagged VIX ETP return (column (2) and (4)). In column (1) and (2), the retail order imbalance is measured in terms of trading volume, while in column (3) and (4), it is measured using the number of trades. $^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$.

	mroibvol		mroibtrd	
	(1)	(2)	(3)	(4)
$r_{i,t+1}$	-0.0015	-0.0021^{*}	-0.0034^{**}	-0.0047^{***}
	(-1.2741)	(-1.7411)	(-2.2986)	(-3.1775)
$r_{i,t+2}$	-0.0005	-0.0006	-0.0029^{**}	-0.0030^{**}
	(-0.4434)	(-0.4774)	(-1.9758)	(-2.0379)
$r_{i,t+3}$	-0.0011	-0.0011	-0.0018	-0.0018
	(-0.9057)	(-0.9172)	(-1.2116)	(-1.2613)
$r_{i,t+4}$	-0.0023^{*}	-0.0023^{*}	-0.0023	-0.0023
	(-1.9160)	(-1.9420)	(-1.5381)	(-1.5716)
$r_{i,t+5}$	-0.0014	-0.0014	-0.0003	-0.0004
	(-1.1808)	(-1.2385)	(-0.2240)	(-0.2720)

A positive value of b indicates that retail investors have market timing ability since retail order imbalance is on average higher on days where the future return is high relative to other days with lower order imbalance.

The regression results are shown in Table 7. As indicated by the first row of the table, retail investors have some tendency to systematically mistime trades in VIX ETPs with respect to the next-day return since the estimate of b is negative. As for the results on selection from Section 4.2, the volume-based order imbalance is less significant than the trade-based measure and the magnitude of the estimated coefficients are similar to those of Table 6. Only when controlling for the lagged return in column (2), the coefficient on the volume-based measure is significant at a 10% significance level. For the trade-based order imbalance, the coefficient is significant at a 5% or 1% significance level.

As shown in Table 7, the predictability of returns over the following days is weaker and the sign of the coefficient estimate does not reverse. Again, these patterns are similar to the results on selection. Overall, the results suggest that retail investor trades are characterized by some degree of poor market timing which is not reversed over the next days. Thus, together with poor selection ability, lack of market timing could also contribute to retail investor losses.

4.4 Naïve profit and return

What can explain that retail investors display poor investment performance in VIX ETPs? In this section, I explore whether retail investors suffer from product confusion in the way that they mistakenly believe that they can buy or sell the VIX index by trading VIX ETPs. As described in Section 2.3, the behavior of the VIX ETP price and the VIX index can be very different. In particular, VIX ETPs are not designed to track the VIX index but a VIX futures index. Aligned with this, Tang & Xu (2019) show that VIX ETPs are fairly good at tracking the return on the relevant VIX futures index but not the return on the leverage-scaled VIX index. Ignorant of these features, retail investors potentially confuse the two and believe that it is possible to trade the VIX index through VIX ETPs. In part, confusion may be exacerbated by the media focus on VIX and its mean-reverting nature and the similarity between VIX and the tickers of VIX ETPs. Since the VIX index is not tradable, it is not obvious how to exploit the predictability in the VIX index dynamics. Thus, retail investors could form views about the future movements of VIX which they mistakenly try to express by trading VIX ETPs. Therefore, the leverage-scaled change in the VIX index and return on the VIX index may be viewed as the retail investor's naïve profit and return, respectively.

To examine the product confusion hypothesis, I here analyze the naïve profit and return. Based on retail investors' order imbalance in VIX ETPs, I compute the naïve profit of retail investors, i.e. the profit as it would have been if their VIX ETP trades were in fact trades in the VIX index. The naïve dollar profit of product i on day t based on the investment horizon h is defined as

$$profit^{\$,\text{naïve}}_{i,t,t+h} = \frac{P_{i,t}}{VIX_t} L_i (VIX_{t+h} - VIX_t) \sum_{k=1}^{K_{i,t}} mrvol_{i,t,k} (I^b_{i,t,k} - I^s_{i,t,k}) \tag{8}$$

where VIX_t is the level of the VIX index at close and $P_{i,t}$ the closing price of the product. The ratio $P_{i,t}/VIX_t$ accounts for the fact that VIX ETPs of the same leverage ratio mostly trade at quite different price levels meaning that the change in the VIX index must be scaled accordingly for a meaningful comparison of profit across products.[10]

[10]Take for instance a long position of one share in two different normal VIX ETPs which trade at \$20 and \$100, respectively. If $VIX_t = 20$ and $VIX_{t+h} = 25$, the naïve profit for the product trading at \$20 is \$5, i.e., identical to the change in the VIX index. The naïve profit of the other is \$25 which is five times higher due to the fact that the initial price of the ETP is five times higher. If there is no scaling to account for this, the naïve profit would be the same irrespective of the price of the given ETP which would result in a misleading naïve profit when aggregated across products.

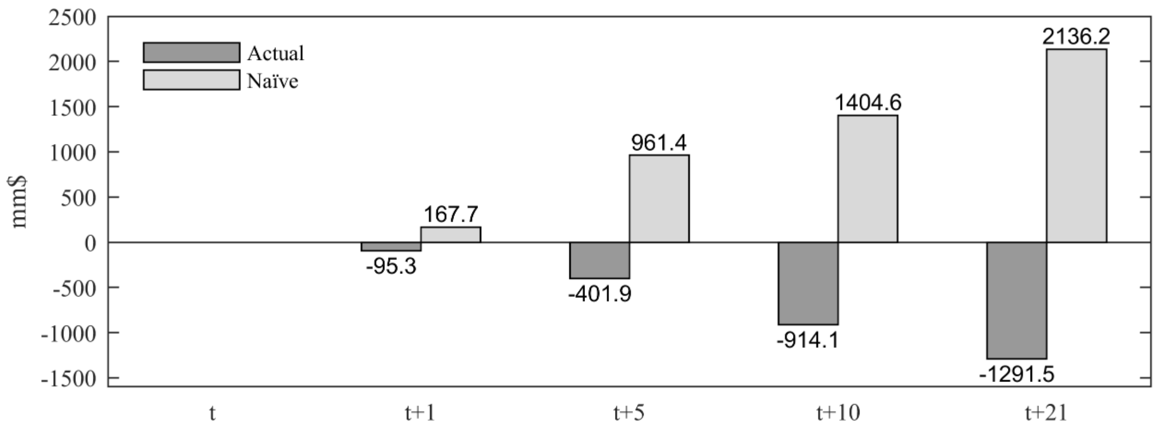

Figure 7: Actual and naïve dollar profit of retail investors in VIX ETPs over the sample period. The dollar profit is aggregated across all products and sample dates. For $t+h$, the profit is computed from the closing price of day t and $t+h$ based on the retail order imbalances of day t. The naïve profit of retail investors in product i is computed as in (8). Without access to intraday data on the VIX index, it is not possible to compute the naïve day-of-trading profit. In order to better compare the actual and naïve profit, the actual day-of-trading profit is ignored here such that the figures on actual profit reported here are identical to those of Table 5 after subtracting the day-of-trading profit.

The aggregate naïve profit is shown for different investment horizons in Figure 7. To highlight the difference in the actual and naïve profit, the actual profit of Section 4.1 is also shown in the figure. For any horizon, the naïve profit is positive indicating that the trades of retail investors would have been profitable if they were trading the VIX index directly. This clearly contrasts the actual losses experienced by retail investors. The positive naïve profit and negative actual profit is consistent with product confusion. When new information arrives, it would generally influence both the VIX index and the VIX ETP price. The difference in the sign of the two profits indicates that retail investors trade to exploit something in VIX which does not influence the VIX ETP price. This could be an expected uncertainty resolution that gives rise to mean-reversion in VIX or any other predictable pattern of the VIX index since this is already priced in the VIX ETP market.

Figure 8 shows the aggregate naïve profit of retail investors separately for each leverage category. The results aggregated across all ETPs, shown in Figure 7, resemble those of the normal and leveraged products. For the inverse products, the same pattern is not visible. The sign of both the actual and naïve profit depends on the holding period and the sign of the two does not necessarily differ. Hence, product confusion does not necessarily apply to retail investors trading inverse ETPs.

The results on selection and market timing from Section 4.2 and 4.3 can also be revisited using the naïve return in place of the actual return. The dependent variable of the regressions in (6) and (7) is

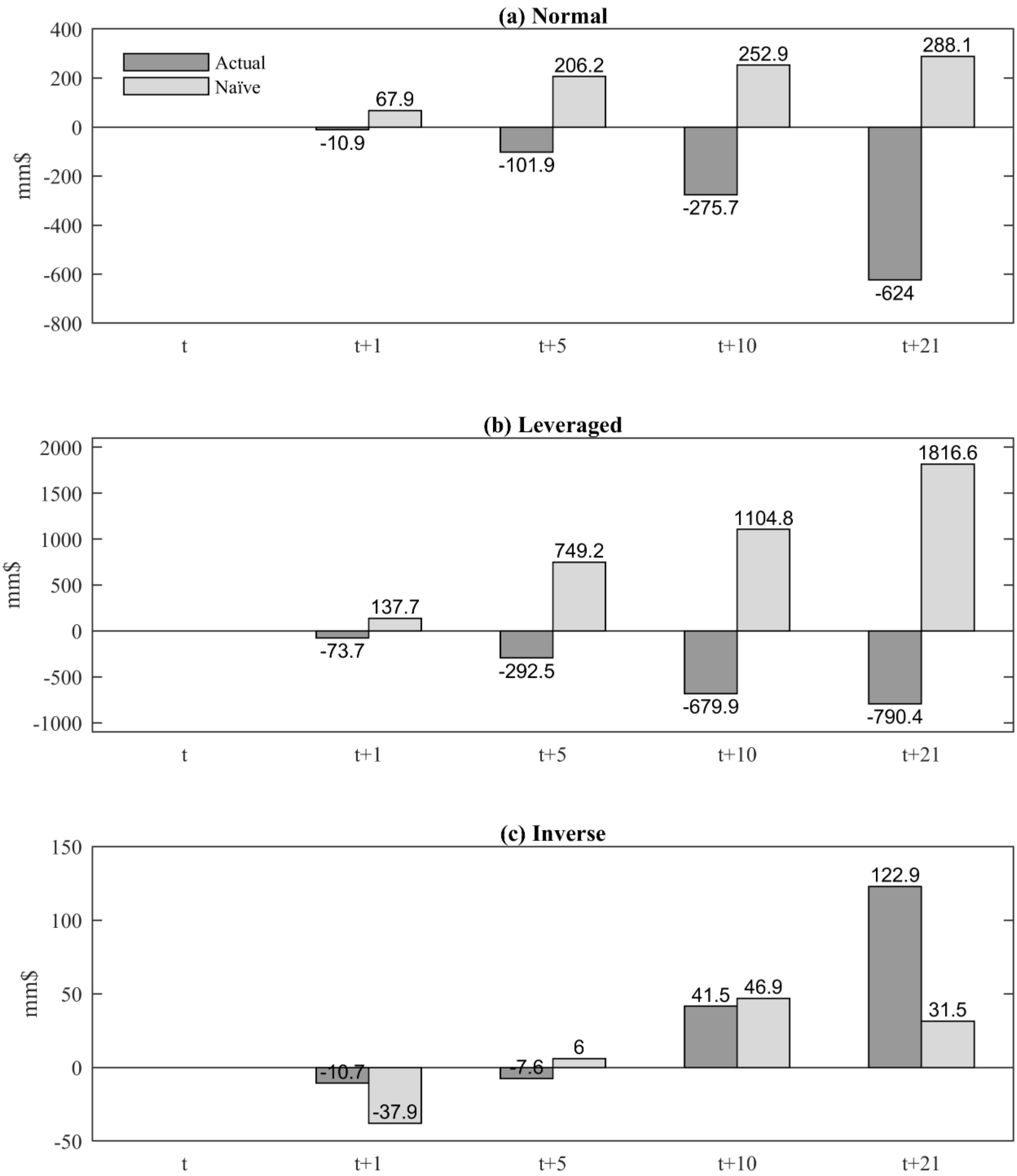

Figure 8: Actual and naïve dollar profit of retail investors in VIX ETPs split by leverage ratio.

therefore replaced by the leverage-scaled VIX index return, $L_i \cdot r_t^{VIX}$, reflecting the naïve return on VIX ETP i. Firstly focusing on selection, the results in Table 8 reveal that the retail order imbalance has a positive relation with the next day leverage-scaled return on the VIX index that is significant at the 1% level when using *mroibtrd*. The sign of the coefficient remains positive but is less significant when controlling for the leverage-scaled VIX index return at time t (column (4)). When order imbalance is measured through *mroibvol*, the coefficients is insignificant except for naïve returns at $t+2$. Although

Table 8: Selection. Relation between retail order imbalance and future naïve returns.
The table reports the estimation results from the model $L_i \cdot r_{t+h}^{VIX} = \gamma_{t+h} + b \cdot mroib_{i,t} + e_{i,t+h}$ where the naïve return (leverage-scaled VIX index return) on day $t+h$ is regressed on the retail order imbalance of day t. Each row of the table shows the coefficient on $mroib_{i,t}$ while changing the dependent variable as indicated by the row names. The coefficient on $mroib_{i,t}$ is shown where it is the only explanatory variable (column (1) and (3)) and when controlling for the lagged naïve return (column (2) and (4)). In column (1) and (2), the retail order imbalance is measured in terms of trading volume, while in column (3) and (4) it is measured using the number of trades. $^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$.

	mroibvol		mroibtrd	
	(1)	(2)	(3)	(4)
$L_i \cdot r_{t+1}^{VIX}$	0.0030	0.0019	0.0082***	0.0049*
	(1.3007)	(0.8029)	(2.8814)	(1.7116)
$L_i \cdot r_{t+2}^{VIX}$	0.0049**	0.0051**	0.0043	0.0047*
	(2.1255)	(2.1997)	(1.4947)	(1.6547)
$L_i \cdot r_{t+3}^{VIX}$	0.0032	0.0035	0.0080***	0.0083***
	(1.3739)	(1.5049)	(2.8271)	(2.9218)
$L_i \cdot r_{t+4}^{VIX}$	0.0024	0.0026	0.0055*	0.0059**
	(1.0425)	(1.1245)	(1.9247)	(2.0931)
$L_i \cdot r_{t+5}^{VIX}$	0.0018	0.0019	0.0062**	0.0066**
	(0.7941)	(0.8589)	(2.2232)	(2.3428)

the results are not strongly significant in all cases, the positive relation is somewhat surprising in light of the negative predictive relation between retail order imbalance and VIX ETP returns documented in Section 4.2. The positive relation suggests that retail investors tend to correctly choose among the available VIX ETPs if their return had instead been given by the leverage-scaled VIX index return. The stronger positive relation detected for the trade-based order imbalance can again be seen in light of the discussion in Section 4.2: With less wealthy retail investors displaying a lower level of sophistication, they may also be at a higher risk of misunderstanding complex financial products such as VIX ETPs.

Turning to market timing, the results shown in Table 9 provide a similar intuition as those on the selection ability of investors. Although the coefficients on the order imbalance is mostly insignificant when the time t leverage-scale VIX index return is included as regressor (column (2) and (4)), it is positive and significant in the univariate regressions of column (1) and (3). This could indicate that retail investors have some ability to time trades in a given product buying more on days with higher next-day returns relative to other days if, however, the actual return on the product would instead have been given by the naïve return.

These results shows that the assessment of retail investor performance differs significantly when

Table 9: Market timing. Relation between retail order imbalance and future naïve returns.
The table reports the estimation results from the model $L_i \cdot r^{VIX}_{t+h} = \gamma_i + b \cdot mroib_{i,t} + e_{i,t+h}$ where the naïve return (leverage-scaled VIX index return) on day $t+h$ is regressed on the retail order imbalance of day t. Each row of the table shows the coefficient on $mroib_{i,t}$ while changing the dependent variable as indicated by the row names. The coefficient on $mroib_{i,t}$ is shown where it is the only explanatory variable (column (1) and (3)) and when controlling for the lagged naïve return (column (2) and (4)). In column (1) and (2), the retail order imbalance is measured in terms of trading volume, while in column (3) and (4) it is measured using the number of trades. $^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$.

	mroibvol		mroibtrd	
	(1)	(2)	(3)	(4)
$L_i \cdot r^{VIX}_{t+1}$	0.0049*	0.0026	0.0093***	0.0043
	(1.7509)	(0.9314)	(2.8907)	(1.3396)
$L_i \cdot r^{VIX}_{t+2}$	0.0054**	0.0046*	0.0047	0.0029
	(1.9797)	(1.6840)	(1.4669)	(0.9032)
$L_i \cdot r^{VIX}_{t+3}$	0.0041	0.0037	0.0081***	0.0074**
	(1.4999)	(1.3556)	(2.5834)	(2.3473)
$L_i \cdot r^{VIX}_{t+4}$	0.0018	0.0004	0.0066**	0.0034
	(0.6771)	(0.1400)	(2.0819)	(1.0887)
$L_i \cdot r^{VIX}_{t+5}$	0.0005	0.0001	0.0063**	0.0055*
	(0.2020)	(0.0448)	(2.0128)	(1.7588)

based on the actual VIX ETP prices and the VIX index, respectively. As hypothesized, the above results on naïve profit, selection, and market timing are consistent with retail investors attempting to exploit the predictable patterns of VIX by trading VIX ETPs which they mistakenly believe is equivalent to trading the VIX index.

If trading in VIX ETPs is unrelated to the VIX index, we would expect that the naïve profit is zero. Hence, the positive naïve profit could indicate that VIX, at least in part, plays a role for investors' VIX ETP trades. In general, using the VIX index as a trading signal does not necessarily hurt investment performance or imply that investors are unsophisticated. Conversely, VIX is an important state variable in many settings, and being able to predict the VIX index most likely leads to highly profitable trades. The important distinction is whether the predictions regarding VIX are associated with unexpected changes in the VIX index which are not anticipated and, therefore, not already priced in the VIX futures market. Changes in VIX that are predictable will already be reflected in the VIX futures market and attempts to trade on this in VIX ETPs are therefore not expected to be profitable.

As an example, retail investors might expect VIX to be mean-reverting such that whenever it is higher or lower than its normal level, it is expected to decrease or increase, respectively. A simple (infeasible) trading strategy that attempts to exploit this by buying the VIX index when it is below its median and selling again when it is above, will result in a positive profit when applied over the sample period.[11] This illustrates that due to the mean-reverting behavior of VIX even simple trading rules can result in a positive naïve profit, albeit the investor not being particularly sophisticated. To further understand how retail investors trade VIX ETPs, I compute the weighted average level of the VIX index for days where the retail order imbalance in normal and leveraged ETPs is positive and negative, respectively. This indicates that on average VIX is lower (higher) on days where retail investor trades are dominated by buying (selling). This pattern would be consistent with retail investors applying the type of simple trading rules described above, i.e., using the products to trade on the mean-reversion of the VIX index by buying low and selling high.

On its own, the positive naïve profit therefore does not imply that investors confuse VIX ETPs with the VIX index. In principle, the positive naïve profit could reflect that retail investors are able to forecast more than the expected VIX changes, i.e., to trade ahead of news that influence VIX. However, under this scenario, we would expect that the actual profit is also positive since they would be able to capitalize on their ability to forecast the unforeseen surges in market volatility by trading VIX ETPs. Thus, the fact that only the naïve profit is positive indicates that investors forecast and trade on some of the already anticipated (and priced) future movements of the VIX index. This supports the presence of product confusion among retail investors as it illustrates that investors do not fully understand that VIX ETPs do not track or replicate the VIX index but are instead based on VIX futures contracts.

4.5 Retail order imbalance

This section further analyzes how retail investors use VIX ETPs by focusing on patterns in retail order imbalance aggregated within each leverage category. The order imbalance is aggregated within each category while weighted by dollar volume. Take for instance normal VIX ETPs for which I define the aggregated retail order imbalance as

$$aggmroib_t^{nor} = \frac{\sum_{i=1}^{M} I_i^{nor} P_{i,t}(mrbvol_{i,t} - mrsvol_{i,t})}{\sum_{i=1}^{M} I_i^{nor} P_{i,t}(mrbvol_{i,t} + mrsvol_{i,t})} \tag{9}$$

[11] Here the median level of VIX is computed over the period January 1, 2005 to January 28, 2009 and the trading strategy is implemented over the sample period used in the rest of the paper, i.e., from January 29, 2009 to December 30, 2022. All of this is based on the closing value of VIX.

where $P_{i,t}$ is the closing price of product i on day t. I_i^{nor} is an indicator function equal to one if the ith product is a normal VIX ETP and is zero otherwise. As reflected by the indicator function, the sum is taken over VIX ETPs with leverage ratios of a given type with similar definitions applying to leveraged ($aggmroib_t^{lev}$) and inverse ($aggmroib_t^{inv}$) products.

The analysis of the aggregate retail order imbalance within each leverage category is carried out by estimating time series regressions of the form

$$aggmroib_t^{nor} = a + \sum_{j=0}^{5} b_j \Delta VIX_{t-j} + \sum_{j=0}^{5} c_j \Delta VVIX_{t-j} + dEPU_t + e_t. \tag{10}$$

where the dependent variable is the aggregate retail order imbalance for normal VIX ETPs using the definition in (9) and similar regressions are estimated with the dependent variable being replaced by $aggmroib_t^{lev}$ and $aggmroib_t^{inv}$. The change in the VIX index is included as an explanatory variable to understand how order imbalance is connected to the VIX index. A pattern that would be consistent with the product confusion hypothesis is that retail investors bet on mean-reversion in VIX by selling (buying) normal and leveraged products following an increase (decrease) in VIX and vice versa for inverse products.

The change in the VVIX index is also included in the regression. Since VVIX is somewhat related to the expected volatility of VIX over the next 30 days, it can help uncover whether uncertainty about the future level of the VIX index influences the use of VIX ETPs. Moreover, VVIX is used as a measure of ambiguity about volatility (see, e.g., Hollstein & Prokopczuk (2018), Huang et al. (2019)), and ambiguity has been shown to influence investment decisions (Dimmock et al. 2016, Kostopoulos et al. 2022, Meyer & Uhr 2024).

Studies have also found that sentiment plays a significant role in retail trading behavior as weaker sentiment tends to be accompanied by an increased tendency to sell (Schmittmann et al. 2015, Kaustia & Rantapuska 2016, Kostopoulos et al. 2020). A widely applied sentiment measure is the FEARS index of Da et al. (2015) which, however, is not available over the full sample period of this study. Instead, I measure sentiment using the economic policy uncertainty index (EPU) following Baker et al. (2016). It is common to view the VIX index itself as a measure of market sentiment. Hence, controlling directly for other sentiment measures such as EPU should help disentangle whether VIX influences order imbalance because it proxies sentiment or because investors trade VIX ETPs attempting to profit from the mean-

Table 10: Determinants of aggregate retail order imbalance.

The table shows the results of the regression in (10) with aggregate order imbalance of normal, leveraged, and inverse products, respectively. The retail order imbalances are aggregated across products within each category of leverage ratios according to (9). The explanatory variables are the change in the VIX index, ΔVIX_t, and the change in the VVIX index, $\Delta VVIX_t$, and five lags hereof. Additionally, the economic policy uncertainty index, EPU_t, is included. All variables are standardized. t-statistics are shown in parentheses and are based on Newey-West standard errors. $^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$.

	$\text{aggmroib}^{\text{nor}}$			$\text{aggmroib}^{\text{lev}}$			$\text{aggmroib}^{\text{inv}}$		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
ΔVIX_t	-0.1504^{***}		-0.1118^{***}	-0.3000^{***}		-0.1695^{***}	0.0829^{**}		0.0920^{**}
	(-5.8519)		(-3.0234)	(-6.4915)		(-3.3569)	(2.5512)		(2.1530)
ΔVIX_{t-1}	-0.1202^{***}		-0.1463^{***}	-0.1167^{***}		-0.1290^{***}	0.1161^{***}		0.1679^{***}
	(-5.4963)		(-3.4321)	(-5.6930)		(-3.8280)	(4.1467)		(3.7802)
ΔVIX_{t-2}	-0.0591^{***}		-0.0567	-0.0751^{***}		-0.0679^{**}	0.1055^{***}		0.1345^{***}
	(-2.8833)		(-1.5938)	(-3.4086)		(-2.0876)	(3.4134)		(2.7725)
ΔVIX_{t-3}	-0.0584^{***}		-0.0822^{**}	-0.0588^{***}		-0.0665^{**}	0.0716^{**}		0.0758
	(-3.1098)		(-2.2343)	(-2.6426)		(-2.1348)	(2.2598)		(1.5070)
ΔVIX_{t-4}	-0.0382^{*}		-0.0690^{*}	-0.0651^{***}		-0.0795^{***}	0.0253		0.0491
	(-1.9571)		(-1.7500)	(-3.6288)		(-3.3154)	(1.0310)		(1.1199)
ΔVIX_{t-5}	-0.0158		-0.0091	-0.0252		-0.0253	0.0202		0.0029
	(-0.7189)		(-0.1987)	(-1.4907)		(-1.0121)	(0.7736)		(0.0755)
$\Delta VVIX_t$		-0.1309^{***}	-0.0544^{**}		-0.2848^{***}	-0.1650^{***}		0.0579^{***}	-0.0031
		(-9.0298)	(-2.0653)		(-10.7648)	(-4.4647)		(2.7355)	(-0.1107)
$\Delta VVIX_{t-1}$		-0.0733^{***}	0.0355		-0.0692^{***}	0.0238		0.0600^{***}	-0.0592^{*}
		(-5.3987)	(1.1384)		(-4.1040)	(0.8470)		(2.9664)	(-1.9065)
$\Delta VVIX_{t-2}$		-0.0519^{***}	-0.0096		-0.0735^{***}	-0.0198		0.0667^{***}	-0.0330
		(-3.8465)	(-0.3556)		(-4.2724)	(-0.7414)		(3.2255)	(-1.0112)
$\Delta VVIX_{t-3}$		-0.0379^{***}	0.0263		-0.0508^{***}	0.0020		0.0581^{***}	-0.0024
		(-3.0504)	(0.9371)		(-2.9730)	(0.0826)		(3.1602)	(-0.0745)
$\Delta VVIX_{t-4}$		-0.0136	0.0402		-0.0405^{**}	0.0193		0.0071	-0.0354
		(-1.0541)	(1.4053)		(-2.3463)	(0.8182)		(0.4021)	(-1.2422)
$\Delta VVIX_{t-5}$		-0.0218^{*}	-0.0125		-0.0331^{**}	-0.0113		0.0276	0.0224
		(-1.7754)	(-0.3445)		(-1.9764)	(-0.4434)		(1.5721)	(0.8017)
EPU_t	-0.0617^{***}	-0.0548^{**}	-0.0612^{**}	-0.0250	-0.0146	-0.0225	0.0060	-0.0008	0.0059
	(-2.5846)	(-2.4465)	(-2.5559)	(-0.8200)	(-0.5335)	(-0.7424)	(0.2187)	(-0.0311)	(0.2117)
Adj. R^2	0.04	0.02	0.04	0.10	0.09	0.11	0.03	0.01	0.03
N	3497	3483	3483	2996	2989	2989	2977	2970	2970

reversion of the VIX index.

Table 10 presents the estimated coefficients of the model in (10). For normal and leveraged products there is a strong and negative relation between the contemporaneous aggregate order imbalance and the change in the VIX index (column (1) and (4)). This observation is consistent with retail investors selling (buying) relatively more when VIX experiences a larger increase (decrease). The same applies for the lagged values of the VIX change but generally with a weaker association as the lag increase. The pattern is aligned with investors betting on mean-reversion of the VIX index when trading VIX ETPs and, therefore, fits under the product confusion hypothesis. If the VIX index had been tradable via VIX ETPs, their order imbalance is in line with an attempt to exploit the expected movements of the VIX index. It could also reflect a situation where retail investors rebalance their VIX ETP position by selling after an increase in VIX if the VIX increase was accompanied by an increase in the VIX ETP price.

I find a similar negative relation between changes in VVIX and the order imbalance meaning that the order imbalance is lower when VVIX increases (column (2) and (5)). Changes in VIX and VVIX display a fairly high correlation of 0.77 so to understand whether ambiguity as measured by VVIX actually is associated with retail order imbalance, column (3) and (6) controls for changes in both indices. The estimates show that the negative contemporaneous relation with $\Delta VVIX$ remains significant meaning that investors tend to sell more on days of increased ambiguity. Thus, retail investors do not only tend to reduce their stock market investment in response to rising ambiguity (Kostopoulos et al. 2022, Meyer & Uhr 2024) but it also seems that their long volatility exposure is reduced.

Column (7)-(9) shows the corresponding results for inverse products. In contrast to the normal and leveraged ETPs, the signs of the estimated coefficients on the lagged VIX and VVIX in (7) and (8), respectively, are now positive. For VIX changes, this suggests the same type of behavior: An investor trying to profit from the predictable VIX changes would tend to buy more in inverse products when VIX is high betting that spot volatility will fall again. When changes in VIX and VVIX are accounted for simultaneously, (9) shows that the relation with the VIX index persists while order imbalance and VVIX innovations seems to be unrelated. To some extend, this finding can be reconciled with retail investor heterogeneity. Kostopoulos et al. (2022) show that while ambiguity averse investors reduce stock market exposure under ambiguity shocks, ambiguity-seeking investors respond by increasing their exposure. Possibly, the different VIX ETPs attract investors with different preferences, and those who seek ambiguity may be more inclined toward inverse products.

Sentiment appears to be related to order imbalance only for normal products. In line with the literature, the negative sign indicates a greater propensity to sell as sentiment deteriorates (Kostopoulos et al. 2020).

4.6 Risk-adjusted returns

Section 4.1 documents that retail investors in VIX ETPs tend to incur losses across all three leverage categories irrespective of the holding period considered. If retail investors' trades are purely speculative, the loss clearly suggests that such speculation is unsuccessful, and it could reflect a lack of sophistication among retail investors. On the other hand, losses can also arise from rational trading motives. Due to liquidity, rebalancing, or tax considerations, it may be optimal for retail investors to trade and incur a loss because it leads to some other positive effect on their portfolio or their total gains from trading. In the context of the stock market, these external factors cannot fully justify the excessive trading of retail investors (Odean 1999, Barber & Odean 2000, Barber et al. 2009).

For VIX ETPs, losses could also be rational due to the insurance against adverse stock market movements and spikes in market volatility provided by products with a long volatility exposure. This means that a loss on the VIX ETP position is compensated through other positive effects on the overall portfolio performance. Therefore, losses do not necessarily imply that retail investors in VIX ETPs are irrational or unsophisticated but could in fact be the result of investors rationally choosing to pay a premium for the insurance. Whether the position in the VIX ETP results in a profit of the retail investor is determined by future market movements, but ex-ante, the decision to buy the insurance could be rational. Since retail investors lose money in the VIX ETP market, it is, therefore, natural to ask whether losses can be justified by the insurance provided by the products. While the loss would indicate that retail investors realize negative returns, returns should approach zero from below once they are adjusted for, e.g., market risk if their trading in the products is driven by a demand for hedging such risks. Rather than focusing on the dollar profits of retail investors, the object of interest is here the return realized by retail investors as it allows for a risk adjustment.[12]

[12] Up to this point, the motivation for using profit as a measure of the actual gains from trading is that it ensures a proper weighting of the dollar gains over time. On the other hand, the actual profit over a given time period is not necessarily reflected in the time series of returns because returns do not capture variations in trading across days. Days of high returns may be associated with low trading volume, resulting in overestimation of the actual gains and vice versa (Barber et al. 2024).

In addition to compensation for exposure to the market risk and the size and value factors of the Fama-French three-factor model, there are studies indicating that the market prices variance risk (Coval & Shumway 2001, Carr & Wu 2009, Bondarenko 2014) and systematic coskewness (Harvey & Siddique 2000). Given the nature of VIX ETP returns, these two factors could be particularly important here. The volatility risk factor is measured as the excess return on the one-month constant maturity VIX futures, $r_t^{VX,1m} - r_t^f$,[13] and coskewness as the square of the market excess return, $(r_t^{mkt} - r_t^f)^2$, following Harvey & Siddique (2000).

The return on the portfolio constructed from retail investor trades in a subset of VIX ETPs, r_{t+1}^p, is the weighted average return on all retail trades in those ETPs executed on day t, assuming that the positions are held until the close on the following day, $t+1$. The return on each retail trade is calculated from the closing price on day t, $P_{i,t}$, and the closing price one day later, $P_{i,t+1}$, and is weighted by the dollar value of the trade relative to the total dollar value of all retail trades across the relevant subset of VIX ETPs on the same day. Specifically, the return is computed as

$$r_{t+1}^p = \sum_{i=1}^{M} \frac{P_{i,t+1} - P_{i,t}}{P_{i,t}} \sum_{k=1}^{K_{i,t}} \frac{mrvol_{i,t,k} P_{i,t}}{\sum_{j=1}^{M} \sum_{g=1}^{K_{j,t}} mrvol_{j,t,g} P_{j,t}} (I_{i,t,k}^b - I_{i,t,k}^s). \tag{11}$$

The risk-adjusted return of retail investors in the VIX ETP market is analyzed from the daily excess return on the portfolio of retail investors, $r_t^p - r_t^f$, where r_t^p is computed separately for the group of normal and leveraged products and for inverse products. Since the day-of-trading return (which is based on the actual retail trading price and the same day closing price) does not reflect the return over a full trading day, I perform no risk-adjustment of this return. Instead, Table 11 simply reports the raw return and the associated t-statistic. The day-of-trading return in normal and leveraged ETPs is -2.81 bps per day and significant at the 1% significant level when the daily returns are weighted by dollar volume. The results are even stronger with equal weighting across sample days. For inverse products, the return is insignificant.

Panel A of Table 12 shows that the risk-adjusted return, α, on the portfolio of normal and leveraged products held by retail investors is significantly negative. The first three model specifications which contains the excess market return as a regressor, reveals that the portfolio return has a negative beta. Despite the negative beta, risk-adjusted returns are negative meaning that they way retail investors trade

[13] Ang et al. (2006) and Eraker & Wu (2017) present alternative ways to construct a volatility risk factor.

Table 11: Day-of-trading return on the retail investor portfolio in normal, leveraged, and inverse VIX ETPs.

The day-of-trading return is obtained based on the trading price of the retail trade, $P_{i,t,k}$, and the closing price on the same day, $P_{i,t}$, as $\sum_{i=1}^{M}\sum_{k=1}^{K_{i,t}} \frac{mrvol_{i,t,k}P_{i,t}}{\sum_{j=1}^{M}\sum_{g=1}^{K_{j,t}} mrvol_{j,t,g}P_{j,t}} \frac{P_{i,t}-P_{i,t,k}}{P_{i,t,k}}(I^{b}_{i,t,k} - I^{s}_{i,t,k})$. Hence, for each day, the return from each retail trade is weighted by retail dollar volume as in (11). The average return across days is obtained either by weighting sample days equally or by retail dollar volume. Returns are daily and reported in percentages. t-statistics are shown in parentheses. $^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$.

	Normal and leveraged VIX ETPs		Inverse VIX ETPs	
	Equal weighted	Dollar volume weighted	Equal weighted	Dollar volume weighted
Avg. return (%)	-0.0306^{***}	-0.0281^{***}	0.0013	-0.0019
t-statistic	(-7.1500)	(-4.1796)	(0.3327)	(-0.3925)

Table 12: Factor regressions for the return on the retail investor portfolio in normal, leveraged, and inverse VIX ETPs.

The results show the risk-adjusted return and loadings on the risk factors for the retail investor portfolio return, $r_t^p - r_t^f$. r_t^p is the weighted average return on the trades of retail investors in normal and leveraged VIX ETPs (Panel A) and inverse VIX ETPs (Panel B), respectively, assuming a holding period of one day obtained from the closing price on the day of trading and the closing price one day later. All variables are in percentages. t-statistics are shown in parentheses and are based on Newey-West standard errors. $^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$.

α	$r_t^{mkt} - r_t^f$	$(r_t^{mkt} - r_t^f)^2$	SMB_t	HML_t	$r_t^{VX,1m} - r_t^f$	Adj. R^2	N
Panel A: Normal and leveraged VIX ETPs							
-0.022^{**}	-0.060^{**}					0.02	3496
(-2.334)	(-2.559)						
-0.014^{*}	-0.062^{***}	-0.005				0.02	3496
(-1.814)	(-2.806)	(-0.956)					
-0.022^{**}	-0.060^{**}		-0.025	0.036^{**}		0.02	3496
(-2.350)	(-2.560)		(-1.342)	(1.964)			
-0.022^{**}					0.017^{**}	0.02	3495
(-2.418)					(2.542)		
-0.021^{**}	-0.027				0.012	0.02	3495
(-2.318)	(-0.840)				(1.302)		
Panel B: Inverse VIX ETPs							
-0.008	0.046					0.02	2983
(-0.999)	(1.490)						
-0.008	0.046	0.000				0.01	2983
(-0.919)	(1.630)	(0.018)					
-0.008	0.046		0.002	0.018		0.02	2983
(-0.996)	(1.476)		(0.115)	(1.052)			
-0.008					-0.016^{***}	0.03	2982
(-1.044)					(-2.767)		
-0.008	-0.004				-0.017^{***}	0.03	2982
(-0.996)	(-0.127)				(-3.132)		

these products does not generate a beta that is negative enough to justify the losses they incur. This result helps mitigate the concern that losses arise exclusively because investors benefit from the built-in stock market hedge of normal and leveraged ETPs. In addition to the empirical results presented here, it has been documented how retail investors tend to hold underdiversified portfolios (Goetzmann & Kumar 2008), suffers from the disposition effect (Odean 1998, Grinblatt & Keloharju 2001) and mental accounting (Thaler 1999). As indicated by these results, investors often struggle to evaluate investment decisions from a portfolio perspective, casting further doubt on whether retail investors would trade VIX ETPs to benefit from a built-in hedge.

Panel B shows that risk-adjusted returns are not statistically significant for the inverse products. Here, the portfolio return loads negatively on the volatility factor similar to what is expected for a long position in an inverse VIX ETP. The insignificant risk-adjusted return implies that there is no support for claiming that the returns of retail investors in inverse products should have been higher based on the risk exposure of the products.

4.7 Robustness checks

Next, I test whether the results are driven by trading costs or the fees charged by VIX ETP issuers. I also examine whether trades that are not classified as retail trades displays the same investment performance as retail trades.

4.7.1 Trading costs

Until now, profit and returns have been computed based on the daily closing price. This means that the results are potentially influenced by trading costs in the form of the bid-ask spread. From the results of Section 4.2 it is therefore not clear whether the performance of retail investors is solely driven by retail investors' timing and selection of VIX ETPs or by trading costs. In light of this, I instead compute profit and returns using the midquote at market close as the daily closing price. The profit and day-of-trading returns both rely on the price at which the individual retail order is executed. As described in Section 3.3, this price should involve a price improvement relative to NBBO, and I, therefore, continue to use this price rather than replacing it by the midquote prevailing at the time of the trade. Repeating the analysis of Section 4.1, 4.2, 4.3, and 4.6 where closing prices are derived from midquotes yields similar results. Take for instance, the day-of-trading return where the loss based on the regular closing price is \$192.6 million and the one based on midquotes is \$196.7 million. The rest of the results are not reported here but are available upon request. Hence, trading costs do not appear to explain retail investor losses, selection and market timing abilities, and the risk-adjusted returns.

4.7.2 Expense ratios

Besides trading costs, the expenses of VIX ETPs is also a factor that could contribute to retail investor losses. Roughly speaking, VIX ETPs delivers a daily return that matches the leverage-scaled return on the VIX futures index after accounting for fees. The expense ratios range between 0.85% and 1.65% (except for two products with a much lower and higher expense ratio which exist for only a few years). In principle, the impact of fees could be large enough to create a scenario where retail investor trades would result in a positive profit if these fees did not apply. To analyze this, I construct a hypothetical profit of each product under a setting with an expense ratio equal to 0%. For this, I use a hypothetical no-fee ETP price, $P^{\text{no fee}}_{i,t+h}$, which is equal to the current ETP price, $P_{i,t}$ compounded by a daily return equal to the leveraged-scaled return on the relevant index. Specifically, I construct the no fee profit of the *i*th ETP as

$$
\begin{aligned}
profit^{\$,\text{no fee}}_{i,t,t+h} &= (P^{\text{no fee}}_{i,t+h} - P_{i,t}) \sum_{k=1}^{K_{i,t}} mrvol_{i,t,k}(I^b_{i,t,k} - I^s_{i,t,k}) \\
&= \left[(1 + r^{SPVIXTR}_{t+1} L_i)(1 + r^{SPVIXTR}_{t+2} L_i) \cdots (1 + r^{SPVIXTR}_{t+h} L_i) - 1\right] P_{i,t} \sum_{k=1}^{K_{i,t}} mrvol_{i,t,k}(I^b_{i,t,k} - I^s_{i,t,k})
\end{aligned}
$$

where $r^{SPVIXTR}_t$ denotes the daily return on the index which is the short-term or the mid-term VIX futures index depending on the ETP. Although some of the ETPs track the excess return version of the index,[14] I impose the simplifying assumption that the short-term or mid-term index is always the total return version of the index, i.e., SPVIXSTR or SPVIXMTR. While the purpose is to analyze the impact of fees, this calculation also accounts for any other potential differences in the actual ETP price change and the leverage-scaled change in the VIX futures index which could arise, e.g., due to a deviation between the price of the ETP and its intrinsic value.

Together with the actual profit from Section 4.1, the aggregate no fee profit is shown in Figure 9.

[14] UVIX and SVIX track two other indices, LONGVOL and SHORTVOL, respectively, which are provided by Cboe instead of S&P Global.

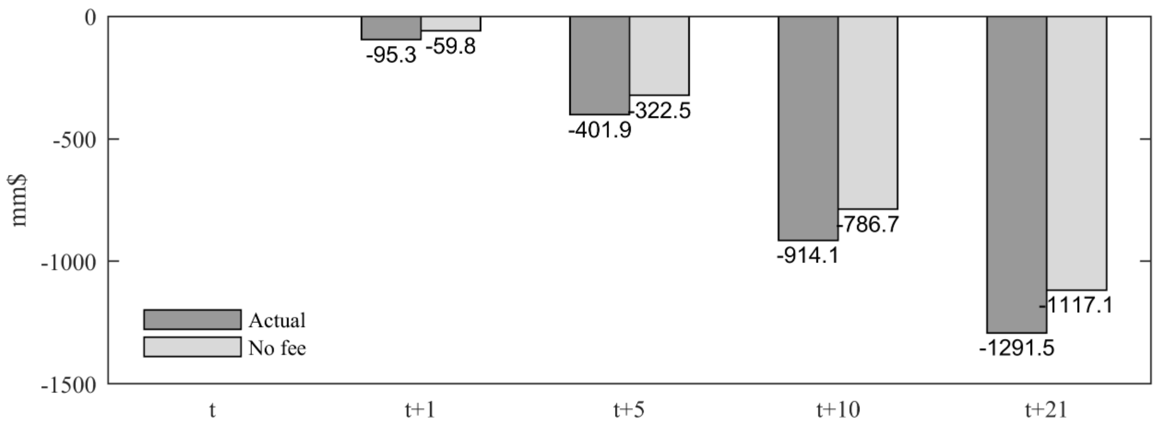

Figure 9: The actual and no fee dollar profit of retail investors in VIX ETPs.

Comparing the two profit series suggests that fees naturally have a negative influence on the investment performance as the no fee profit is negative but smaller in magnitude than the actual profit. However, since the no fee profit is also negative the fees charged by issuers explain losses only partially.

4.7.3 Residual trades

This section examines the investment performance in VIX ETPs associated with the residual trades to understand whether this differs from the performance of retail investors. The trades that are not identified as marketable retail orders cannot necessarily be classified as non-retail trades and are, therefore, referred to as residual trades. Signing the residual trades requires a more careful matching of trades with quotes after which the direction of the trades can be inferred. This procedure is described in Appendix A.1.2.

The negative risk-adjusted returns of retail investors in normal and leveraged ETPs mitigates the concern that retail investors indirectly benefit from these ETPs through their built-in stock market hedge. To further understand whether any investor trading normal or leveraged ETPs is inevitably positioned to lose money, the residual trades can be exploited. Constructing the aggregate dollar profit from these trades reveals that these trades in fact generate a positive profit as illustrated in Figure 10. The day-of-trading profit of $6.3 million is equivalent to an annual return of 0.06%. A further decomposition of the day-of-trading profit reveals a positive profit in normal and leveraged products of $4.3 and $3.2 million, respectively, and a loss in inverse products of $1.2 million. Unlike retail investors, residual investors do not incur losses in normal and leveraged products.

While the residual trades result in a positive profit, the next question is whether this profit is fair in

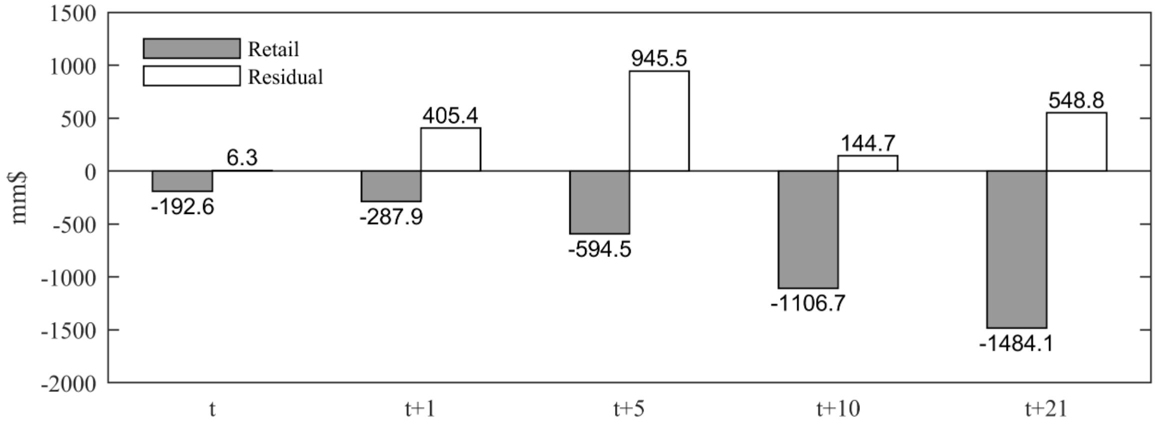

Figure 10: The dollar profit of retail and residual investors in VIX ETPs.

light of the associated product risks. First, Table A.3 reports that the day-of-trading return is significantly positive for normal and leveraged ETPs at a daily level of 1.12 bps when weighting by dollar volume. Under the same weighting, the corresponding return for inverse products is insignificant. It is, however, significantly positive when sample days are weighted equally. Next, Table A.4 documents that the risk-adjusted returns are not significantly different from zero for normal and leveraged products or for inverse products. Hence, residual trades neither result in a return that is too small or too large relative to the risk exposure. This suggests that while retail investors tend to experience negative day-of-trading returns as well as negative risk-adjusted returns when trading VIX ETPs, the day-of-trading returns and risk-adjusted returns are not negative for the remaining pool of investors.

The results of Section 4.2 reveal a negative relation between retail order imbalances and next-day VIX ETP returns. In order to assess whether this relation is unique to retail order imbalances, the next regression model modifies and extends the one in (6) by including the order imbalance computed from the residual trades, *resoib*. As for the retail order imbalance, the residual order imbalance is measured both in terms of trading volume and number of trades. Table A.5 shows the regression results when using the residual order imbalance as the only regressor (column (1) and (3)). The coefficient estimate is positive but further from statistical significance relative to the estimated coefficient on *mroib* in Table 6. The table also reports the regression results that includes both *mroib* and *resoib* as regressors (column (2) and (4)). Here, the coefficient on the residual order imbalance is still insignificant, while the coefficient on the retail order imbalance retains its negative sign and the magnitude of the t-statistic as without controlling for *resoib* in Table 6. The results suggest that the residual order imbalance does not appear to contain any significant information about the cross-section of VIX ETP returns, and that the selection of VIX ETPs is somewhat poorer for retail trades compared to residual trades.

The results on market timing with respect to the next-day ETP return based on the residual order imbalance are shown in Table A.6. Relative to Table 7, the residual order imbalance does not influence the results as the coefficient and t-statistic on *mroib* is essentially unaffected by the inclusion of *resoib*. The residual order imbalance itself is insignificant in explaining next-day VIX ETP returns and therefore does not indicate either good or bad market timing.

Overall, these results indicate that residual trades do not share the poor investment performance of retail investors. While the residual trades do not necessarily capture only institutional trades, the finding that retail investors perform worse than institutional investors aligns with the existing literature (see, e.g., Barber et al. (2009), Jones et al. (2025)).

5 Conclusion

This study presents the first evidence on the behavior of retail investors in the market for VIX ETPs and introduces product confusion as an explanation for the investment performance of retail investors. Combined with the general concern on retail investor sophistication, product complexity stemming from the interlinkages and layered structure of the VIX index, VIX futures contracts, and VIX ETPs gives rise to the hypothesis of product confusion: Retail investors believe that VIX ETPs allow investors to directly trade the VIX index. Contrary to this belief, the VIX index is non-tradable and VIX ETPs are linked to a VIX futures index, not the VIX index directly.

As evidenced by the negative aggregate dollar profits from retail trading, I show that retail investors, in aggregate, incur losses in the VIX ETP market. With negative risk-adjusted returns on retail investors' VIX ETP portfolio in normal and leveraged products, my results also suggest that the use of VIX ETPs as a means to acquire protection against surges in market volatility or stock market downturns appears to be insufficient in explaining losses. Instead, I show that retail trading would not be characterized by losses and poor selection and market timing if the VIX ETPs do in fact track the leverage-scaled VIX index. If retail investors trade VIX ETPs attempting to exploit the mean-reverting behavior or other predictable patterns of VIX, these trades would generally not be profitable since such predictable future movements of VIX are already priced in the VIX futures market and thereby in the VIX ETP market. Hence, these results are consistent with product confusion where retail investors believe that they buy and sell the VIX index when trading VIX ETPs. Although there may exist theoretical justifications in terms of diversification and hedging benefits to provide retail investors with access to the VIX ETP market, my findings indicate that, in aggregate, their ability to extract value from the products is limited and that retail investor sophistication is a potential cause of this.

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A.1 Data

A.1.1 TAQ data filtering

The cleaning of TAQ data is based on a produce similar to Barndorff-Nielsen et al. (2009). Any trade where the price or volume is zero or less is removed. So are trades with a trade correction code (CORR) different from zero or abnormal sale condition (COND), meaning that I keep only trades when COND is blank or contains a combination of "E" and "F" before 2014 and "E", "F", "I", and "T" for data from 2014. Using a window of 25 trades before and after each trade, observations are also removed if the price of the trade differs from the median price over the window by more than five times the average absolute deviation of the other trades included in the window.

Similar conditions are applied to the quote data where quotes are removed if either the bid size, ask size, bid price, or ask price are not positive numbers or the bid-ask spread is below zero. If the bid-ask spread is greater than ten times the average bid-ask spread over the day, the quote is also removed. Quotes with quote condition different from "R" (before 2014) or "12" (starting 2014) are likewise removed. As for the trades, quotes are removed if the midquote deviates from a rolling centered median by more than five times the mean absolute deviation.

A.1.2 Signing residual trades

The signing of the residual trades is based on the following procedure. Residual trades are matched only with quotes from the same exchange using the quote prevailing at the time of the trade, i.e. with a timestamp closest to but strictly smaller than that of the trade. Trades with the same timestamp occuring on the same exchange are all matched with the same quote. When the variable ParticipantTime is available (see Schwenk-Nebbe (2022)), timestamps are measured from this variable and otherwise from the variable utcsec. Once each trade is matched with a quote, the trade is labeled as buyer-initiated (seller-initiated) if the trade price is above (below) the midquote. When the trade price equals the midquote, the trade is signed based on the tick-rule with a positive price change relative to the preceding trade indicating that the trade is buyer-initiated and vice versa for a negative price change. If the price change is equal to zero, the sign of the trade will be the same as that of the preceding trade.

A.2 Supplementary tables

Table A.1: Regression results based on the VIX ETP returns and leverage-scaled VIX index returns (naïve returns).

For each product, the return, $r_{i,t}$, is regressed on the leverage-scaled VIX index return, $L_i \cdot r_t^{VIX}$. The table shows the estimated values of the constant and the coefficient on the leverage-scaled VIX index return and the associated t-statistics. t-statistics are based on Newey-West standard errors. $^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$.

Ticker	Constant	t-stat	Coefficient	t-stat	Adj. R^2	N
VXX	-0.004^{***}	−9.781	0.438^{***}	32.058	0.78	2516
VXXB	-0.002^{***}	−4.008	0.459^{***}	17.002	0.78	1247
VIXY	-0.003^{***}	−9.381	0.467^{***}	31.865	0.80	3018
VIIX	-0.003^{***}	−7.236	0.456^{***}	27.175	0.78	2370
VMAX	-0.005^{***}	−5.148	0.426^{***}	18.133	0.72	560
UVXY	-0.006^{***}	−10.205	0.456^{***}	29.272	0.79	2829
TVIX	-0.007^{***}	−7.653	0.435^{***}	30.285	0.77	2414
UVIX	-0.005^{***}	−3.225	0.565^{***}	19.381	0.87	190
IVO	0.000	0.258	0.368^{***}	10.257	0.64	169
IVOP	0.003	1.318	0.246^{***}	3.811	0.25	230
SVXY	0.002^{***}	4.980	0.433^{***}	15.157	0.61	2829
XIV	0.003^{***}	3.232	0.394^{***}	8.721	0.51	1816
VMIN	0.001	0.521	0.349^{***}	10.068	0.37	647
SVIX	0.002^{***}	2.577	0.542^{***}	16.518	0.83	190
VXZ	-0.002^{***}	−6.049	0.184^{***}	28.411	0.61	2282
VXZB	−0.000	−0.012	0.142^{***}	5.730	0.33	1243
VIXM	-0.001^{***}	−5.099	0.187^{***}	24.578	0.58	3018
VIIZ	-0.001^{***}	−4.168	0.148^{***}	18.464	0.47	1213
TVIZ	-0.004^{***}	−5.933	0.165^{***}	21.683	0.52	1776
ZIV	0.001^{***}	3.837	0.182^{***}	18.467	0.54	2310

Table A.2: Summary statistics on retail investor activity.

Panel A shows the proportion of retail activity measured in terms of trading volume, *mrpvol*, while in Panel B, it is shown in terms of the number of trades, *mrptrd*. Statistics are computed across trading days and reported in percentages. The row *All* shows the statistics for the pooled sample combined across all products and days.

Ticker	Mean	Std. dev.	Min	Q1	Med	Q3	Max
Panel A: mrpvol							
VXX	9.73	3.18	0.00	7.80	9.83	11.70	25.30
VXXB	7.97	3.13	0.00	5.80	7.14	9.59	21.72
VIXY	9.21	4.36	1.04	6.14	8.50	11.42	30.10
VIIX	5.15	5.05	0.00	1.56	3.63	6.95	37.13
VMAX	-	-	-	-	-	-	-
UVXY	18.41	4.71	5.53	15.18	18.23	21.51	39.80
TVIX	21.05	5.53	4.34	16.90	20.85	24.80	49.04
UVIX	15.68	4.17	6.27	12.73	15.50	18.24	33.73
IVO	3.47	3.22	0.00	1.07	2.06	4.79	13.68
IVOP	20.90	23.56	0.00	0.25	17.90	27.44	61.90
SVXY	11.33	5.33	0.87	7.03	10.81	14.79	33.39
XIV	15.97	5.00	2.14	12.71	15.61	18.98	42.32
VMIN	21.83	8.12	6.27	14.80	23.23	28.58	38.21
SVIX	13.50	6.04	2.16	9.23	13.32	17.78	30.64
VXZ	5.08	4.75	0.03	2.37	3.93	6.42	67.59
VXZB	6.79	6.60	0.00	1.95	5.02	9.68	30.65
VIXM	14.32	9.09	0.00	7.22	13.29	20.10	51.58
VIIZ	-	-	-	-	-	-	-
TVIZ	-	-	-	-	-	-	-
ZIV	13.87	6.31	0.45	9.63	12.87	17.62	36.59
All	12.26	7.15	0.00	6.72	11.34	17.04	67.59
Panel B: mrptrd							
VXX	3.77	1.95	0.00	2.43	3.12	4.78	14.17
VXXB	4.06	2.19	0.00	2.40	3.57	5.31	14.64
VIXY	4.12	2.47	0.60	2.41	3.48	5.17	17.37
VIIX	3.36	3.29	0.00	1.13	2.32	4.42	26.13
VMAX	-	-	-	-	-	-	-
UVXY	8.16	2.90	2.04	6.11	7.73	9.79	23.75
TVIX	10.88	4.39	2.11	7.72	10.07	13.13	30.44
UVIX	9.37	2.75	4.32	7.43	8.85	10.94	20.55
IVO	2.24	2.33	0.00	0.53	1.25	3.62	9.84
IVOP	22.24	24.97	0.00	0.02	18.81	30.46	65.36
SVXY	4.51	2.21	0.38	2.94	4.13	5.58	15.70
XIV	5.75	2.18	1.25	4.12	5.41	6.99	19.86
VMIN	21.40	5.78	9.45	17.26	21.01	24.82	36.47
SVIX	7.06	3.20	1.65	4.62	6.72	9.01	16.92
VXZ	3.40	2.21	0.13	1.79	2.90	4.47	19.64
VXZB	5.98	4.66	0.10	2.10	4.72	8.99	19.87
VIXM	10.67	5.86	0.00	6.13	10.16	15.18	33.69
VIIZ	-	-	-	-	-	-	-
TVIZ	-	-	-	-	-	-	-
ZIV	9.07	3.70	0.78	6.54	8.70	11.11	24.90
All	5.84	4.00	0.00	2.89	4.89	7.79	65.36

Table A.3: Day-of-trading return on the residual investor portfolio in normal, leveraged, and inverse VIX ETPs.

The day-of-trading return is obtained based on the trading price of the residual trade and the closing price on the same day. For each day, the return from each residual trade is weighted by residual dollar volume in a manner similar to (11). The average return across days is obtained either by weighting sample days equally or by residual dollar volume. Returns are daily and reported in percentages. t-statistics are shown in parentheses. $^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$.

	Normal and leveraged VIX ETPs		Inverse VIX ETPs	
	Equal weighted	Dollar volume weighted	Equal weighted	Dollar volume weighted
Avg. return (%)	0.0087***	0.0112***	0.0051***	0.0031
t-statistic	(4.8504)	(2.9915)	(2.7018)	(0.8465)

Table A.4: Factor regressions for the portfolio return of residual investors in normal, leveraged, and inverse VIX ETPs.

The results show the risk-adjusted return and loadings on the risk factors for the residual investor portfolio return. The portfolio return is the weighted average return on the trades of residual investors in normal and leveraged VIX ETPs (Panel A) and inverse VIX ETPs (Panel B), respectively, assuming a holding period of one day obtained from the closing price on the day of trading and the closing price one day later. All variables are in percentages. t-statistics are shown in parentheses and are based on Newey-West standard errors. $^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$.

α	$r_t^{mkt} - r_t^f$	$(r_t^{mkt} - r_t^f)^2$	SMB_t	HML_t	$r_t^{VX,1m} - r_t^f$	Adj. R^2	N
Panel A: Normal and leveraged VIX ETPs							
0.004	−0.020					0.01	3499
(0.760)	(−1.151)						
−0.010	−0.017	0.010				0.06	3499
(−1.442)	(−1.311)	(1.565)					
0.004	−0.020		0.008	−0.011*		0.02	3499
(0.766)	(−1.183)		(0.734)	(−1.854)			
0.003					0.004	0.01	3498
(0.687)					(0.974)		
0.004	−0.022				−0.001	0.01	3498
(0.751)	(−1.248)				(−0.306)		
Panel B: Inverse VIX ETPs							
−0.005	0.039***					0.04	2983
(−1.161)	(3.340)						
−0.002	0.038***	−0.002				0.05	2983
(−0.541)	(3.595)	(−0.886)					
−0.005	0.039***		0.001	0.013*		0.05	2983
(−1.158)	(3.434)		(0.088)	(1.743)			
−0.004					−0.007**	0.03	2982
(−0.962)					(−2.504)		
−0.005	0.037***				−0.001	0.04	2982
(−1.154)	(2.858)				(−0.308)		

Table A.5: Selection and residual order imbalance. Predicting next-day VIX ETP returns from residual order imbalance.

The table reports the estimation results from regressing the VIX ETP return on the residual order imbalance of the previous day. The regression includes time fixed effects. In column (1) and (2), the order imbalance is measured in terms of trading volume, while in column (3) and (4) it is measured using the number of trades. $^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$.

	mroibvol		mroibtrd	
	(1)	(2)	(3)	(4)
$mroib_{i,t}$		-0.0020^{*}		-0.0040^{***}
		(-1.8602)		(-2.8925)
$resoib_{i,t}$	0.0004	0.0008	0.0002	0.0005
	(0.1607)	(0.3200)	(0.0620)	(0.1505)
$r_{i,t}$		-0.0065		-0.0087
		(-0.6857)		(-0.9212)
R^2	0.0000	0.0001	0.0000	0.0003
Adj. R^2	-0.2030	-0.2029	-0.2030	-0.2026
N	20733	20720	20733	20720

Table A.6: Market timing and residual order imbalance. Predicting VIX ETP returns from residual order imbalance.

The table reports the estimation results from regressing the VIX ETP return on the residual order imbalance of the previous day. The regression includes product fixed effects. In column (1) and (2), the order imbalance is measured in terms of trading volume, while in column (3) and (4) it is measured using the number of trades. $^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$.

	mroibvol		mroibtrd	
	(1)	(2)	(3)	(4)
$mroib_{i,t}$		-0.0021^{*}		-0.0046^{***}
		(-1.7185)		(-3.1548)
$resoib_{i,t}$	-0.0017	0.0002	-0.0027	-0.0013
	(-0.6440)	(0.0769)	(-0.8362)	(-0.3965)
$r_{i,t}$		-0.0253^{***}		-0.0276^{***}
		(-2.8635)		(-3.1108)
R^2	0.0000	0.0007	0.0000	0.0010
Adj. R^2	-0.0005	0.0001	-0.0005	0.0003
N	20733	20720	20733	20720

A.3 Supplementary figures

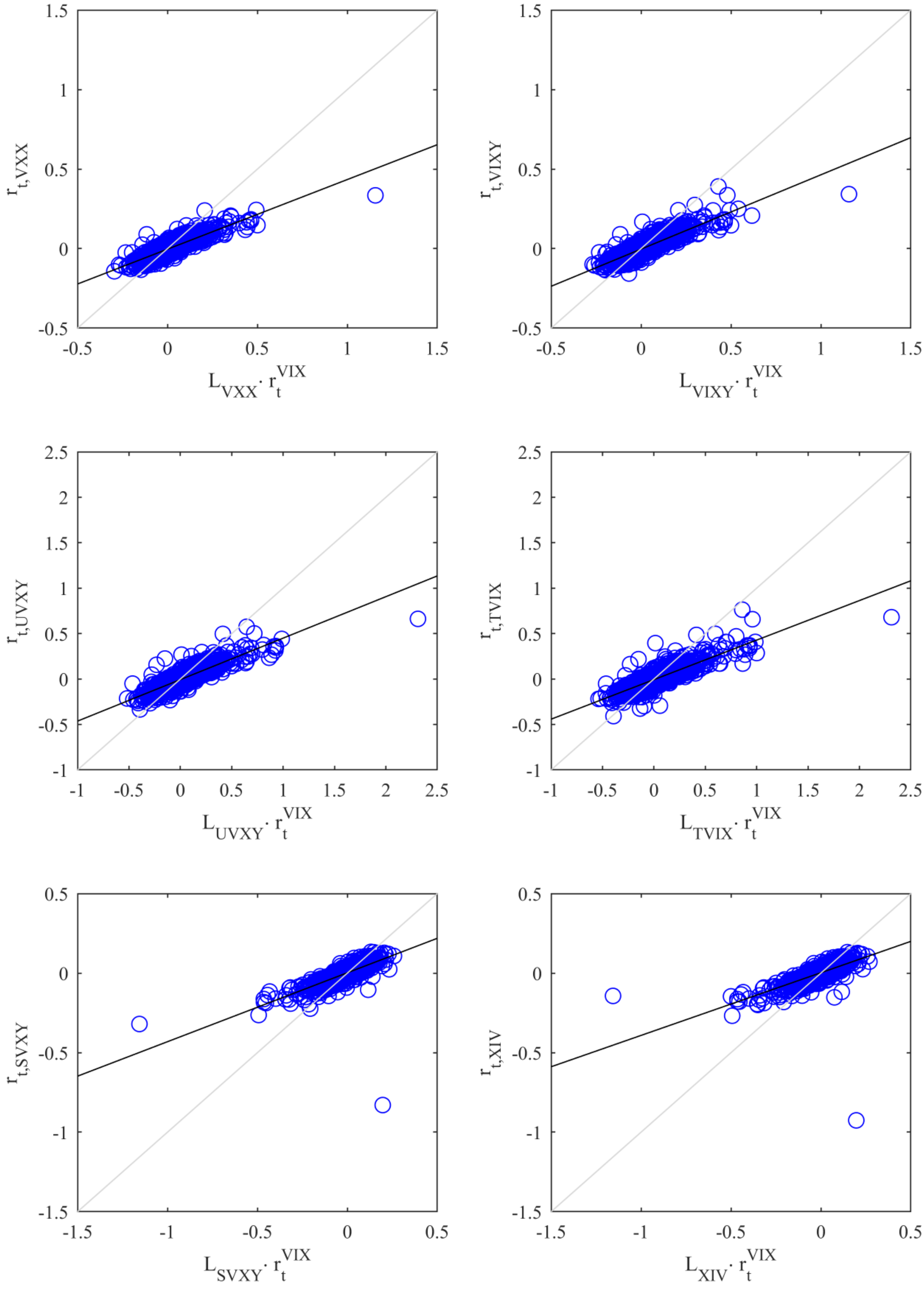

Figure A.1: Scatter plot of VIX ETP returns and leverage-scaled VIX index returns (naïve returns).

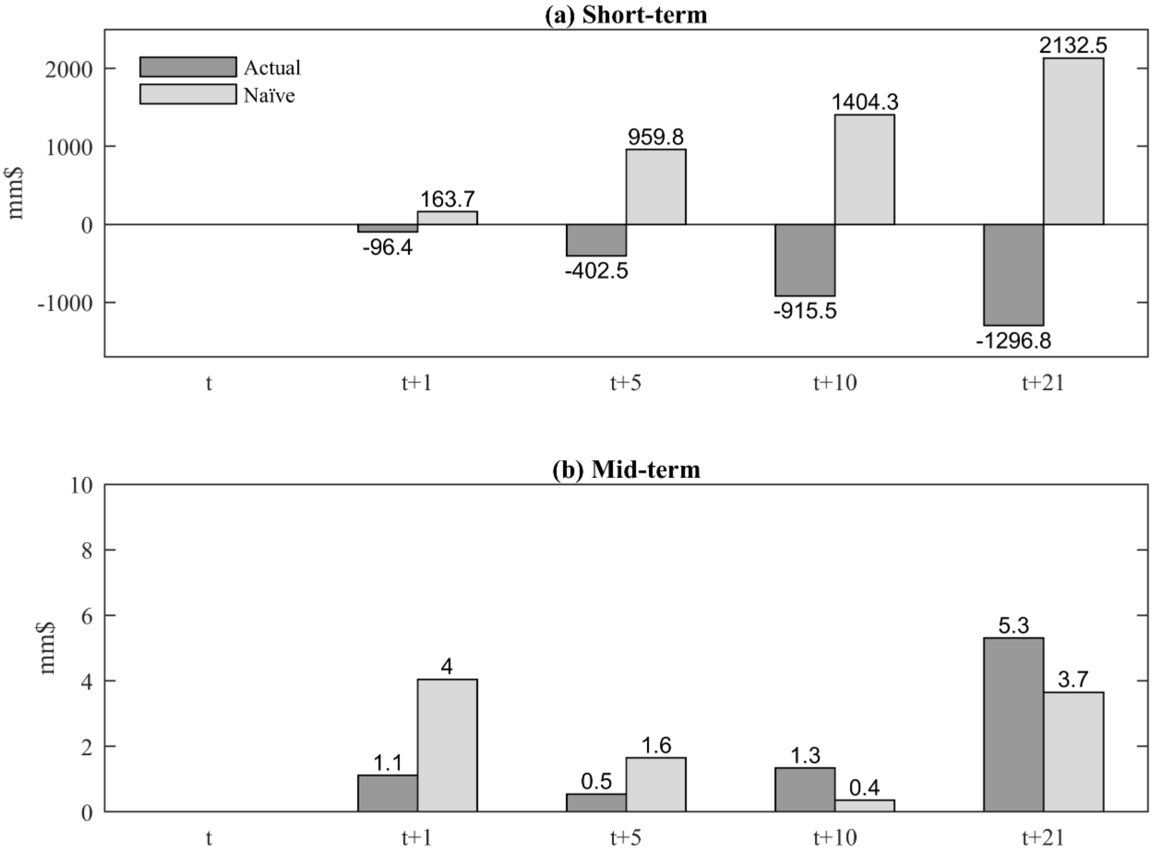

Figure A.2: The actual and naïve dollar profit of retail investors in VIX ETPs split by short-term and mid-term products.