Liquidity risk and exchange-traded fund returns, variances, and tracking errors

JFE-202010

汇报人：王光耀

2021-05-19

Author: Kyounghun Bae

- Assistant Professor, Hanyang University, Republic of Korea (March 2017 - Present)
- Education
- Ph.D. in Finance, the University of Maryland at College Park (2015)
- M.S. in Economics, the University of Texas at Austin (2010)
- M.S. in Business, Seoul National University, Republic of Korea (2008)
- B.S. in Engineering, Seoul National University, Republic of Korea (2005)
- Research Interests
- Primary: Market Microstructure, Asset Pricing, Portfolio Choice
- Other: Textual Analysis, Blockchain, Cryptocurrency
- Publications
- 1. “Do investors use options and futures to trade on different types of information? Evidence from an aggregate stock index” joint with Dixon, Journal of Futures Markets 38, no. 2 (2018): 175-198.
- 2. “Liquidity risk and Exchange-traded-fund returns, variances, and tracking errors” joint with Kim (Forthcoming at the Journal of Financial Economics)
- 3. “A study on Overseas ISA Cases and their Implications” joint with Kang, Park, and Oh (Forthcoming at the Korean Journal of Financial Studies)

Author: kim,daejin

- 國立蔚山科學技術研究院 (UNIST | Ulsan National Institute of Science and Technology)
- School of Business Administration / Graduate School of Technology and Innovation Management
- Financial Investments, Markets and Trading Lab.
- Research Keywords
- Finance, Derivatives, Market Microstructure, Portfolio Management, High Frequency Trading, Algorithmic Trading, Hedge Funds, ETFs, ETNs
- Pubs:
- **Derivatives use and the value of cash holdings: Evidence from the U.S. oil and gas industry** “JOURNAL OF FUTURES MARKETS”
- **Market value of 10-K readability and corporate cash holdings** “ECONOMICS LETTERS”
- **Liquidity risk and exchange-traded fund returns, variances, and tracking errors** “JOURNAL OF FINANCIAL ECONOMICS”

Abstract

We investigate the effect of **exchange-traded fund (ETF)** **liquidity** on **ETF tracking errors**, **returns**, and **volatility** in the US. We find that illiquid ETFs have large tracking errors. The effect is more pronounced when underlying assets are less liquid. Returns and liquidity of illiquid ETFs are more sensitive to underlying index returns or ETF market liquidity, or both. Thus, a positive liquidity premium exists in US ETF markets. The ETF variance could be larger than its net asst value variance owing to infrequent trading. In summary, illiquid ETFs are more likely to deviate from their underlying indexes and could be riskier than underlying portfolios.

Part 1 Introduction

The development of US ETF market(background)

- US exchange-traded funds (ETFs), introduced in 1993,have grown significantly in recent years. At the end of 2016, their market size was about $3 trillion, accounting for nearly 30% of the dollar trading volume and 23% of the share volume in US stock markets.

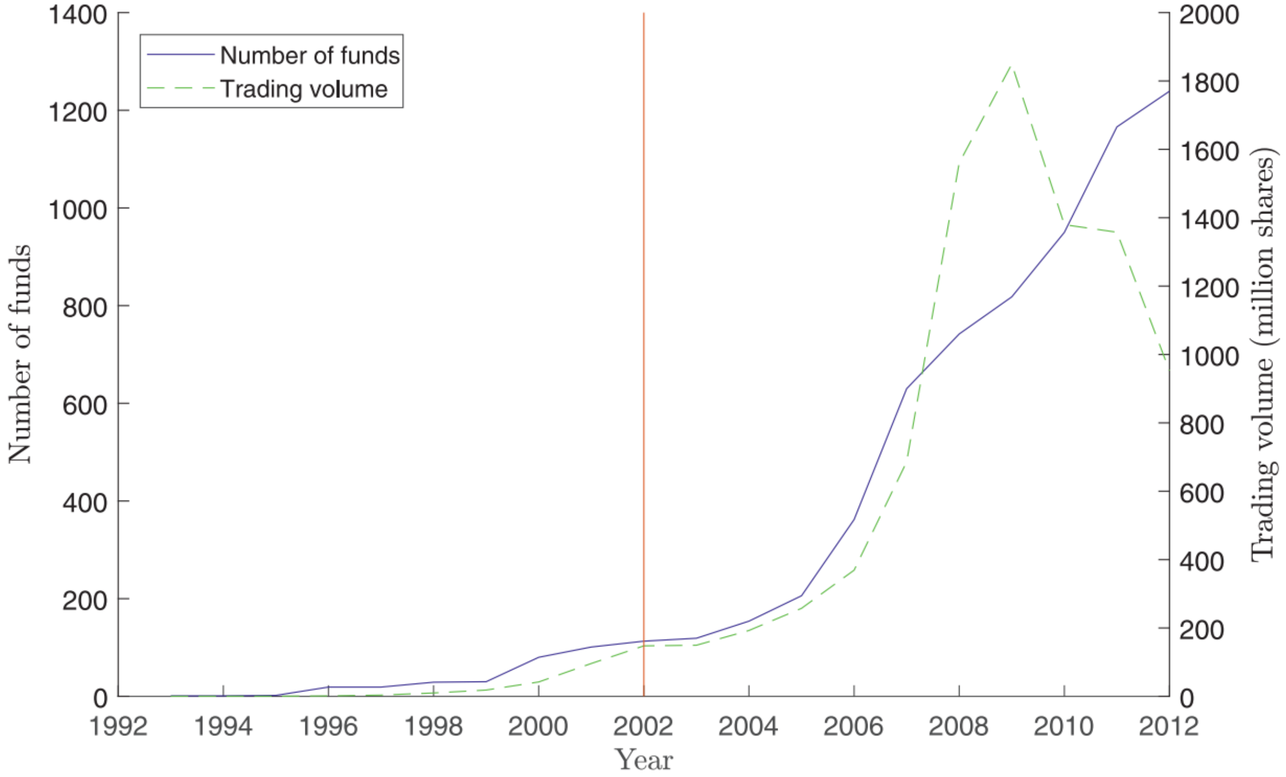

Fig. 1. The number of funds and market value of exchange-traded funds (ETFs). This figure illustrates the number of ETFs and trading volume of US ETFs at year-end from 1993 to 2012. The solid line plots the number of funds available at the end of each year. The dotted line plots the share trading volume of funds at the end of each year. The solid vertical line denotes 2002.

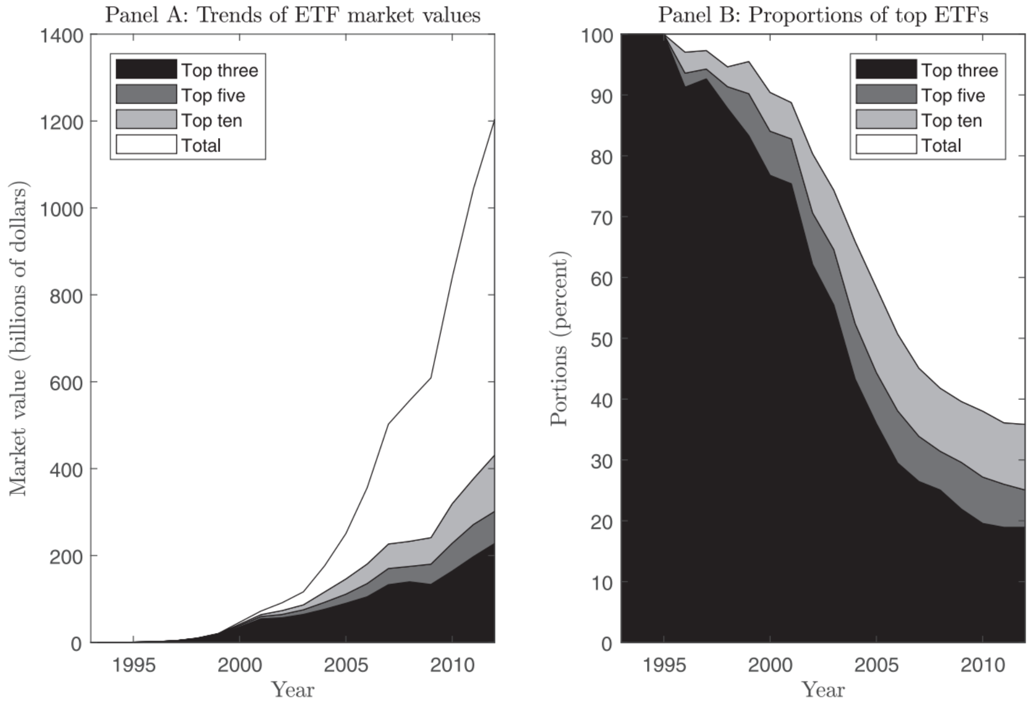

Fig. 2. Market value by top exchange-traded funds (ETFs). This figure plots the market values of the top three, five and ten ETFs in the US ETF market by calendar year. For each ETF, we compute the annual average daily net asset values and the total market values by summing all average values for each ETF. We compute the portions of the top three (five, ten) ETFs by summing the top three (five, ten) values divided by total market value.

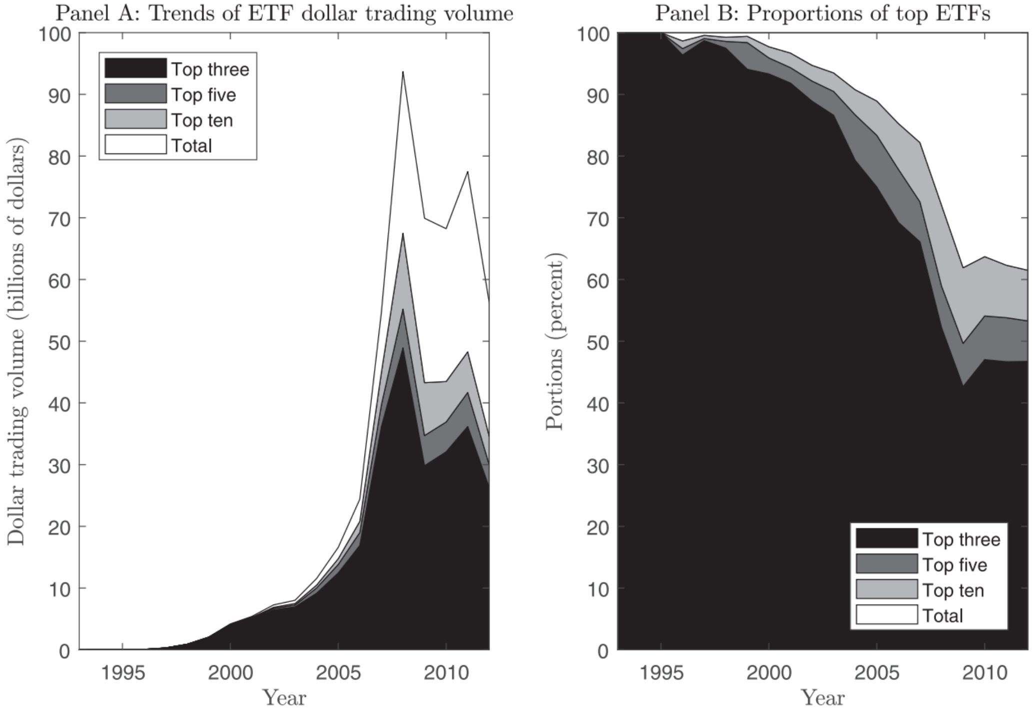

Fig. 3. Trading volume by top exchange-traded funds (ETFs). This figure plots the trading volumes of the top 3 (5, 10) ETFs in the US ETF market by calendar year. For each ETF, we compute the annual average daily trading volumes and the total market trading volumes by summing all average values for each ETF. We compute the portions of the top 3 (5, 10) ETFs by summing the top 3 (5, 10) values divided by total market trading volume.

- ETFs have grown to become the most popular asset class for many institutional and individual investors. Despite such rapid growth, most of the money flowing into ETFs is concentrated in a few well-known ETFs.
- For example, at the end of 2012, the top three (ten) ETFs accounted for 46.7% (61.5%) of the total ETF dollar trading volume (Figs. 1–3). In addition,the assets under management (AUM) of the top 10 ETFs accounted for 36% of the total AUM in the US ETF market.

- The lack of liquidity in non-popular ETFs could prevent market makers from developing proper markets and, consequently, increase transaction costs for ETF investors.
- This study sheds light on secondary market liquidity issues by examining how ETF liquidity affects the price formation of ETFs, especially relative to their benchmark indexes or net asset values (NAVs).

ETF (Exchange-traded fund) ***

- An exchange-traded fund (ETF) is a type of investment fund and exchange-traded product, i.e. they are traded on stock exchanges.
- ETFs are similar in many ways to mutual funds, except that ETFs are bought and sold throughout the day on stock exchanges while mutual funds are bought and sold based on their price at day's end.
- An ETF holds assets such as stocks, bonds, currencies, and/or commodities such as gold bars, and generally operates with an **arbitrage mechanism** designed to keep it trading close to its net asset value, although deviations can occasionally occur.
- Most ETFs are index funds: that is, they hold the same securities in the same proportions as a certain stock market index or bond market index. The most popular ETFs in the U.S. replicate the S&P 500 Index, the total market index, the NASDAQ-100 index, the price of gold, the "growth" stocks in the Russell 1000 Index, or the index of the largest technology companies.
- With the exception of non-transparent actively managed ETFs, in most cases, the list of stocks that each ETF owns, as well as their weightings, is posted daily on the website of the issuer.
- ETFs may be attractive as investments because of their low costs, tax efficiency, and tradability.

ETF ***

- Costs
- Since most ETFs are index funds, they incur **low expense ratios** because they are not actively managed. An index fund is much simpler to run, since it does not require security selection, and can be done largely by computer.
- Taxation
- ETFs are structured for tax efficiency and can be more attractive tax-wise than mutual funds.
- Unless the investment is sold, ETFs generally generate no capital gains taxes, because they typically have low turnover of their portfolio securities. While this is an advantage they share with other index funds, their tax efficiency compared to mutual funds is further enhanced because ETFs do not have to sell securities to meet investor redemptions.
- Trading
- ETFs can be bought and sold at current market prices at any time during the trading day, unlike mutual funds and unit investment trusts, which can only be traded at the end of the trading day.

TYPES of ETF ***

- Index ETFs
- Commodity ETFs
- Currency ETFs
- Actively managed ETFs
- Inverse ETFs
- Leveraged ETFs

Risks of ETF ***

- Tracking error
- Liquidity risk
- Risks of Synthetic ETFs
- Counterparty risk
- Effects on price stability

- **Exchange-Trade Funds**
  - Shares float / Trade
- **Close-End Funds**
  - Shares fixed / Trade
- **Open-End Funds**
  - Shares float / ~~Trade~~

- This unique structure results in the existence of two prices for a single asset: one is ETF market prices determined on stock exchanges and the other is its NAV calculated based on the value of underlying securities.
- Intuitively, a no-arbitrage condition implies that the daily ETF returns and the NAV returns must be identical.
- However, various factors can widen the gaps between them.
- This study is interested in **the secondary market liquidity**, which could affect the ETF returns and volatility, as well as ETF tracking errors.

AP - authorized participants

- ETFs are fundamentally similar to, but are not, mutual funds.
- They are structured, managed, and regulated just like traditional mutual funds.
- Different from conventional open-ended mutual funds, ETFs are traded continuously on regular exchanges, like regular stocks are.
- In addition,ETFs are similar to closed-end funds (CEFs) in that they are traded on exchanges.
- Unlike CEFs, the total number of shares can be increased or decreased depending on market demand and supply.
- In other words, ETFs are designed to combine **the creation and redemption process of open-end funds** with **the continuous trading of the CEFs**.
- These characteristics form the crucial mechanism that enables the facilitation of **arbitrage** between the ETF and its underlying assets.
- **The arbitrage activities of authorized participants (APs),** who are responsible for creating or redeeming ETF shares or constructing the underlying ETF portfolios, should eliminate the ETF return deviations from its NAV returns.
- This arbitrage mechanism can be limited if either ETFs or the underlying assets are less liquid.

- The **lack of liquidity in the underlying assets** can result in tracking errors because low liquidity in underlying assets could discourage APs from replicating the index at the time of trading the basket securities.
- Moreover, **the lack of liquidity in ETF securities causes** a mispricing problem for its NAV or index returns, because arbitrage activities must take place simultaneously on both ETF and underlying asset markets.
- When the ETF is less liquid, APs could find difficult trading at desired prices at the time of setting arbitrage positions or profit realization through unwinding.
- In this situation, APs could be reluctant to actively engage in arbitrage trading for low liquidity ETFs, or they could require additional returns even when available for arbitrage trading.
- As a result, **APs can strategically wait for a tracking error** (i.e., large arbitrage opportunity) to widen or increase the bid-ask spread to meet the additional required return on risk.
- This situation can cause investors to pay higher transaction costs and, thus, should lead to a case in which the elimination of the tracking error is delayed.

The effect of ETF liquidity on tracking errors

- We present evidence that tracking errors and ETF illiquidity are positively related at both daily and yearly levels.
- In particular, our empirical results show that various ETF illiquidity measures have consistently positive relations with ETF tracking errors.
- We further test the causal link from illiquidity to tracking errors by exploiting liquidity shocks of threshold stocks as an instrumental variable. According **to Evans et al. (2017),** failures-to-deliver (FTDs) are associated with liquidity changes, and excessive consecutive FTDs could force ETFs to be threshold stocks when accompanied by liquidity shocks.
- Our empirical analysis confirms that the instrumental variable regressions with various liquidity measures show a causal link between ETF illiquidity and ETF tracking errors.
- We also examine the effect of ETF illiquidity on EF tracking errors depending on how ETFs are structured.
- Our empirical analysis shows that tracking errors of the in-kind type of ETFs are less sensitive to ETF illiquidity than other types of ETFs are.

The effect of ETF liquidity on tracking errors

- These results imply that ETF companies could choose the in-kind method strategically instead of the cash method when they are able to easily construct the assets of the index at the time of the fund inception.
- We employ ETF portfolio holding data to examine the extent to which ETF illiquidity affects ETF tracking errors owing to liquidity differences in underlying assets.
- We select only non-leveraged US stocks-based ETFs to investigate the effects of underlying asset illiquidity and ETF illiquidity on the tracking errors.
- We find that both underlying asset illiquidity and ETF illiquidity affect ETF tracking errors.
- More important, the analysis confirms that illiquidity of ETFs investing in less liquid assets can have a greater impact on their tracking errors even if they hold the same asset classes of the same market.
- In summary,our overall empirical results confirm that ETF illiquidity is a very important factor affecting ETF tracking errors.

The effect of ETF liquidity on returns

- Next, we investigate whether liquidity shocks to ETFs are priced based on the LCAPM of Acharya and Pedersen (2005).
- We construct ten portfolios sorted by ETF liquidity or by various measures of tracking errors.
- Consistent with the regression analysis, the sorted portfolios provide evidence that ETF illiquidity is positively related to ETF tracking errors. Moreover, the relations between ETF illiquidity and tracking errors are persistent over time.
- We further estimate ETF liquidity betas to investigate whether any systematic risk factors associated with liquidity exist.
- The estimated results show that illiquid ETFs tend to reveal large absolute liquidity betas and have a positive liquidity risk premium.
- In other words, illiquid ETFs returns tend to be more sensitive to either market liquidity or the market return.
- In addition, using pre-estimated betas, we estimate the liquidity premium using the generalized method of moments (GMM).
- The annualized return due to liquidity risk is approximately 0.14%, suggesting a positive liquidity premium in the ETF market.

The liquidity effect on volatility

- Finally, we examine whether infrequent trading affects ETF variance relative to the NAV variance, which is presumed to be the true variance of the ETF.
- To examine the effect of secondary market liquidity on volatility, we extend the Lo and MacKinlay (1990) econometric model to derive ETF variance with respect to the NAV variance.
- The difference between the ETF variance and NAV variance can be interpreted as volatility arising from the trading effect in the secondary market, in addition to the inherent risk arising from the underlying asset portfolios.
- Considering the autocorrelation of the index return, we show that the non-trading probability is positively related to the increase in the ETF variance with respect to the NAV variance.
- In other words, the derived equation shows that the ETF return variance can be expressed as the sum of the NAV return variance and the additional term caused by infrequent trading of the ETF security in the secondary markets.
- Furthermore, our empirical analysis confirms that non-trading probability is positively related to the variance difference between ETF returns and NAV returns.
- These results suggest that investors investing in illiquid ETFs could bear additional unnecessary risk arising from the secondary market trading instead of investing directly in underlying portfolios or similar mutual funds.

Literature

- Many previous studies show the effect of liquidity on asset returns and suggest that systematic liquidity risk is priced in asset returns.
- For example, **Acharya and Pedersen (2005) develop a liquidity-adjusted capital asset pricing model (LCAPM)** and find that individual asset returns are significantly affected by liquidity risk.
- Pastor and Stambaugh (2003) suggest that individual stock returns are affected by aggregate market liquidity, which is a cross-sectional average of the individual return reversals.
- In addition to studies on the relations between asset returns and liquidity in US equity markets, numerous studies investigate the effect of liquidity on asset returns in other markets or asset categories: emerging markets (Bekaert et al., 2007), global markets (Lee, 2011), hedge funds (Getmansky et al., 2004; Sadka, 2010), initial public offering markets (Eckbo and Norli, 2005), and closed-end funds (Cherkes et al., 2009).

Literature

- Only a few studies analyze the effect of liquidity on ETFs, although the literature on ETFs is growing (Madhavan, 2014; Ben-David et al., 2017).
- Related existing studies consider ETF pricing problems on the Flash Crash of May 6, 2010 (Borkovec et al., 2010; Madhavan, 2012),
- the interactions between the ETF market and the underlying securities markets (Cespa and Foucault, 2014;Bhattacharya and O'Hara, 2017; Dannhauser, 2017; Israeli et al., 2017; Ben-David et al., 2018; Da and Shive, 2018),
- whether the ETF is priced efficiently with respect to its NAV or index (Elton et al., 2002; Engle and Sarkar, 2006),
- the relations between ETFs and traditional funds (Huang and Guedj, 2009; Barnhart and Rosenstein, 2010; Agapova,2011),
- and the ETF investors' behavior (Clifford et al., 2014;Wermers and Xue, 2015; Bhattacharya et al., 2017).

Literature

- Only a few studies analyze the effect of ETF liquidity.
- For example,Borkovec et al. (2010) report that a sharp increase in the bid-ask spread leads to failure of ETF price discovery during the Flash Crash.
- Cespa and Foucault (2014) develop a theoretical model showing that the lack of liquidity in ETFs can lead to an increase in the uncertainty of the underlying securities, which results in a decrease in the liquidity of the corresponding ETFs.
- To the best of our knowledge, no empirical studies cover the effects of liquidity on ETF returns and tracking errors comprehensively.

contribution

- In summary, the results of this research reveal that lack of ETF liquidity is related to its expected return and variance, as well as ETF tracking errors.
- To the best of our knowledge, ours is **the first comprehensive empirical study to examine the liquidity effects in the ETF market in relation to returns, risks, and tracking errors by using the entire US ETF market data.** Extending the literature of liquidity effects on asset returns, this study shows that the liquidity of ETFs affects their returns or volatility.
- In other words, the lack of liquidity in the ETF causes APs to increase the transaction costs for arbitrage trading, for failing to resolve the tracking errors immediately,and for failing to follow the index properly, thereby resulting in failure to meet the objectives of ETF investors.
- As a result, trading illiquid ETFs can increase the cost of market making and raise the transaction costs of ETF investors.

Structure of this paper

- Part 1. Introduction
- Part 2. Data and variables
- Part 3. The effect of ETF liquidity on tracking errors
- Part 4. The effect of ETF liquidity on returns
- Part 5. The liquidity effect on volatility
- Part 6. Conclusion

Part 2 Data and variables

The data used in this paper includes all ETFs listed on the major US stock exchanges from 1993 to 2012.

ETF data

- All ETFs that have ever been listed and traded on the major US stock exchanges. The country of domicile for each ETF is limited to the US at the inception date. The initial data also include all delisted ETFs that were traded in the US market during the sample period.
- Period: from 1993 to 2012.
- Source:
- Bloomberg: daily historical prices for ETFs, NAVs, and the underlying indexes, as well as institutional details about the ETFs
- CRSP: ETF split information and the expense ratio
- Thomson 12D mutual fund holding data : ETF holding information

Sample exclude actively managed funds

- To investigate the effect of liquidity on the ETF returns and variances effectively, we exclude actively managed funds from the sample. Actively managed funds were first introduced in 2008.
- They are administered to achieve excess returns on the typical benchmark index by frequently buying or selling assets in the portfolio instead of passively following the index.
- As a result, actively managed funds are more likely to deviate from their underlying index returns, because their portfolio composition weights change frequently.
- **Because the tracking errors of actively managed funds could be caused by management style, separating the effect of liquidity from the effect of management style on return and variance is difficult.**
- Therefore, excluding actively managed funds from the sample is reasonable for an analysis of the liquidity effect on return and variance.
- As a result, **the final sample contains only index-based passive ETFs**. We **exclude ETFs that do not contain enough information about the traded prices, NAV, or underlying index**. Details about the sample construction procedure are included in Appendix A, Table A1. Our final sample consists of 1,307 US-listed ETFs.

We restrict the data after 2002 for two reasons.

- First,a sufficient number of ETFs to construct ten portfolios in Section 4 is not available before 2002. At the end of 2001, 101 ETFs were listed in the US market. Each portfolio could contain more than ten ETFs per year after 2001.
- Table 1 reports the annual breakdown of the sample by the number of funds initiated, delisted, and available at the end of the year, as well as the average market value, average trading volume, and average dollar trading volume.
- As seen in Table 1 and Fig. 1, the number of funds and trading volume increase sharply after the early 2000s,and the number of ETFs traded in the US increases to 1,239 by the end of 2012. Consequently, each portfolio in 2012 could have more than one hundred ETFs.
- Second, the minimum tick size of the bid-ask spread reduces from 1/16to 1/100 in 2001.
- The change in the minimum tick size is related to the exogenous shock to the liquidity.
- Moreover,Fig. 1 shows a significant increase in the trading volume of the ETF market after 2002, although there was a decrease after the 2007–2009 financial crisis. The increase in trading volume and the decrease in the bid-ask spread imply an important change in the liquidity measure. For these reasons, this study uses the data since 2002.

Table 1

Exchanged-traded fund (ETF) trends.

This table reports the annual breakdown of the sample by number of funds created, number of funds delisted, number of funds available at the end of year, average market value, average trading volume, and average dollar trading volume. This table also provides the market share of the top three (five and ten) ETFs in each year. The sample contains all the US ETFs that were listed on the US exchange during 1993–2012.

				Market value			Volume			Dollar volume		
Year	Created	Delisted	N	(Bill. $)	To3(%)	Top10(%)	(Mill. Sh)	To3(%)	Top10(%)	(Bill. $)	To3(%)	Top10(%)
1993	1	0	1	0.3	100.0	100.0	0.2	100.0	100.0	0.0	100.0	100.0
1994	0	0	1	0.5	100.0	100.0	0.4	100.0	100.0	0.0	100.0	100.0
1995	1	0	2	0.7	100.0	100.0	0.3	100.0	100.0	0.0	100.0	100.0
1996	17	0	19	1.7	91.3	97.0	1.2	85.0	94.3	0.1	96.4	98.7
1997	0	0	19	4.0	92.6	97.3	3.7	92.0	97.8	0.3	98.7	99.6
1998	10	0	29	10.0	87.8	94.6	9.9	85.5	96.7	0.9	97.5	99.3
1999	1	0	30	20.6	83.3	95.5	18.4	81.8	96.4	2.1	94.1	99.4
2000	50	0	80	46.4	76.8	90.4	42.1	87.2	94.8	4.2	93.3	97.7
2001	21	0	101	72.1	75.4	88.8	96.2	91.5	96.2	5.4	91.8	96.7
2002	15	3	113	91.3	62.1	80.3	147.7	88.3	94.1	7.3	88.9	94.7
2003	12	6	119	116.4	55.5	74.3	149.6	84.2	91.9	8.0	86.6	93.5
2004	35	0	154	176.4	43.3	65.9	192.7	76.9	89.5	11.6	79.3	90.7
2005	52	0	206	250.5	36.0	58.3	257.5	66.7	86.0	16.6	75.0	88.9
2006	157	1	362	355.9	29.5	50.7	369.1	60.8	80.7	24.4	69.3	85.3
2007	268	0	630	502.3	26.5	45.1	686.0	54.5	75.2	54.7	66.1	82.2
2008	162	50	742	556.8	25.1	41.8	1560.3	42.0	64.5	93.7	52.2	72.0
2009	127	51	818	608.8	21.9	39.6	1849.5	28.3	56.4	69.9	42.6	61.9
2010	180	48	950	839.3	19.6	38.0	1379.7	28.5	51.8	68.2	47.0	63.7
2011	231	15	1,166	1043.7	18.9	36.1	1357.6	27.8	49.5	77.5	46.7	62.3
2012	155	82	1,239	1203.7	18.9	35.8	952.6	27.1	46.3	56.2	46.7	61.5

Table A1

Study sample.

This table presents the process of constructing the sample used in this study. Initial exchange-traded fund (ETF) data are extracted from the Bloomberg database for all the ETFs that have ever been listed and traded in the US from 1993 through 2012.

Description	Number of ETFs
Initial sample (1)	1,495
ETFs on the BATs global market (2)	17
Actively managed funds (3)	57
Underlying index data are missing	
Barclays Capital Bond Index (4)	68
Combination of commodity prices (5)	11
Index level data are not available (6)	20
NAV data are missing (7)	6
Price data are missing (8)	9
Total number of samples deleted (9) [(2) – (8))]	188
Final sample (1) – (9)	1,307

Liquidity measure

- The daily individual ETF liquidity is measured using the daily **relative effective spread** calculated from the NYSE Trade and Quote (TAQ) database.
- The **effective half-spread** is defined as the absolute difference between the quote midpoint and the corresponding trade price, that is,

$$c_t^i = \frac{1}{n_t^i} \sum_{k=1}^{n_t^i} \frac{|p_{k,t}^i - m_{k,t}^i|}{p_{k,t}^i}, \qquad (1)$$

- where pik,t is the traded price, mik,t is the quote midpoint, and nit is the number of trades at time k on day t for each security i.

- The relative effective spread is similar to the liquidity measure of "dollar cost per dollar invested" used in Acharya and Pedersen (2005, p. 386).
- They normalize the Amihud illiquidity measure so as to be similar to the cross-sectional mean and variance of the effective half-spread reported in Chalmers and Kadlec (1998).
- As a result, their liquidity measure is ultimately similar to the relative effective half-spread, which can be obtained directly from the TAQ data.
- An advantage of using the TAQ data is that the spread variables can be observed on a daily basis.
- Examining the effect of liquidity on tracking errors is better using daily level measures than monthly-level measures because APs manage the ETF market through arbitrage activities, which affect tracking errors of ETFs on a daily basis.
- Moreover,the daily liquidity measure is suitable for the leveraged or inverse ETFs, because the use of the monthly measure can cause a mechanical difference between the monthly realized return and the monthly holding return (Cheng and Madhavan, 2009; Tang and Xu, 2013).

Tracking errors

- ETF NAV INDEX on daily and yearly
- To examine the effect of ETF liquidity on tracking errors, we examine the return differences between ETF and NAV, NAV and index, and ETF and index.
- We calculate **annual tracking errors for the three kinds of return differences** and **construct daily tracking errors using the absolute value of return differences.**
- For the annual panel data analysis, yearly tracking errors are defined using the following two methods.
- The first is regression analysis, in which the tracking error is defined as the absolute difference between one and the coefficient of the regression of two return series: ETF returns versus NAV returns(ETFNAV), NAV returns versus index returns(NAV-index), or ETF returns versus index returns(ETF-index).
- The second is calculating the standard deviation of the return difference between the two return series.

Table 2

Summary statistics and correlations of exchange-traded fund (ETF) tracking errors.

This table provides the summary statistics and correlations of estimated tracking errors for ETFs from the inception date to the end of 2012 or the delisting date. Two tracking errors are defined. $\theta(Y-X)$ is the tracking error by taking the absolute value of the difference between one and the coefficient of X from the regression of Y on X. $\sigma(Y-X)$ is the standard deviation of the return difference between Y and X. The six tracking errors are estimated for each ETF using all daily returns. r_t, v_t, and f_t denote the daily ETF, net asset value (NAV), and index returns, respectively.

	Variable					
	$\sigma(r_t-f_t)$	$\sigma(v_t-f_t)$	$\sigma(r_t-v_t)$	$\theta(r_t-f_t)$	$\theta(v_t-f_t)$	$\theta(r_t-v_t)$
Panel A: Summary statistics for estimated tracking errors						
Mean	1.194%	0.419%	1.147%	15.846%	4.076%	16.470%
Std.Dev.	1.223%	0.952%	1.004%	17.680%	9.254%	17.615%
Panel B: Tracking error correlations for individual ETFs						
$\sigma(r_t-f_t)$	1.000					
$\sigma(v_t-f_t)$	0.712	1.000				
$\sigma(r_t-v_t)$	0.811	0.319	1.000			
$\theta(r_t-f_t)$	0.437	0.133	0.403	1.000		
$\theta(v_t-f_t)$	0.302	0.526	0.088	0.319	1.000	
$\theta(r_t-v_t)$	0.310	−0.008	0.447	0.808	0.093	1.000

Threshold ETF data

- When a stock is traded in the US market, the transaction should be settled three business days after the order is executed. An **FTD** occurs when a market participant does not deliver the underlying security he or she sold or does not meet his or her contractual obligation.
- According to SEC Rule 203 of Regulation SHO, a stock is classified as a threshold stock if it has an aggregate FTD position over five consecutive settlement days with a registered clearing agency, with trading totaling **ten thousand shares** or more and **amounting to at least 0.5% of the total outstanding shares** of the issuer.
- The event of listing as a threshold stock can trigger a **liquidity shock** to the corresponding stock **because of the regulatory enforcement to close out FTDs and to forbid naked shorting** (Boni, 2006; Fotak et al.,2014). To explain the causal effects of liquidity on tracking errors, we use a threshold stock listing as an instrumental variable.
- The SEC provides the FTD data on its website. The SEC requires exchanges to publish a threshold list on a daily basis, and we acquire these lists from the various listing exchanges. Threshold stocks are identified by CRSP Permnos after finding CUSIP codes in the FTD data by matching the ticker symbols of the FTD data with those of threshold data. Our data show that about **71.16% of ETFs** are classified as a threshold stock at least once during the sample period.

Settlement Cycle ***

- Settlement Period—The Details
- The specific length of the settlement period has changed over time. For many years, the trade settlement period was five days. Then in 1993, the SEC changed the settlement period for most securities transactions from five to three business days—which is known as T+3. Under the T+3 regulation, if you sold shares of stock Monday, the transaction would settle Thursday. The three-day settlement period made sense when cash, checks, and physical stock certificates still were exchanged through the U.S. postal system.

- New SEC Settlement Mandate—T+2
- In the digital age, however, that three-day period seems unnecessarily long. In March 2017, the SEC shortened the settlement period from T+3 to T+2 days. The SEC's new rule amendment reflects improvements in technology, increased trading volumes and changes in investment products and the trading landscape. Now, most securities transactions settle within two business days of their trade date. So, if you sell shares of stock Monday, the transaction would settle Wednesday. In addition to being more aligned with current transaction speeds, T+2 could reduce credit and market risk, including the risk of default on the part of a trading counterparty.

Regulation SHO ***

- Regulation SHO is a set of rules from the Securities and Exchange Commission (SEC) implemented in 2005 that governs short sale practices.
- Regulation SHO established "locate" and "close-out" requirements aimed at curtailing **naked short selling** and other practices.
- Naked shorting takes place when investors sell short shares that they do not possess and have not confirmed their ability to possess.

Part 3 The effect of ETF liquidity on tracking errors

- No-arbitrage conditions imply that three daily return series (ETF, NAV, and index returns) must be identical owing to arbitrage activities of APs in a frictionless market.
- These return differences can be caused by various factors, such as trading activities, product structures, underlying securities markets, and ETF market conditions.
- A potential channel causing such return gaps is liquidity problems in the ETF market. Because the lack of liquidity in the ETF can lead to an increase in the cost of arbitrage activities of APs, it could prevent them from actively participating in the ETF market even if ETF prices deviate from their NAVs.
- This section investigates whether liquidity is related to ETF tracking errors by using panel regression analysis.

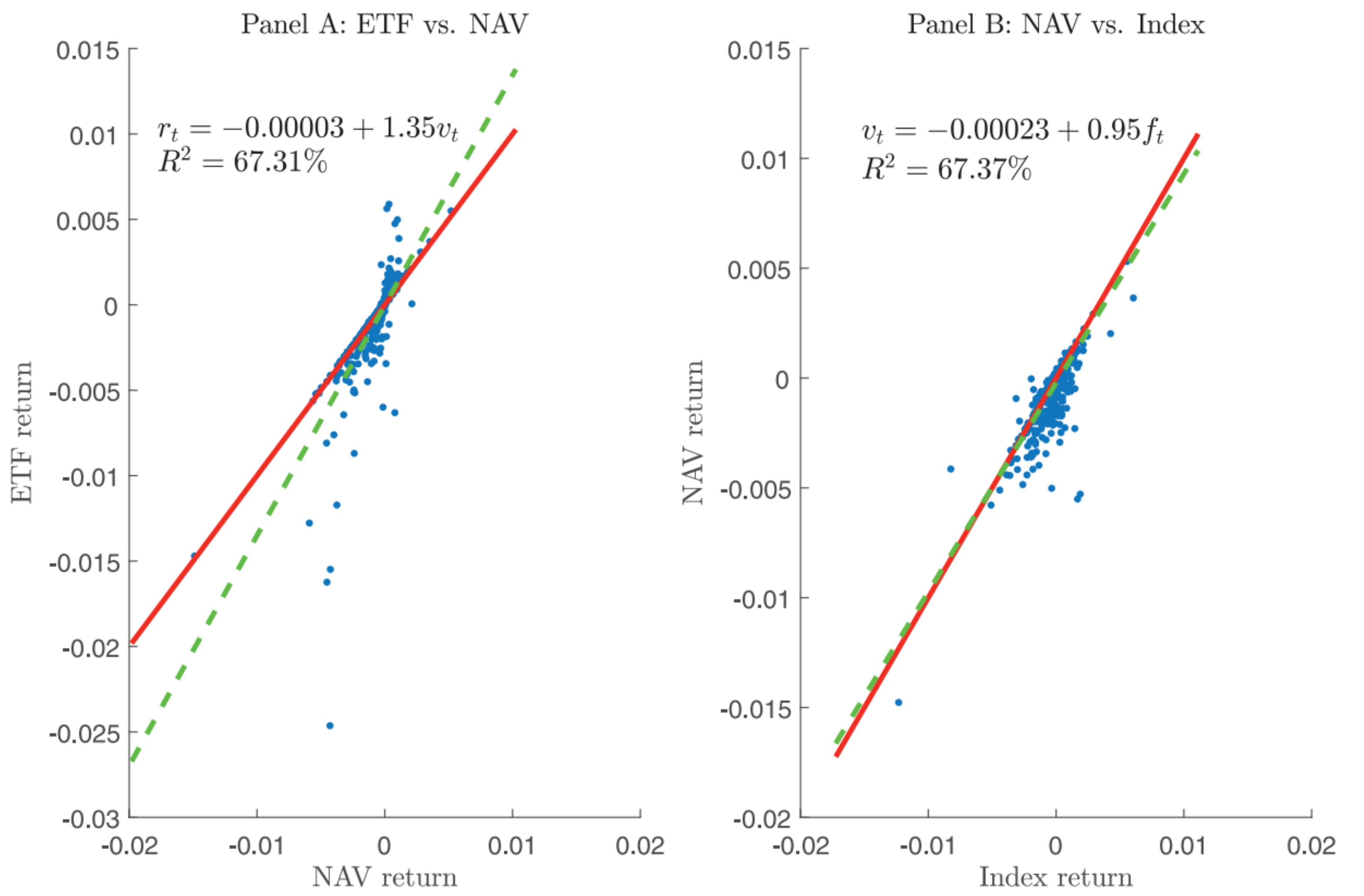

Fig. 4. Return distributions among exchange-traded fund (ETF), net asset value (NAV), and index returns. This figure illustrates cross-sectional relations between ETF returns and NAV returns (Panel A), and between NAV returns and underlying index returns (Panel B). Each point represents the time series average daily return series for the entire sample period. The solid line represents the fitted regression line and the dotted line is the forty five degree line.

Fig. 4 shows the cross-sectional relations between ETF and NAV returns (Panel A) and between NAV and index returns (Panel B).

Each point represents the time series average daily return of each ETF from the inception date to the end of 2012 or the delisting date.

The solid lines indicate the fitted regression lines between two return series, and the dotted lines are the 45-degree lines.

Fig. 4 suggests that ETF returns can deviate from NAV returns even if ETF portfolios are managed precisely to mimic their underlying indexes.

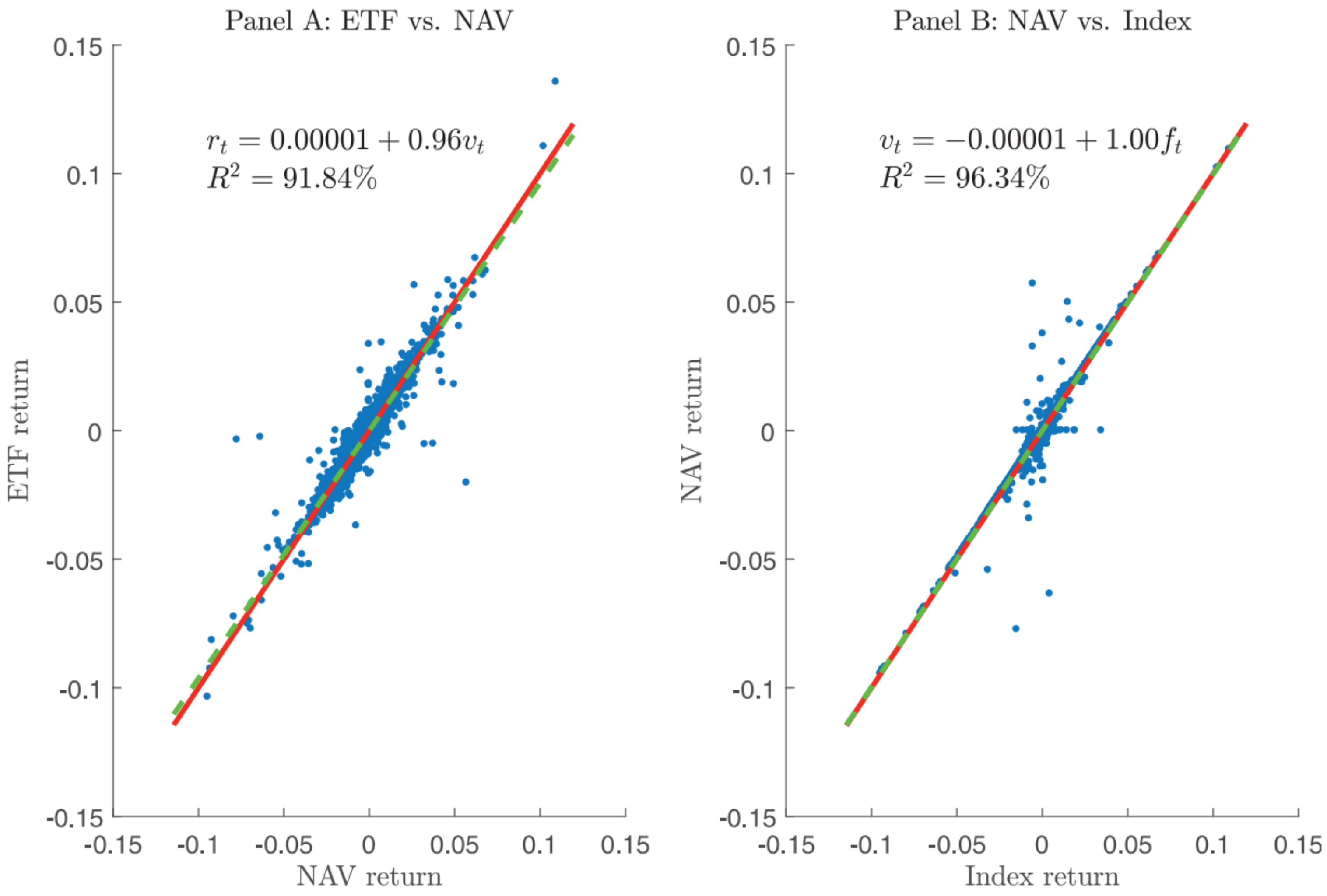

Fig. 5. Return distributions among exchange-traded fund (ETF), net asset value (NAV), and index returns: SPY. This figure illustrates ETF, NAV, and index returns of SPY, which is SPDR S&P 500 ETF issued by State Street Global Advisors. Panel A depicts the relation between daily ETF and NAV returns, and Panel B depicts the relation between daily NAV and index returns, from January 22, 1993 to December 31, 2012. The solid line represents the fitted regression line and the dotted line is the forty five degree line.

Fig. 5 shows the return relations for SPDR S&P 500 ETF Trust (SPY)

Incepted in 1993, the SPY, the oldest and the largest ETF in the US, tracks the performance of the S&P 500 index.

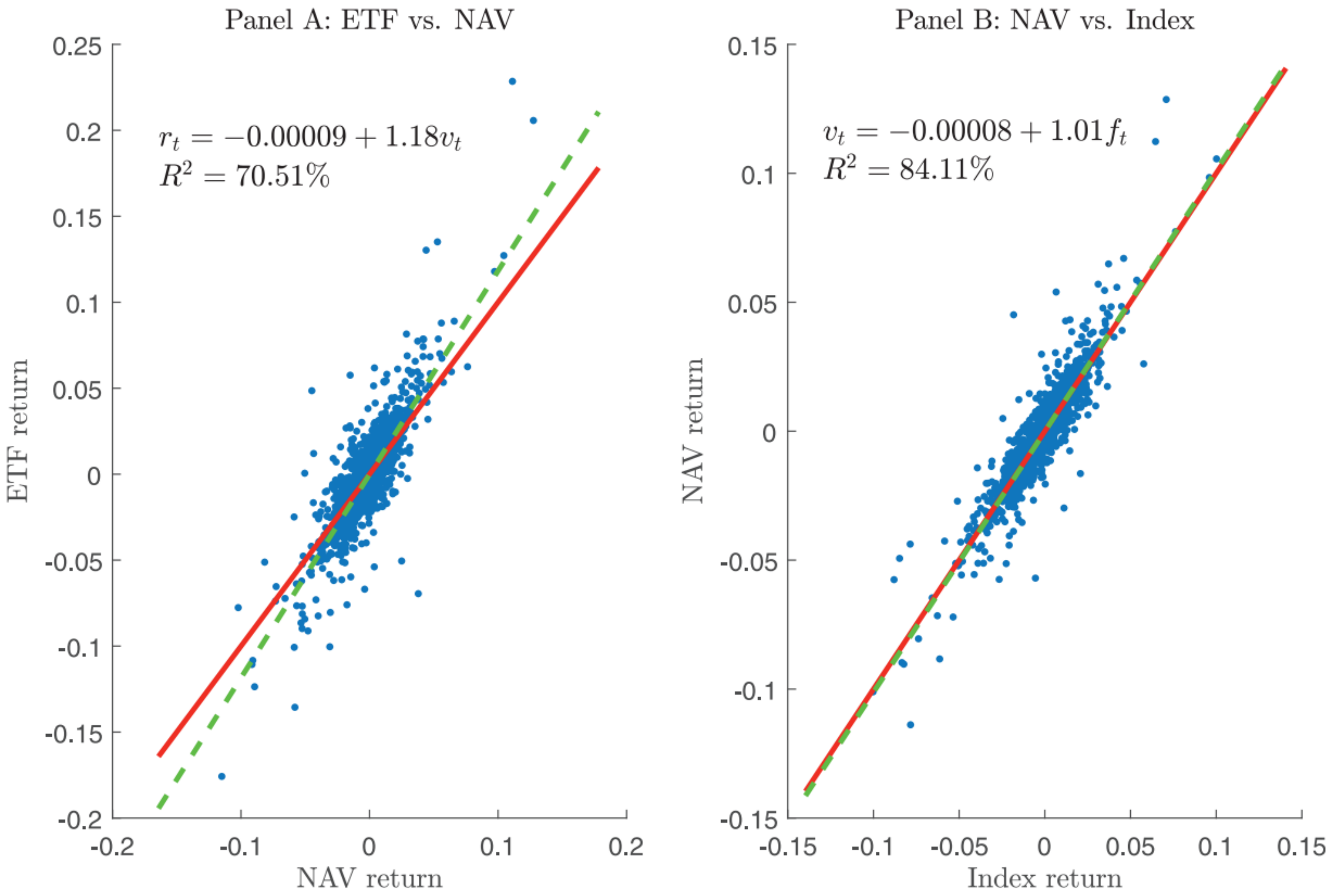

Fig. 6. Return distributions among exchange-traded fund (ETF), net asset value (NAV), and index returns: EEM. This figure illustrates ETF, NAV, and index returns of EEM, which is iShares MSCI Emerging Market Index ETF issued by iShares. Panel A depicts the relation between daily ETF and NAV returns, and Panel B depicts the relation between daily NAV and index returns, from April 11, 2003 to December 31, 2012. The solid line represents the fitted regression line and the dotted line is the forty five degree line.

Fig. 6 shows those for iShares MSCI Emerging Markets Index (EEM).

The EEM in Fig. 6 appears to have relatively larger tracking errors than the SPY does.

The EEM, one of the most popular international ETFs in the US, is designed to track the performance of the MSCI emerging market index.

Because the EEM physically holds emerging market stocks,EEM market prices could fail to reflect the changes in the underlying index immediately.

In summary, both figures suggest that tracking errors in the ETF-NAV returns are more severe than those in the NAV-index returns.

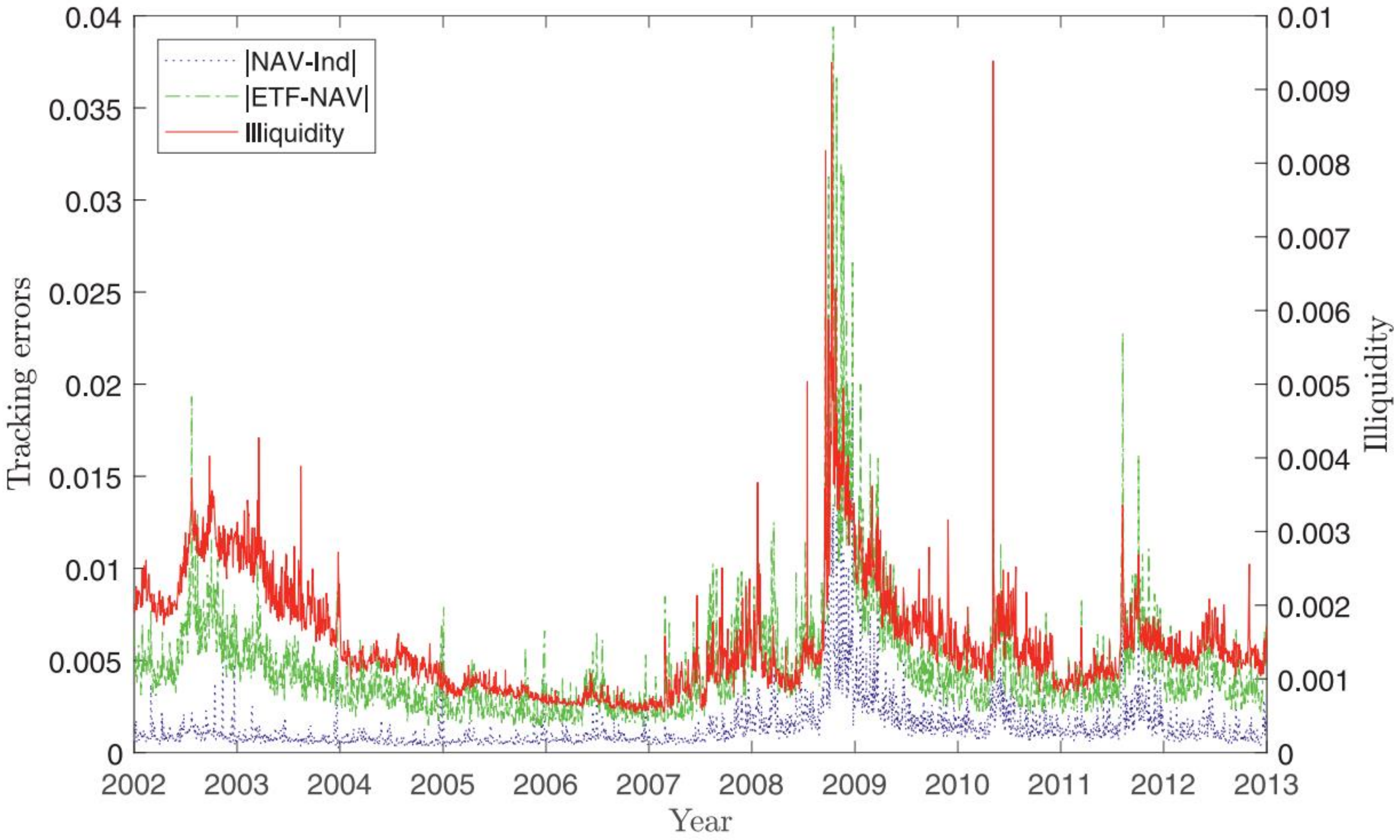

Fig. 7. Daily time series for illiquidity and return differences. This figure illustrates historical time series of illiquidity and absolute values of return differences from 2002 to 2012. The solid line is the average illiquidity, which is the cross-sectional average of daily relative effective spreads of all US exchange-traded funds (ETFs). The dotted line is the average absolute values of return differences between net asset value (NAV) and index returns, the dashed line is the average absolute value of return differences between ETF and NAV returns.

The time series relations between return differences and illiquidity are illustrated in Fig. 7

Fig. 7 intuitively shows the relations between ETF illiquidity and the ETF's tracking errors.

Panel regression

- This section formally tests the effect of ETF illiquidity on tracking errors using panel regressions. To this end, we estimate illiquidity and tracking errors at the daily or yearly frequency to investigate their relations.
- The main variable of interest is **illiquidity**, which is defined as the relative effective half-spread. Thus, high values of relative spread imply low liquidity.
- ETF prices are affected by both **product structures (eg. invest in other countries, the replication methods)** and **ETF market conditions (eg. Illiquid)**.

- ETF market conditions:
- AUM, dollar trading volume, underlying index return volatility, shares outstanding, and volatility of share growth.
- Annual underlying index return volatility
- The log of the average annual dollar trading volume
- The logarithm of the average number of shares and the standard deviation of the share growth rate during the year.

- ETF characteristics (US-based)
- whether the underlying securities in the ETF baskets invested in US assets;
- derivatives based: whether the ETF uses derivatives to replicate the underlying index return;
- swap based: whether the ETF uses swaps to replicate the underlying index return;
- futures available: whether the ETF has futures contracts based on it;
- options available: whether the ETF has option contracts based on it;
- leveraged funds: whether the ETF is leveraged or inverse;
- expense ratio: the annual expense ratio of the ETF;
- in-kind: whether the ETF is replicated physically;
- and optimized: whether the ETF is replicated by optimizing the basket of securities.

Table B1
Variable definitions.

Variable	Definition	Freq.	Source
Absolute Order Imbalance	Absolute value of normalized order imbalance. Normalized order imbalance is the order imbalance divided by the fund creation and redemption size. Order imbalance is calculated by the difference of the number of trading volume between traded at ask side and traded at bid side.	Daily	NYSE TAQ, Bloomberg
AR(1) Coefficient(ϕ)	Coefficient estimate of the AR(1) model for daily underlying index returns.	Yearly	Bloomberg
AUM	Assets under management, which are net asset value times the number of shares outstanding.	Daily	Bloomberg
Derivatives-Based	Indicator variable of one if the ETF uses the derivatives contracts to replicate its underlying index.	Daily	Bloomberg
Dollar Trading Volume	Trading volume times the daily closing price. Set to zero if no trading volume.	Daily	Bloomberg
Effective Spread	Average of the trade-weighted effective half-spread, which is the absolute difference between the trade price and the quote midpoint of the associated price.	Daily	NYSE TAQ
Equity-Type ETF	Indicator variable of one if the underlying portfolio of the ETF consists of equity.	Daily	Bloomberg
Expense Ratio	Annual expense ratio.	Yearly	CRSP MF, Bloomberg

(*continued on next page*)

Table B1 (*continued*)

Variable	Definition	Freq.	Source
Futures Available	Indicator variable of one if the ETF has futures contracts based on itself. The futures contracts are available after the approval date of the Commodities Futures Trading Commission (CFTC).	Daily	Bloomberg,CFTC
Index Volatility	Annual standard deviation of daily index returns.	Yearly	Bloomberg,ETF webpage
In-Kind	Indicator variable of one if the ETF delivers or receives physical assets when creating or redeeming shares.	Daily	Bloomberg
Intraday Volatility	Daily standard deviation of intraday price changes.	Daily	NYSE TAQ
Invested in US Assets	Indicator variable of one if the underlying portfolio of the ETF consists of US assets.	Daily	Bloomberg
Leveraged Fund	Indicator variable of one if the ETF is either inverse or leveraged.	Daily	Bloomberg
Non-trading Prob(p)	Number of non-trading days divided by total business days each year.	Yearly	Bloomberg
Optimized	Indicator variable of one if the ETF optimizes the portfolio when replicating its underlying index.	Daily	Bloomberg
Options Available	Indicator variable of one if the ETF has option contracts based on itself. Option contracts are available after the first day recorded in OptionMetrics.	Daily	Bloomberg, Option-Metrics
Quoted Spread	Average trade-weighted half-spread, which is the difference between the ask and bid prices of the quote divided by two.	Daily	NYSE TAQ
ETF Illiquidity	Average relative effective half-spread of the day. The variable is defined as the effective half-spread divided by the trade price in which the effective half-spread is the absolute difference between the trade price and the quote midpoint of the associated price.	Daily	NYSE TAQ
Relative Quoted Spread	Average trade-weighted relative half-spread, which is the half-spread divided by the quote midpoint.	Daily	NYSE TAQ
Shares Outstanding Growth	Log of shares outstanding to the lagged shares outstanding at daily level.	Daily	Bloomberg,ETF webpage
Shares Volatility	Volatility of shares outstanding growth defined as the standard deviation of daily share outstanding growth.	Yearly	Bloomberg,ETF webpage
Shares Outstanding	Number of shares outstanding	Daily	Bloomberg, ETF webpage
Swap Based	Indicator variable of one if the ETF uses the swap contracts to replicate its underlying index.	Daily	Bloomberg
Underlying Asset Liquidity	Weighted average of relative effective spreads of stocks contained in the ETF. Individual weight is computed by dividing the value of each stock by the sum of stock values.	Daily	Thompson 12D, NYSE TAQ

Table 3

Exchange-traded fund (ETF) illiquidity and tracking errors: regression-based tracking errors.

This table reports coefficients estimates of yearly regressions of ETF tracking errors on ETF illiquidity. The dependent variables are annual tracking errors, calculated by taking the absolute difference between one and regression coefficients of ETF returns on its index returns (Columns 1 and 4), of ETF returns on net asset value (NAV) returns (Columns 2 and 5), or of NAV returns on index returns (Columns 3 and 6). Columns 1–3 show the estimation results for the whole sample period; Columns 4–6 for the financial crisis period. The main independent variable is annual average of daily relative effective spread (ETF illiquidity) computed from the NYSE Trade and Quote (TAQ) database. All independent variables are yearly averages of daily variables. All daily variables are defined in Appendix B. All regressions include year fixed effects. t-statistics based on standard errors double-clustered at the fund and year level are in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

	All sample			Financial crisis period		
Variable	θ(ETF-IND) (1)	θ(ETF-NAV) (2)	θ(NAV-IND) (3)	θ(ETF-IND) (4)	θ(ETF-NAV) (5)	θ(NAV-IND) (6)
ETF Illiquidity	13.038**	12.938**	−0.777	15.818**	16.540**	−1.795
	(2.42)	(2.38)	(−0.62)	(2.91)	(3.15)	(−1.71)
Log(AUM)	−1.483	−0.787	0.337	−1.136	−0.444	−0.063
	(−1.59)	(−0.85)	(0.69)	(−1.23)	(−0.48)	(−0.17)
Log(Dollar Trading Volume)	0.621	0.872*	−0.236	0.734	1.068*	−0.035
	(0.95)	(1.88)	(−0.98)	(0.95)	(2.11)	(−0.17)
Index Volatility	−0.068	−1.006*	0.808	0.145	−0.803	−0.076
	(−0.11)	(−2.03)	(1.22)	(0.20)	(−1.23)	(−0.19)
Log(Shares Outstanding)	0.204	−0.830	−0.637	0.041	−0.824	−0.432
	(0.21)	(−0.94)	(−1.42)	(0.04)	(−0.96)	(−1.22)
Shares Volatility	−24.290*	−22.446**	4.821	−23.295	−15.881*	2.995
	(−2.19)	(−3.07)	(1.65)	(−1.58)	(−1.86)	(0.78)
Equity-Type ETF	−12.866***	−14.187***	−6.113***	−14.492***	−16.073***	−4.966***
	(−4.00)	(−5.21)	(−4.82)	(−4.63)	(−6.80)	(−5.10)
Invested in US Assets	−3.971**	−2.603*	−4.242***	−4.062**	−2.699*	−3.841***
	(−3.04)	(−2.14)	(−5.61)	(−2.91)	(−2.02)	(−5.39)
Swap Based	10.782*	3.873	9.048*	11.579**	6.631*	8.428*
	(2.12)	(0.90)	(2.09)	(2.60)	(1.90)	(2.22)
Derivatives Based	−9.518**	−11.912**	−2.130	−9.598**	−11.888**	−2.138
	(−2.67)	(−2.92)	(−1.43)	(−2.50)	(−3.13)	(−1.79)
Leveraged Fund	−4.465	2.327	−7.212	−3.716	0.586	−4.777
	(−0.77)	(0.84)	(−1.27)	(−0.77)	(0.30)	(−0.97)
Futures Available	0.547	0.868	0.241	−0.579	−1.010	0.120
	(0.44)	(0.60)	(0.54)	(−0.50)	(−1.04)	(0.21)
Options Available	−2.688**	−3.160**	0.780	−2.373*	−2.573**	0.733
	(−2.68)	(−2.85)	(1.65)	(−2.16)	(−2.31)	(1.70)
In-Kind	0.423	0.202	−0.720	1.137	1.405	−0.621
	(0.34)	(0.15)	(−1.09)	(0.89)	(1.34)	(−0.94)
Optimized	0.239	1.558	−1.177*	0.084	1.367	−0.926
	(0.25)	(1.46)	(−1.97)	(0.09)	(1.35)	(−1.49)
Expense Ratio	1.354	2.139	0.299	−0.267	1.073	0.428
	(0.74)	(1.67)	(0.22)	(−0.13)	(0.61)	(0.28)
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	5,471	5,484	5,611	4,378	4,379	4,488
Adjusted R^2	0.092	0.206	0.109	0.086	0.214	0.099

Table 3 reports results from the pooled panel regressions of **yearly** tracking errors on the ETF illiquidity measure and other control variables.

Table 4

Exchange-traded fund (ETF) illiquidity and tracking errors: standard deviation–based tracking errors.

This table reports coefficients estimates of yearly regressions of ETF tracking errors on ETF illiquidity. The dependent variables are annual tracking errors, calculated by taking the standard deviation of differences between ETF returns and index returns (Columns 1 and 4), between ETF returns and net asset value (NAV) returns (Columns 2 and 5), or between NAV returns and index returns (Columns 3 and 6). Columns 1–3 show the estimation results for the whole sample period; Columns 4–6 for the financial crisis period. The main independent variable is annual average of daily relative effective spread (ETF Illiquidity) computed from the NYSE Trade and Quote (TAQ) database. All independent variables are yearly averages of daily variables. All daily variables are defined in Appendix B. All regressions include year fixed effects. t-statistics based on standard errors double-clustered at the fund and year level are in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

	All sample			Financial crisis period		
Variable	σ(ETF-IND) (1)	σ(ETF-NAV) (2)	σ(NAV-IND) (3)	σ(ETF-IND) (4)	σ(ETF-NAV) (5)	σ(NAV-IND) (6)
ETF Illiquidity	0.014***	0.015***	0.001	0.014***	0.015***	−0.000
	(12.67)	(13.79)	(0.98)	(11.88)	(13.65)	(−0.65)
Log(AUM)	0.001	0.001	0.002	0.000	0.000	0.000
	(0.87)	(1.13)	(1.33)	(0.30)	(0.60)	(0.72)
Log(Dollar Trading Volume)	−0.000	−0.000	−0.001	−0.000	−0.000	−0.000
	(−1.46)	(−1.16)	(−1.55)	(−1.06)	(−0.28)	(−1.35)
Index Volatility	0.003***	0.002***	0.004**	0.003***	0.002***	0.001***
	(6.95)	(4.92)	(2.43)	(6.09)	(5.13)	(5.91)
Log(Shares Outstanding)	−0.001	−0.001	−0.001	−0.000	−0.000	−0.000
	(−1.11)	(−1.46)	(−1.39)	(−0.78)	(−1.31)	(−1.13)
Shares Volatility	0.000	−0.001	0.005	−0.000	−0.000	0.002
	(0.06)	(−0.98)	(1.79)	(−0.07)	(−0.27)	(1.49)
Equity-Type ETF	−0.002*	−0.001*	−0.002*	−0.002*	−0.001	−0.001
	(−1.91)	(−1.89)	(−2.10)	(−1.89)	(−1.68)	(−1.79)
Invested in US Assets	−0.005***	−0.003***	−0.004***	−0.005***	−0.003***	−0.004***
	(−5.64)	(−5.73)	(−5.28)	(−5.29)	(−5.43)	(−5.35)
Swap Based	0.001	−0.004	0.005*	0.003	−0.000	0.006**
	(0.18)	(−1.12)	(2.15)	(1.50)	(−0.41)	(2.91)
Derivatives Based	−0.002	−0.003	−0.001	−0.000	−0.001	−0.000
	(−0.82)	(−1.31)	(−0.85)	(−0.19)	(−0.78)	(−0.26)
Leveraged Fund	−0.000	0.003	−0.004	−0.003	−0.002	−0.003
	(−0.08)	(0.66)	(−1.54)	(−1.25)	(−1.80)	(−1.13)
Futures Available	0.001	0.001	0.000	−0.000	0.000	−0.000
	(0.89)	(1.15)	(0.36)	(−0.10)	(0.17)	(−1.00)
Options Available	−0.001**	−0.002***	0.000	−0.001	−0.001***	0.001**
	(−2.40)	(−3.40)	(0.85)	(−1.77)	(−3.91)	(2.67)
In-Kind	−0.001*	−0.001	−0.001*	−0.001	−0.000	−0.000
	(−1.88)	(−1.66)	(−1.83)	(−1.45)	(−1.18)	(−1.42)
Optimized	−0.000	0.000	−0.001**	−0.000	0.000	−0.001**
	(−0.90)	(0.82)	(−2.55)	(−1.14)	(0.77)	(−2.41)
Expense Ratio	0.002	0.003**	−0.001	0.000	0.001*	−0.001
	(1.29)	(2.62)	(−1.78)	(0.12)	(1.95)	(−1.44)
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	5,471	5,484	5,611	4,378	4,379	4,488
Adjusted R^2	0.532	0.500	0.322	0.511	0.485	0.286

Table 5

Exchange-traded fund (ETF) illiquidity and tracking errors: instrumental variable approach.

This table reports coefficients estimates of daily regressions of ETF tracking errors on ETF illiquidity. The dependent variables are daily tracking errors, calculated by taking the absolute values of daily return differences between ETF and its index (Columns 1 and 4), between ETF and its net asset value(NAV) (Columns 2 and 5), or between NAV and its index (Columns 3 and 6). Columns 1–3 are pooled ordinary least square estimation results; Columns 4–6, two-stage regression results by employing an instrumental variable. The instrumental variable is an indicator variable if an ETF receives a threshold flag. The first day of the threshold flag as the indicator value is one if the ETF receives the threshold flag on consecutive days. The main independent variable is the daily relative effective spread (ETF Illiquidity) computed from the NYSE Trade and Quote (TAQ) database. All other daily variables are defined in Appendix B. All regressions include day fixed effects. t-statistics based on standard errors double-clustered at the fund and day level are in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

	Panel regression			Instrumental variable regression		
Variable	|ETF-IND| (1)	|ETF-NAV| (2)	|NAV-IND| (3)	|ETF-IND| (4)	|NAV-IND| (5)	|ETF-NAV| (6)
ETF Illiquidity	0.453***	0.541***	0.025	3.529***	4.581***	−0.368
	(11.43)	(12.42)	(0.95)	(2.98)	(3.76)	(−0.50)
Log(AUM)	−0.001***	−0.001***	−0.000	0.001	0.002**	−0.000
	(−4.40)	(−3.50)	(−0.32)	(1.22)	(2.26)	(−0.61)
Log(Dollar Trading Volume)	0.001***	0.001***	0.000**	0.000***	0.000**	0.000**
	(5.92)	(6.30)	(2.29)	(3.23)	(2.50)	(2.46)
Absolute Order Imbalance	−0.000	−0.000	0.000	−0.000**	−0.000**	0.000
	(−1.51)	(−1.12)	(0.49)	(−2.24)	(−2.07)	(0.68)
Intraday Volatility	0.000***	0.000***	0.000*	−0.001	−0.001**	0.000
	(3.81)	(4.19)	(1.96)	(−1.59)	(−2.20)	(0.91)
Shares Outstanding Growth	0.001***	0.000	0.001***	0.001**	0.000	0.001***
	(2.63)	(0.04)	(3.47)	(2.13)	(0.11)	(3.47)
Log(Shares Outstanding)	0.000**	0.000	−0.000*	−0.000	−0.001*	−0.000
	(2.05)	(1.36)	(−1.80)	(−0.66)	(−1.80)	(−0.84)
Equity-Type ETF	−0.000	−0.001	−0.000	0.000	0.001	−0.000
	(−0.56)	(−0.98)	(−0.58)	(0.62)	(0.81)	(−0.76)
Invested in US Assets	−0.005***	−0.003***	−0.003***	−0.003***	−0.000	−0.003***
	(−13.10)	(−13.15)	(−7.77)	(−2.80)	(−0.13)	(−4.99)
Swap Based	0.002	−0.001	0.004*	0.003	−0.000	0.004
	(0.89)	(−1.01)	(1.68)	(1.24)	(−0.23)	(1.62)
Derivatives Based	−0.001	−0.002	0.000	0.001	−0.000	0.000
	(−0.48)	(−1.61)	(0.59)	(0.52)	(−0.18)	(0.38)
Leveraged Fund	0.000	0.001	−0.001	0.000	0.001	−0.001
	(0.14)	(1.64)	(−0.36)	(0.14)	(1.29)	(−0.36)
Futures Available	−0.001*	−0.000	−0.000	−0.001***	−0.001**	−0.000
	(−1.87)	(−0.70)	(−1.29)	(−2.90)	(−2.55)	(−0.67)
Options Available	−0.000	−0.001***	0.001***	0.001*	0.001	0.001**
	(−1.39)	(−5.12)	(4.09)	(1.68)	(1.32)	(1.97)
In-Kind	−0.000	−0.000	−0.000	−0.000	−0.000	−0.000
	(−1.13)	(−0.95)	(−1.55)	(−0.78)	(−0.58)	(−1.54)
Optimized	0.000	0.001***	−0.001***	0.001*	0.001***	−0.001***
	(0.53)	(3.01)	(−4.23)	(1.82)	(3.64)	(−3.58)
Expense Ratio	0.002***	0.003***	−0.000	0.001	0.002***	−0.000
	(2.69)	(5.66)	(−0.69)	(1.62)	(3.12)	(−0.56)
Day fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	1,113,226	1,155,597	1,113,376	1,113,226	1,155,597	1,113,376
Adjusted R^2	0.254	0.219	0.109	−0.126	−0.536	0.097

The first three columns in Table 5report the results for pooled daily panel regressions.

Strategic FTDs & Rule 203 204

Instrumental variable regression: Reg SHO threshold flag

- FTD
- Evans et al. (2017) report that etfs account for a significant portion of ftds in the US stock markets. They argue that market makers or aps can strategically decide ftds to reduce transaction costs when a demand shock occurs in the ETF security.
- These **strategic ftds** are particularly effective for etfs with high creation fees or illiquid underlying basket securities. Strategic ftds enable aps to delay the creation process after they sell new etf shares to meet large order imbalances.
- Despite the potential benefits of market making, the sec regulates large and persistent ftds.
- The **sec rule 203** of reg sho requires listing exchanges to classify a stock as a threshold stock if large ftds occur for five consecutive settlement days. When a security receives a threshold flag, it becomes subject to the mandatory closeout requirement and the pre-borrowing requirement. Aps must immediately close out of unsettled positions if ftds persist for 13 consecutive settlement days. Despite these requirements, ftds still increase before the amendment of the SEC rule in 2009.
- In 2009, **sec rule 204** required the reduction of its mandatory close-out requirement to four days for general traders and six days for market makers.23until all ftds that need to be delivered immediately are closed, aps cannot short sell threshold securities without borrowing.
- Such regulatory restrictions can result in exogenous liquidity shocks once etfs receive a threshold flag. Aps can strategically fail to deliver certain etfs for saving creation or redemption fees.

.

- However, endogenous actions of aps perhaps do not apply to threshold securities, which force the regulatory enforcement of immediate close-out and pre-borrowing requirements and, thus, can increase their operating costs.
- For example, an ap can short sell new etfs to meet order imbalances without borrowing or creating shares, but it could strategically fail to deliver etf securities to save the costs.
- If the security is classified as a threshold security, aps must create or purchase additional etf shares to close out failed positions because such strategic ftds are impossible.
- The efforts of aps to resolve failed positions could lead to additional transactions or an increase in the number of etf shares, which, in turn,could increase etf liquidity. Therefore, a threshold security flag would be a valid instrument that is associated with liquidity changes

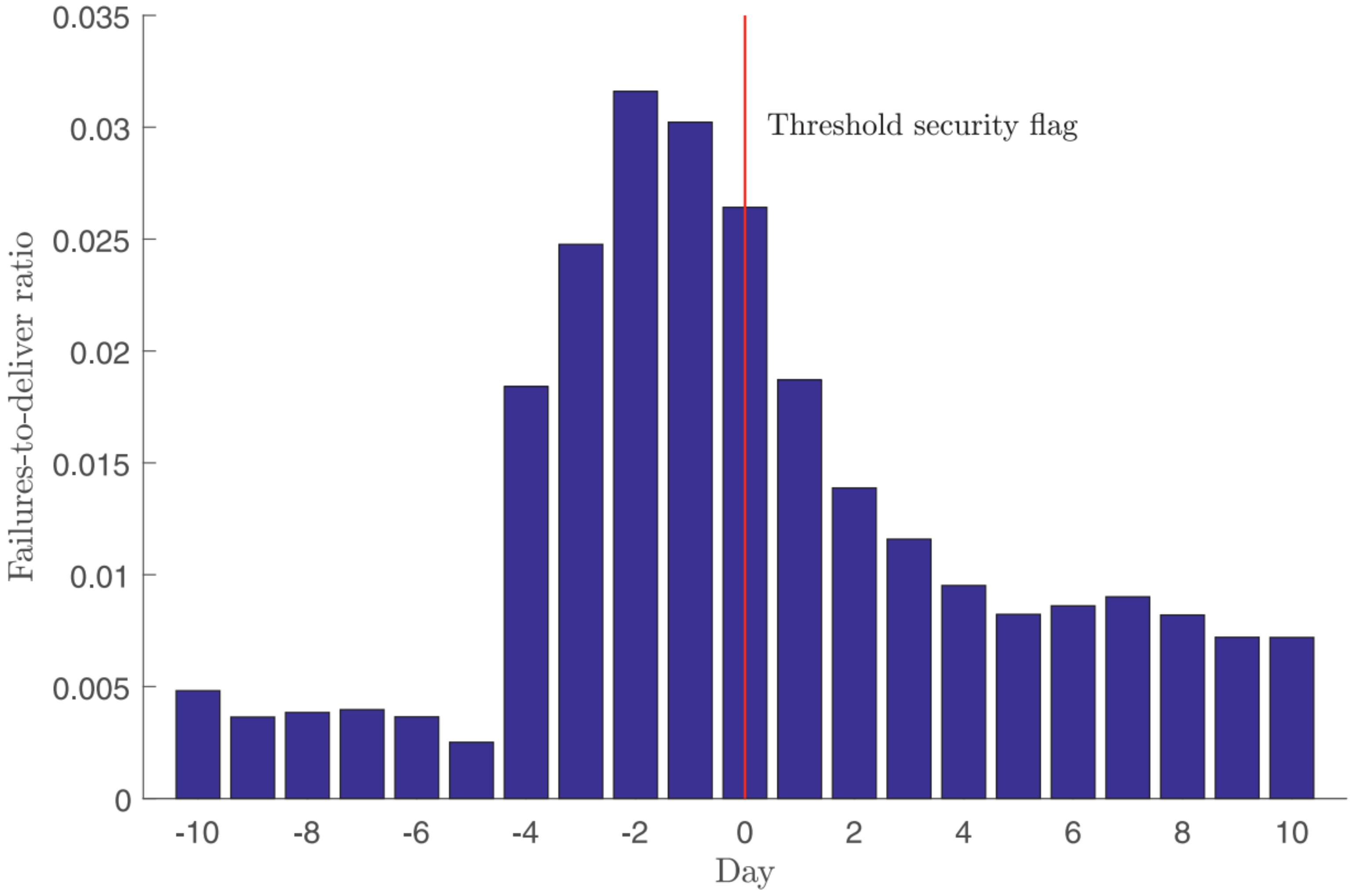

Fig. 8. Failures-to-deliver (FTD) ratio around the day as listed as threshold stocks. This figure illustrates the FTD ratio around the first day when an exchange-traded fund (ETF) is assigned as the threshold stocks. Day 0 denotes the first day of receiving the threshold of the ETFs. The FTD ratio is the number of outstanding failed positions reported on day $t+3$ divided by the total number of shares outstanding on day t of the ETF. The bar denotes the value-weighted average of FTD ratios.

According to Fig. 8, FTDs increase sharply before a threshold flag. This rapid increase is driven by sudden buying pressure or the strategic delay of ETF creation by APs. After a threshold flag, FTDs sharply decrease. This sharp decline is due to the close-out and pre-borrowing requirements imposed by Rule 203(b)(3) of Regulation SHO.

These two regulatory requirements bring about exogenous changes in ETF market liquidity, which we exploit to identify a causal link from ETF liquidity to tracking errors.

- We examine ETFs that are classified as threshold securities by using the threshold flag as an instrument for ETF liquidity shock.
- The first-stage estimation regresses daily liquidity measures (relative spread) on a dummy variable indicating a threshold flag along with other control variables used in the second-stage regression. The estimation result of the first stage regression is

$$\text{ETF } \widehat{\text{illiquidity}}_t = -0.0001191 \times \mathit{Threshold}_t + \text{Other controls} \tag{2}$$

$$\text{t-statistics}: \quad [-4.50^{***}]$$

- where Threshold is a dummy variable indicating a Reg SHO threshold flag for a given ETF.
- The first-stage regression includes day fixed effects, and standard errors are double-clustered at the fund and day level. The estimated coefficient on Threshold is negative and significant, **implying that the ETF listed as a threshold security experiences improved liquidity owing to bona fide market-making activities, which is consistent with Evans et al.** (2017).
- The first-stage regression result confirms that the instrument used in the analysis satisfies the relevance condition that the instrumental variable is correlated with the endogenous variable, namely, the ETF liquidity measure.
- The second-stage estimation regresses the dependent variable of tracking errors on the fitted liquidity estimated from the first-stage regression along with other control variables.

Table 5

Exchange-traded fund (ETF) illiquidity and tracking errors: instrumental variable approach.

This table reports coefficients estimates of daily regressions of ETF tracking errors on ETF illiquidity. The dependent variables are daily tracking errors, calculated by taking the absolute values of daily return differences between ETF and its index (Columns 1 and 4), between ETF and its net asset value(NAV) (Columns 2 and 5), or between NAV and its index (Columns 3 and 6). Columns 1–3 are pooled ordinary least square estimation results; Columns 4–6, two-stage regression results by employing an instrumental variable. The instrumental variable is an indicator variable if an ETF receives a threshold flag. The first day of the threshold flag as the indicator value is one if the ETF receives the threshold flag on consecutive days. The main independent variable is the daily relative effective spread (ETF Illiquidity) computed from the NYSE Trade and Quote (TAQ) database. All other daily variables are defined in Appendix B. All regressions include day fixed effects. t-statistics based on standard errors double-clustered at the fund and day level are in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

	Panel regression			Instrumental variable regression		
	|ETF-IND|	|ETF-NAV|	|NAV-IND|	|ETF-IND|	|NAV-IND|	|ETF-NAV|
Variable	(1)	(2)	(3)	(4)	(5)	(6)
ETF Illiquidity	0.453***	0.541***	0.025	3.529***	4.581***	−0.368
	(11.43)	(12.42)	(0.95)	(2.98)	(3.76)	(−0.50)
Log(AUM)	−0.001***	−0.001***	−0.000	0.001	0.002**	−0.000
	(−4.40)	(−3.50)	(−0.32)	(1.22)	(2.26)	(−0.61)
Log(Dollar Trading Volume)	0.001***	0.001***	0.000**	0.000***	0.000**	0.000**
	(5.92)	(6.30)	(2.29)	(3.23)	(2.50)	(2.46)
Absolute Order Imbalance	−0.000	−0.000	0.000	−0.000**	−0.000**	0.000
	(−1.51)	(−1.12)	(0.49)	(−2.24)	(−2.07)	(0.68)
Intraday Volatility	0.000***	0.000***	0.000*	−0.001	−0.001**	0.000
	(3.81)	(4.19)	(1.96)	(−1.59)	(−2.20)	(0.91)
Shares Outstanding Growth	0.001***	0.000	0.001***	0.001**	0.000	0.001***
	(2.63)	(0.04)	(3.47)	(2.13)	(0.11)	(3.47)
Log(Shares Outstanding)	0.000**	0.000	−0.000*	−0.000	−0.001*	−0.000
	(2.05)	(1.36)	(−1.80)	(−0.66)	(−1.80)	(−0.84)
Equity-Type ETF	−0.000	−0.001	−0.000	0.000	0.001	−0.000
	(−0.56)	(−0.98)	(−0.58)	(0.62)	(0.81)	(−0.76)
Invested in US Assets	−0.005***	−0.003***	−0.003***	−0.003***	−0.000	−0.003***
	(−13.10)	(−13.15)	(−7.77)	(−2.80)	(−0.13)	(−4.99)
Swap Based	0.002	−0.001	0.004*	0.003	−0.000	0.004
	(0.89)	(−1.01)	(1.68)	(1.24)	(−0.23)	(1.62)
Derivatives Based	−0.001	−0.002	0.000	0.001	−0.000	0.000
	(−0.48)	(−1.61)	(0.59)	(0.52)	(−0.18)	(0.38)
Leveraged Fund	0.000	0.001	−0.001	0.000	0.001	−0.001
	(0.14)	(1.64)	(−0.36)	(0.14)	(1.29)	(−0.36)
Futures Available	−0.001*	−0.000	−0.000	−0.001***	−0.001**	−0.000
	(−1.87)	(−0.70)	(−1.29)	(−2.90)	(−2.55)	(−0.67)
Options Available	−0.000	−0.001***	0.001***	0.001*	0.001	0.001**
	(−1.39)	(−5.12)	(4.09)	(1.68)	(1.32)	(1.97)
In-Kind	−0.000	−0.000	−0.000	−0.000	−0.000	−0.000
	(−1.13)	(−0.95)	(−1.55)	(−0.78)	(−0.58)	(−1.54)
Optimized	0.000	0.001***	−0.001***	0.001*	0.001***	−0.001***
	(0.53)	(3.01)	(−4.23)	(1.82)	(3.64)	(−3.58)
Expense Ratio	0.002***	0.003***	−0.000	0.001	0.002***	−0.000
	(2.69)	(5.66)	(−0.69)	(1.62)	(3.12)	(−0.56)
Day fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	1,113,226	1,155,597	1,113,376	1,113,226	1,155,597	1,113,376
Adjusted R^2	0.254	0.219	0.109	−0.126	−0.536	0.097

Table 5 reports the results from the ordinary least squares (OLS) panel regressions for comparison without instruments (Columns 1, 2, and 3) and the second-stage estimation (Columns 4, 5, and 6).

Fund characteristics, underlying asset liquidity, and tracking errors

- Which ETF illiquidity affects tracking errors, depending on the creation or redemption method or replication strategy.
- Bloomberg categorizes ETFs into in-kind, cash, and cash and in-kind according to the create or redeem method and into full replication, optimized, and derivatives-used according to the replication strategy.
- The creation or redemption method or the replication strategy could change the impact of ETF illiquidity on tracking errors. On the one hand, the effect of illiquidity should be stronger for ETFs with in-kind creation or redemption or full replication, because they have less choice of what and when to trade.
- On the other hand, to promote ease of trading and accounting process of APs,ETF companies can choose in-kind creation or redemption with full replication in the case of liquid underlying assets but cash-based creation or redemption in the case of illiquid underlying assets.

Table 6
Tracking error regression on fund characteristics.

This table reports coefficients estimates of daily regressions of exchange-traded fund (ETF) tracking errors on ETF illiquidity and interaction terms between ETF illiquidity and fund structure variables. The dependent variables are daily tracking errors between ETF and its net asset value (NAV), calculated by taking the absolute values of daily return differences between ETF and its NAV. Columns 1–4 are pooled ordinary least square estimation results for whole sample, and Column 5 is the result for the subsample with non-leveraged US equity–based ETFs without using derivatives to construct funds. All other daily variables are defined in Appendix B. All regressions include day fixed effects. t-statistics based on standard errors double-clustered at the fund and day level are in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

Variable	(1)	(2)	(3)	(4)	(5)
ETF Illiquidity	0.768***	0.686***	0.558***	0.504***	0.636***
	(11.38)	(12.50)	(11.01)	(11.44)	(7.62)
ETF Illiquidity × In-Kind	−0.356***				−0.063
	(−4.66)				(−0.42)
ETF Illiquidity × Full		−0.308***			
		(−4.77)			
ETF Illiquidity × Optimized			−0.112		
			(−1.62)		
ETF Illiquidity × Derivatives				0.484***	
				(4.13)	
Day fixed effects	Yes	Yes	Yes	Yes	Yes
Number of observations	1,155,597	1,155,597	1,155,597	1,155,597	535,280
Adjusted R^2	0.221	0.221	0.220	0.220	0.231

Table 6 reports the effects of ETF illiquidity and the interaction terms between ETF illiquidity and fund characteristics.

In these regressions, the main dependent variable is the tracking error between the ETF returns and the NAV returns, because we are interested in how ETF illiquidity affects the deviation of the former returns from the latter returns owing to the fund structures or characteristics.

the results show that ETFs with full replication are less likely to have tracking errors than are ETFs with optimized or derivatives replication.

Table 7

Underlying asset liquidity and exchange-traded fund (ETF) liquidity.

This table reports coefficients estimates of daily regressions of ETF tracking errors on ETF illiquidity, underlying portfolio illiquidity, and an interaction term between the two. The dependent variables are daily tracking errors, calculated by taking the absolute values of daily return differences between ETF and its index (Columns 1 and 4), between ETF and its net asset value (NAV) (Columns 2 and 5), or between NAV and its index (Columns 3 and 6). We include only non-leveraged US equity-based ETFs to identify underlying portfolio information correctly from Thomson 12D data. The identified sample is 359 US equity-based ETFs. We use the daily relative effective bid–ask spread computed from the NYSE trade and quote (TAQ) database for illiquidity variables of both ETFs and underlying portfolios. The underlying portfolio illiquidity is the value-weighted average of daily relative effective bid–ask spreads of stocks included in each portfolio. All other daily variables are defined in Appendix B. All regressions include day fixed effects. t-statistics based on standard errors double clustered at the fund and day level are in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

	|ETF-IND|		|ETF-NAV|		|NAV-IND|	
Variable	(1)	(2)	(3)	(4)	(5)	(6)
ETF Illiquidity	0.315***	0.509***	0.320***	0.525***	−0.007	0.027**
	(3.32)	(5.99)	(3.16)	(6.02)	(−0.24)	(2.02)
Under Illiquidity	0.161	0.760**	0.284	0.917***	0.211	0.315
	(0.47)	(2.09)	(0.94)	(2.60)	(0.77)	(1.11)
ETF Illiq × Under Illiq	219.042**		227.269**		38.229	
	(2.37)		(2.31)		(1.38)	
Log(AUM)	−0.001***	−0.001***	−0.001***	−0.001***	0.000**	0.000**
	(−4.50)	(−4.33)	(−4.17)	(−3.98)	(2.11)	(2.18)
Log(Dollar Trading Volume)	0.000	0.000	0.000	0.000	0.000	0.000
	(0.66)	(0.47)	(0.38)	(0.14)	(0.86)	(0.81)
Absolute Order Imbalance	0.000*	0.000*	0.000*	0.000*	−0.000	−0.000
	(1.82)	(1.73)	(1.82)	(1.73)	(−1.14)	(−1.21)
Intraday Volatility	0.000*	0.000*	0.000*	0.000*	0.000	0.000
	(1.78)	(1.78)	(1.82)	(1.82)	(1.29)	(1.28)
Shares Outstanding Growth	0.000**	0.000**	0.000	0.000	−0.000	−0.000
	(2.32)	(2.24)	(0.28)	(0.21)	(−1.62)	(−1.63)
Log(Shares Outstanding)	0.000	0.000	0.000	0.000	−0.000	−0.000
	(1.33)	(1.20)	(1.48)	(1.33)	(−1.37)	(−1.41)
Futures Available	0.000**	0.000***	0.000**	0.000**	0.000	0.000
	(2.52)	(2.62)	(2.31)	(2.42)	(0.64)	(0.66)
Options Available	−0.000*	−0.000**	−0.000	−0.000	−0.000	−0.000
	(−1.92)	(−1.97)	(−1.51)	(−1.54)	(−0.38)	(−0.39)
Day fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Fund fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	425,735	425,735	449,322	449,322	425,735	425,735
Adjusted R^2	0.326	0.325	0.306	0.304	0.223	0.223

Table 7 reports the regression results of illiquidity of the underlying portfolio and interactions with ETF illiquidity on ETF tracking errors.

As a result, Table 7 shows that ETF illiquidity is a very crucial variable affecting ETF tracking errors and that the lower the liquidity of underlying assets is, the greater the impact of ETF illiquidity on tracking errors is.

Part 4 The effect of ETF liquidity on returns

To formally test whether ETF liquidity is priced, we adopt the LCAPM developed by Acharya and Pedersen (2005)

Liquidity-adjusted asset pricing model

$$E(r_t^i - r_t^f) = E(c_t^i) + (\beta^{1i} + \beta^{2i} - \beta^{3i} - \beta^{4i})E(r_t^M - c_t^M - r^f), \tag{3}$$

where the four betas are defined as

$$\beta^{1i} = \frac{cov(r_t^i, r_t^M)}{var(r_t^M - c_t^M)}, \tag{4}$$

the conventional market beta

$$\beta^{2i} = \frac{cov(c_t^i, c_t^M)}{var(r_t^M - c_t^M)}, \tag{5}$$

the relations between market liquidity and the individual asset liquidity

$$\beta^{3i} = \frac{cov(r_t^i, c_t^M)}{var(r_t^M - c_t^M)}, \tag{6}$$

between market liquidity and the individual asset return

and $$\beta^{4i} = \frac{cov(c_t^i, r_t^M)}{var(r_t^M - c_t^M)} \tag{7}$$

between individual asset liquidity and the market return

Portfolio construction

- We construct ten liquidity portfolios and ten tracking error portfolios to investigate the effect of liquidity on the ETF return.All the ETFs are value weighted within each portfolio.
- The ten liquidity portfolios are constructed for each month m by ranking all ETFs with their liquidity measures at the end of month $m - 1$. The liquidity for each month is the average of the daily relative effective half-spread of each ETF having at least 15 observations in each month.
- Ten tracking error portfolios are formed for each year y by sorting the ETFs with at least 60 observations in the previous year. We use two tracking error measures to construct tracking error portfolios.

The daily portfolio returns are the value-weighted average of ETF daily returns included in each portfolio.The daily market return is computed as the valueweighted average of the underlying index return for each ETF used in constructing portfolios. The underlying index return tracked by each ETF is not traded in the market. The use of the underlying index return to calculate the market return can avoid potential measurement errors due to the trading effects, that is,

$$r_t^M = \sum_{i=1}^{N_t} w_t^i f_t^i, \tag{8}$$

where wit is each ETF i's NAV weight at time t and fti is the index return of each ETF i at time t.

The daily market liquidity is calculated by taking the value-weighted average of the relative effective bid-ask spreads of all ETFs included in the portfolio's construction. The daily portfolio liquidity is the value-weighted average of the relative effective bid-ask spreads of the securities included in each portfolio, that is,

$$c_t^p = \sum_{i \in p} w_t^{i,p} c_t^i, \qquad (9)$$

where wi,p t is each ETF i's NAV weight at time t and cit is ETF i's daily relative effective spread.

Given the persistence of liquidity, using liquidity innovation, instead of the observed relative effective bid-ask spread, is desirable to compute the LCAPM betas. The liquidity innovation of each security is obtained from the fitted residual of the following AR(2) specification.

$$c_t^i = a_0 + a_1 c_{t-1}^i + a_2 c_{t-2}^i + u_t^i \tag{10}$$

The portfolio and market liquidity innovations are calculated in the same way.

Table 8

Properties of value-weighted portfolios.

This table presents the characteristics of ten value-weighted liquidity and tracking error portfolios. The ten liquidity portfolios are constructed for each month m by ranking all exchange-traded funds (ETFs) with their liquidity measures at the end of month $m-1$. The liquidity (c) for each month is the average of the daily relative effective half-spread of each ETF with at least 15 observations in each month. The ten tracking error portfolios are formed for each month m by sorting the ETFs with at least 15 observations in the previous year with tracking error. The tracking error ($|1-\theta|$) is defined as the absolute difference between one and the estimated coefficient (θ) from the regression of the ETF return on the underlying index return. *Prem* is the ETF premium or discount, defined as the difference between the ETF price and the net asset value (NAV) divided by the NAV. *trn* denotes the daily ETF turnover defined as the trading volume divided by the ETF shares outstanding. $\sigma(r^p)$ is the standard deviation of the daily portfolio return. $\sigma(r^{e,p})$ is the standard deviation of the daily portfolio excess return on the underlying index return. Numbers in parentheses are t-statistics.

	β^{1p} (0.10)	β^{2p} (0.10)	β^{3p} (0.10)	β^{4p} (0.10)	$E(c^p)$ (%)	$\|1-\theta\|$ (%)	*Prem* (%)	*trn* (%)	$\sigma(r^p)$ (%)	$\sigma(r^{e,p})$ (%)
Panel A: Illiquidity portfolios										
1	11.137	0.000	−0.017	−0.012	0.024	9.844	0.042	10.945	1.310	0.292
	(212.77)	(160.92)	(−10.24)	(−11.49)						
2	10.881	0.001	−0.016	−0.016	0.049	13.676	0.089	6.484	1.317	0.382
	(149.55)	(31.55)	(−9.69)	(−5.29)						
3	10.142	0.001	−0.013	−0.020	0.062	15.115	0.072	6.094	1.256	0.434
	(125.26)	(89.35)	(−8.33)	(−10.99)						
4	9.282	0.001	−0.016	−0.026	0.075	14.118	0.103	9.100	1.165	0.525
	(114.80)	(84.54)	(−11.18)	(−9.35)						
5	9.666	0.001	−0.016	−0.031	0.088	13.943	0.061	6.584	1.358	0.678
	(73.04)	(71.06)	(−9.63)	(−9.24)						
6	10.001	0.001	−0.016	−0.035	0.108	14.191	0.052	5.062	1.307	0.470
	(93.86)	(60.72)	(−10.09)	(−8.71)						
7	11.276	0.001	−0.016	−0.044	0.133	17.092	0.037	3.185	1.442	0.506
	(104.17)	(44.44)	(−9.19)	(−8.27)						
8	10.524	0.002	−0.018	−0.060	0.168	21.476	0.037	2.110	1.337	0.607
	(107.12)	(37.35)	(−11.21)	(−7.45)						
9	10.421	0.002	−0.020	−0.091	0.234	22.361	−0.013	1.612	1.317	0.615
	(110.07)	(35.50)	(−12.60)	(−9.00)						
10	10.028	0.003	−0.020	−0.105	0.397	24.932	−0.047	1.381	1.302	0.618
	(96.34)	(26.85)	(−12.85)	(−5.83)						

Table 8 shows the characteristics of the liquidity portfolios (Panel A) and the tracking error portfolios (Panels B and C).

	β^{1p} (0.10)	β^{2p} (0.10)	β^{3p} (0.10)	β^{4p} (0.10)	$E(c^p)$ (%)	$\|1-\theta\|$ (%)	*Prem* (%)	*trn* (%)	$\sigma(r^p)$ (%)	$\sigma(r^{e,p})$ (%)
Panel B: Tracking error portfolios (regression)										
1	10.869	0.001	−0.015	−0.017	0.048	4.996	0.033	8.564	1.343	0.228
	(124.28)	(65.59)	(−8.99)	(−8.62)						
2	11.591	0.001	−0.017	−0.015	0.044	4.929	0.024	8.737	1.397	0.373
	(150.46)	(60.38)	(−10.33)	(−6.28)						
3	11.405	0.001	−0.016	−0.020	0.046	5.322	0.026	9.264	1.376	0.197
	(149.02)	(60.22)	(−9.44)	(−9.09)						
4	11.149	0.001	−0.016	−0.012	0.049	5.953	0.026	9.135	1.346	0.241
	(148.13)	(46.96)	(−10.13)	(−5.26)						
5	11.082	0.001	−0.016	−0.025	0.051	7.820	0.041	8.934	1.362	0.317
	(128.40)	(44.45)	(−9.49)	(−11.13)						
6	10.791	0.001	−0.016	−0.022	0.053	9.224	0.043	8.040	1.347	0.347
	(115.96)	(26.92)	(−9.79)	(−6.81)						
7	10.598	0.001	−0.018	−0.025	0.068	12.895	0.104	6.039	1.359	0.557
	(100.70)	(26.70)	(−11.20)	(−7.68)						
8	10.531	0.001	−0.018	−0.012	0.078	17.134	0.165	4.301	1.388	0.809
	(89.65)	(18.27)	(−11.08)	(−2.71)						
9	9.891	0.001	−0.018	−0.025	0.085	25.181	0.210	3.543	1.332	0.942
	(82.57)	(25.02)	(−11.41)	(−6.25)						
10	7.469	0.000	−0.013	−0.023	0.088	40.993	0.212	2.945	1.131	1.007
	(59.60)	(15.88)	(−9.51)	(−5.58)						

	β^{1p} (0.10)	β^{2p} (0.10)	β^{3p} (0.10)	β^{4p} (0.10)	$E(c^p)$ (%)	$\|1-\theta\|$ (%)	*Prem* (%)	*trn* (%)	$\sigma(r^p)$ (%)	$\sigma(r^{e,p})$ (%)
Panel C: Tracking error portfolios (excess return volatility)										
1	10.631	0.001	−0.015	−0.012	0.037	3.841	0.022	9.577	1.279	0.118
	(152.53)	(71.06)	(−9.82)	(−6.58)						
2	10.591	0.001	−0.017	−0.017	0.039	4.814	0.023	8.284	1.274	0.144
	(153.66)	(63.31)	(−10.78)	(−9.78)						
3	9.913	0.001	−0.014	−0.014	0.043	6.214	0.045	9.153	1.217	0.143
	(129.63)	(55.77)	(−9.33)	(−7.85)						
4	9.924	0.001	−0.013	−0.023	0.050	8.620	0.066	9.960	1.260	0.173
	(105.62)	(56.40)	(−8.43)	(−9.13)						
5	9.593	0.001	−0.013	−0.021	0.060	12.218	0.092	9.900	1.235	0.265
	(99.70)	(54.53)	(−8.98)	(−8.25)						
6	9.588	0.001	−0.013	−0.025	0.078	13.636	0.088	10.827	1.375	0.374
	(68.42)	(31.17)	(−8.06)	(−5.29)						
7	9.489	0.001	−0.014	−0.031	0.090	15.895	0.121	7.947	1.328	0.627
	(73.14)	(26.26)	(−8.46)	(−6.28)						
8	10.717	0.001	−0.021	−0.020	0.098	20.580	0.170	3.963	1.428	0.905
	(85.94)	(13.28)	(−12.44)	(−3.31)						
9	11.469	0.000	−0.017	−0.035	0.092	26.563	0.207	3.068	1.511	1.103
	(89.48)	(17.69)	(−9.16)	(−8.83)						
10	11.500	0.001	−0.018	−0.032	0.109	38.643	0.170	5.401	1.622	1.435
	(71.34)	(15.60)	(−9.16)	(−5.31)						

Table 9
Properties of value-weighted averages of individual exchange-traded funds (ETFs).

This table presents the characteristics of ten value-weighted liquidity and tracking error portfolios based on individual betas of ETFs. The method for constructing portfolios and variable definitions are the same as in Table 8. When estimating individual betas, we use the value-weighted market returns and illiquidity. After estimating yearly betas for each ETF, value-weighted averages within portfolios are reported. Numbers in parentheses are t-statistics.

	β^{1p} (0.10)	β^{2p} (0.10)	β^{3p} (0.10)	β^{4p} (0.10)	$E(c^p)$ (%)	$\|1-\theta\|$ (%)	*Prem* (%)	*trn* (%)	$\sigma(r^p)$ (%)	$\sigma(r^{e,p})$ (%)
Panel A: Illiquidity portfolios										
1	9.288	0.000	−0.013	−0.008	0.022	7.132	0.031	11.963	1.277	0.413
	(108.59)	(2.74)	(−3.40)	(−4.83)						
2	8.824	0.000	−0.013	−0.009	0.043	12.636	0.116	9.746	1.533	0.657
	(62.68)	(2.37)	(−2.69)	(−3.59)						
3	8.902	0.001	−0.013	−0.017	0.052	12.405	0.110	5.303	1.501	0.722
	(37.54)	(2.38)	(−2.58)	(−3.55)						
4	9.160	0.000	−0.010	−0.019	0.066	9.484	0.065	5.919	1.785	0.701
	(40.58)	(1.89)	(−3.37)	(−5.04)						
5	9.284	0.001	−0.012	−0.019	0.078	8.378	0.068	6.560	1.651	0.627
	(63.45)	(2.43)	(−3.10)	(−3.88)						
6	9.316	0.000	−0.009	−0.028	0.091	8.774	0.077	6.085	1.718	0.639
	(47.31)	(1.78)	(−6.61)	(−2.62)						
7	8.895	0.001	−0.021	−0.028	0.108	15.024	0.198	3.607	1.589	0.749
	(43.87)	(0.78)	(−2.07)	(−2.52)						
8	9.074	0.008	−0.135	−0.055	0.133	14.047	0.144	2.249	1.692	0.818
	(39.79)	(1.19)	(−1.16)	(−3.35)						
9	8.569	0.006	−0.034	−0.059	0.165	17.103	0.262	3.194	1.870	1.102
	(62.39)	(0.78)	(−1.58)	(−3.27)						
10	8.909	0.003	−0.016	−0.137	0.258	14.595	0.211	1.515	1.545	1.034
	(38.44)	(2.05)	(−3.28)	(−5.34)						

Table 9reports the value-weighted average betas of the liquidity and tracking errors of individual ETFs.

	β^{1p} (0.10)	β^{2p} (0.10)	β^{3p} (0.10)	β^{4p} (0.10)	$E(c^p)$ (%)	$\|1-\theta\|$ (%)	*Prem* (%)	*trn* (%)	$\sigma(r^p)$ (%)	$\sigma(r^{e,p})$ (%)
Panel B: Tracking error portfolios (regression)										
1	9.777	0.000	−0.010	−0.010	0.038	2.710	0.025	8.951	1.424	0.292
	(257.06)	(2.10)	(−3.25)	(−2.89)						
2	9.767	0.000	−0.010	−0.012	0.037	2.500	0.020	19.761	1.376	0.251
	(225.92)	(2.58)	(−3.71)	(−3.92)						
3	9.776	0.000	−0.011	−0.012	0.042	2.712	0.032	10.522	1.336	0.231
	(206.08)	(2.84)	(−3.18)	(−3.73)						
4	9.781	0.000	−0.011	−0.012	0.046	3.573	0.045	7.692	1.439	0.342
	(147.71)	(2.25)	(−3.67)	(−3.10)						
5	9.480	0.000	−0.009	−0.013	0.048	5.632	0.088	9.192	1.436	0.477
	(67.34)	(3.05)	(−2.97)	(−4.40)						
6	9.656	0.000	−0.010	−0.013	0.047	4.725	0.036	16.949	1.795	0.484
	(160.60)	(2.06)	(−3.59)	(−3.20)						
7	9.442	0.001	−0.018	−0.024	0.061	7.244	0.109	4.246	1.578	0.907
	(82.12)	(1.97)	(−2.31)	(−3.62)						
8	8.959	0.001	−0.009	−0.019	0.068	12.215	0.182	1.953	1.349	0.895
	(61.90)	(4.00)	(−2.00)	(−6.45)						
9	8.140	0.001	−0.019	−0.045	0.094	19.874	0.169	2.435	1.503	1.120
	(54.72)	(2.78)	(−2.86)	(−2.53)						
10	5.887	0.001	−0.017	−0.014	0.054	41.121	0.205	2.974	1.402	1.334
	(19.90)	(3.01)	(−3.15)	(−6.03)						

	β^{1p} (0.10)	β^{2p} (0.10)	β^{3p} (0.10)	β^{4p} (0.10)	$E(c^p)$ (%)	$\|1-\theta\|$ (%)	$Prem$ (%)	trn (%)	$\sigma(r^p)$ (%)	$\sigma(r^{e,p})$ (%)
Panel C: Tracking error portfolios (excess return volatility)										
1	9.762	0.000	−0.015	−0.011	0.034	2.373	0.021	8.477	1.195	0.173
	(280.85)	(2.47)	(−3.07)	(−4.12)						
2	9.668	0.000	−0.009	−0.009	0.028	3.259	0.026	11.166	1.186	0.193
	(380.60)	(2.35)	(−3.66)	(−3.37)						
3	9.793	0.001	−0.018	−0.013	0.041	3.140	0.021	7.211	1.373	0.243
	(407.02)	(2.50)	(−2.78)	(−4.44)						
4	9.427	0.001	−0.008	−0.019	0.052	7.120	0.106	8.581	1.489	0.341
	(41.39)	(3.11)	(−2.70)	(−4.00)						
5	9.371	0.000	−0.016	−0.013	0.055	9.201	0.046	12.101	1.583	0.393
	(36.81)	(0.32)	(−1.59)	(−3.42)						
6	9.647	0.001	−0.014	−0.023	0.069	7.415	0.159	28.909	1.659	0.551
	(51.20)	(2.41)	(−3.82)	(−4.03)						
7	8.448	0.000	−0.011	−0.018	0.073	18.479	0.131	7.150	1.675	0.776
	(14.59)	(3.42)	(−2.83)	(−3.39)						
8	8.487	0.000	−0.013	−0.030	0.087	16.574	0.269	3.263	1.534	0.988
	(24.36)	(2.89)	(−3.18)	(−2.81)						
9	8.012	0.000	−0.015	−0.021	0.064	20.234	0.207	3.297	1.639	1.244
	(23.91)	(3.02)	(−3.21)	(−3.06)						
10	6.870	0.000	−0.010	−0.025	0.084	31.929	0.162	5.083	2.052	1.821
	(17.67)	(3.22)	(−2.83)	(−2.99)						

Liquidity Premium

This section investigates the effect of liquidity on the expected return of the ETF using a cross-sectional regression with pre-estimated betas. The regression is estimated by the GMM method.
Following Acharya and Pedersen (2005), the standard error is calculated by the Newey and West (1987) method with a lag of 2.
The following equations are used to estimate the parameters:

$$E(r_t^p) = \alpha + \kappa E(c_t^p) + \lambda \beta^{net,p}, \tag{11}$$

$$E(r_t^p) = \alpha + \kappa E(c_t^p) + \lambda_1 \beta^{1p} + \lambda \beta^{net,p}, \tag{12}$$

$$\text{and } E(r_t^p) = \alpha + \kappa E(c_t^p) + \lambda_1 \beta^{1p} + \lambda_2 \beta^{2p} + \lambda_3 \beta^{3p} + \lambda_4 \beta^{4p}. \tag{13}$$

The above models are estimated either when the coefficient on the expected trading cost, κ, is fixed as the average turnover rate or when it is considered to be the free parameter.
The estimated parameters using portfolio betas are reported in Table 10, and those using individual betas are reported in Table 11.

Table 10
Liquidity premium from value-weighted portfolio betas.

This table presents the estimated coefficients from cross-sectional regressions of the liquidity-adjusted capital asset pricing model (LCAPM) for ten value-weighted portfolios using daily data during 2002–2012. The odd- and even-numbered lines report the estimation results when κ is fixed as the average daily turnover rate and is treated as the free parameter, respectively. Numbers in parentheses are t-statistics. *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

	Constant (0.01)	$E(c^p)$ (0.01)	β^{1p} (0.01)	β^{2p} (0.01)	β^{3p} (0.01)	β^{4p} (0.01)	$\beta^{net,p}$ (0.01)
Panel A: Illiquidity portfolios							
1	0.00	5.26					0.04***
	(0.13)						(6.30)
2	0.00	−148.68***					0.04***
	(−1.24)	(−10.51)					(6.35)
3	−0.05***	5.26	−3.58**				3.65**
	(−8.13)		(−2.31)				(2.37)
4	−0.05***	−40.68***	−2.97*				3.05**
	(−8.28)	(−4.25)	(−1.93)				(1.99)
5	0.00	5.26	0.05	215.33	18.47	2.54	
	(−0.11)		(0.58)	(0.47)	(0.29)	(0.20)	
6	0.00	−146.97***	0.05	197.00	18.49	2.32	
	(−1.20)	(−10.42)	(0.61)	(0.43)	(0.29)	(0.18)	
Panel B: Tracking error portfolios(regression)							
1	−0.01***	6.95					0.03***
	(−2.67)						(5.21)
2	−0.01***	−249.41***					0.03***
	(−3.10)	(−7.55)					(5.12)
3	−0.06***	6.95	−19.24**				19.27**
	(−8.88)		(−2.38)				(2.39)
4	−0.06***	−64.94**	−18.94**				18.97**
	(−8.93)	(−2.25)	(−2.35)				(2.36)
5	−0.01**	6.95	−0.05	304.02	−37.54	−2.19	
	(−2.42)		(−0.53)	(0.18)	(−0.82)	(−0.17)	
6	−0.01***	−252.66***	−0.05	309.65	−37.82	−3.00	
	(−2.85)	(−7.66)	(−0.56)	(0.18)	(−0.83)	(−0.23)	
Panel C: Tracking error portfolios(standard deviation)							
1	0.00	7.81					0.03***
	(−0.09)						(4.19)
2	0.00	−288.55***					0.03***
	(−0.68)	(−8.49)					(4.14)
3	−0.05***	7.81	−13.26				13.30*
	(−7.55)		(−1.64)				(1.65)
4	−0.05***	−7.86	−13.27*				13.32*
	(−7.57)	(−0.31)	(−1.65)				(1.66)
5	0.00	7.81	0.01	−63.26	−5.46	−5.27	
	(−0.99)		(0.12)	(−0.14)	(−0.13)	(−0.46)	
6	0.00	−287.29***	0.01	−81.32	−2.10	−5.74	
	(−1.55)	(−8.53)	(0.19)	(−0.18)	(−0.05)	(−0.50)	

In Table 10, Panel A reports the estimated results for the liquidity portfolios,and Panels B and C report the estimated results for the tracking error portfolios.

The odd and even numbered lines of each panel report the estimation results when κ is fixed as the average daily turnover rate and treated as the free parameter, respectively.

The first line of each panel of Tables 10 and 11 is the GMM estimation result of Eq. (11).

Table 11

Liquidity premium from individual betas estimated from value-weighted market variables.

This table presents the estimated coefficients from cross-sectional regressions of the liquidity-adjusted capital asset pricing model (LCAPM) for individual securities using daily data during 2002–2012. When estimating individual betas, we use the value-weighted market returns and illiquidity. The odd- and even-numbered lines report the estimation results when κ is fixed as the average daily turnover rate and is treated as the free parameter, respectively. Numbers in parentheses are t-statistics. *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

	Constant (0.01)	$E(c^i)$ (0.01)	β^{1i} (0.01)	β^{2i} (0.01)	β^{3i} (0.01)	β^{4i} (0.01)	$\beta^{net,i}$ (0.01)
1	−0.01***	5.50					0.02***
	(−13.02)						(14.09)
2	−0.01***	−2.15					0.02***
	(−13.02)	(−1.05)					(14.09)
3	−0.03***	5.50	0.07***				−0.01***
	(−22.09)		(16.44)				(−6.45)
4	−0.03***	14.63***	0.07***				−0.01***
	(−21.83)	(6.42)	(16.24)				(−6.18)
5	−0.01***	5.50	0.02***	−0.05**	0.01***	−0.03	
	(−10.34)		(12.63)	(−2.55)	(4.52)	(−1.34)	
6	−0.01***	−5.28***	0.02***	−0.05***	0.01***	−0.03	
	(−12.05)	(−2.59)	(12.73)	(−2.64)	(4.59)	(−1.41)	

Part 5 The liquidity effect on volatility

In this section, the effect of liquidity on ETF variance is investigated using the Lo and MacKinlay (1990) econometric model.

Lo and MacKinlay (1990) develop an econometric model to explain the effect of infrequent trading. They show that non-trading increases the return variance and causes negative serial correlation.

If an individual security trades very frequently with no time delays, then the variance of the observed return must be the same as the variance of the true asset return.

The increase in the expected non-trading days can cause a gap between the observed return variance and the true return variance.

Evaluating whether infrequent trading can increase the asset return variance with respect to the true return variance is not easy, because the true asset return cannot be observed in general.

The NAV return can be considered the ETF's true return, which is publicly announced in the market.

Given the assumption that the NAV return is the true ETF return, we can test whether non-trading increases the ETF return variance with respect to the NAV return variance.

The NAV return can be easily modeled using a single linear factor model, because each ETF is designed to track its particular index.
For the NAV return series, we assume the following linear relations between the NAV return and the underlying index return.

$$v_t = \alpha + \beta f_t + \epsilon_t, \tag{14}$$

where vt is the NAV return and ft is the underlying index return on day t.
If the ETF replicates the underlying index perfectly, then the beta should be close to one and the alpha should be close to the fund’s expense ratio.

While Lo and MacKinlay (1990) assume that the factor return is serially uncorrelated, assuming that serial correlation exists in the factor return series, is more realistic.
The following autoregressive process is suitable to account for the serial correlation of the factor return series:

$$f_t = \phi_0 + \phi f_{t-1} + \xi_t, \qquad (15)$$

where ξ t is zero mean noise with variance σ 2.
The coefficient of the lagged return is the well-known autocorrelation function of the AR(1) process and is equal to the autocorrelation of lag 1.

As introduced in Lo and MacKinlay (1990), the following two random variables are defined to explain the ETF return process with the non-trading effect.
First, the indicator variable δt is set to one if the ETF does not trade at the particular date t with probability p.
Second,the indicator variable Xt(k) is set to one if ETF trades at time t but has not traded in k previous periods.
The indicator variable Xt(k) can be expressed as

$$\begin{aligned} X_t(k) &= (1-\delta_t)\delta_{t-1}\delta_{t-2}\cdots\delta_{t-k}, \qquad k>0 \\ &= \begin{cases} 1, & \text{with probability}(1-p)p^k \\ 0, & \text{with probability}1-(1-p)p^k. \end{cases} \end{aligned} \tag{16}$$

Given the definition of the indicator variable Xt(k), the ETF return can be written as

$$r_t = \sum_{k=0}^{\infty} X_t(k) v_{t-k}. \tag{17}$$

From Eq. (17), the daily ETF return and the daily NAV return should be same if the ETF is traded every day.Thus, Eq. (17) means that the ETF return at time t can be expressed as the sum of the NAV returns from time t − k to time t if the ETF has not been traded during the previous k periods.

Given the definition of the ETF return in Eq. (17), the variance of the ETF return can be expressed as

$$Var(r_t) = Var(v_t) + \frac{2p}{1-p}(\alpha + \beta\mu)^2 + \frac{2\phi p}{1-\phi p}\beta^2 Var(f_t). \tag{18}$$

Eq. (18) shows that the ETF return variance is composed of the NAV return variance and the terms associated with the non-trading and autocorrelation effects.28 If the ETF trades every day, which means that the non-trading probability is close to zero, then the ETF return variance should be the same as the NAV return variance.

The third term, which is related to the product of the non-trading probability and the serial correlation in the underlying index return, is not shown in Lo and MacKinlay (1990).

Table 12 reports the variance of each return series and the difference between return variance.

Table 12

Comparison of exchange-traded fund (ETF) and net asset value (NAV) return variance.

This table reports the variance differences among ETF return, NAV return, and underlying index return. The variance is calculated for individual ETF from the inception date to the end of 2012 or the delisted date. σ_r^2, σ_v^2, and σ_f^2 denote the annual variance of ETF returns, NAV returns, and underlying index returns, respectively. The underlying index returns are adjusted for the leverage factor. *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

Category	N	σ_r^2 (%)	σ_v^2 (%)	σ_f^2 (%)	$\sigma_r^2 - \sigma_v^2$ (%)	$\sigma_r^2 - \sigma_f^2$ (%)	$\sigma_v^2 - \sigma_f^2$ (%)
Panel A: Asset category							
Asset allocation	40	13.27	9.23	8.13	4.04***	5.15***	1.11
Commodity	42	21.02	16.99	17.41	4.03	3.61	−0.43
Currency	20	2.58	2.14	2.14	0.44**	0.44**	0.00
Debt	109	2.53	1.23	1.08	1.29**	1.44**	0.15***
Domestic equity	318	12.21	11.07	10.83	1.14***	1.38***	0.24***
Domestic sector	261	19.61	18.57	17.05	1.05	2.56**	1.51
Global equity	327	17.68	11.43	14.68	6.25***	3.00	−3.25
Global sector	147	15.28	10.91	10.51	4.37***	4.77***	0.40
Real estate	43	20.52	18.82	18.31	1.70	2.21*	0.51
Panel B: Leveraged or inversed							
Non-leveraged	1115	10.43	6.78	7.89	3.65***	2.54*	−1.11
Leveraged	192	41.78	42.81	38.79	−1.02*	2.99**	4.01***

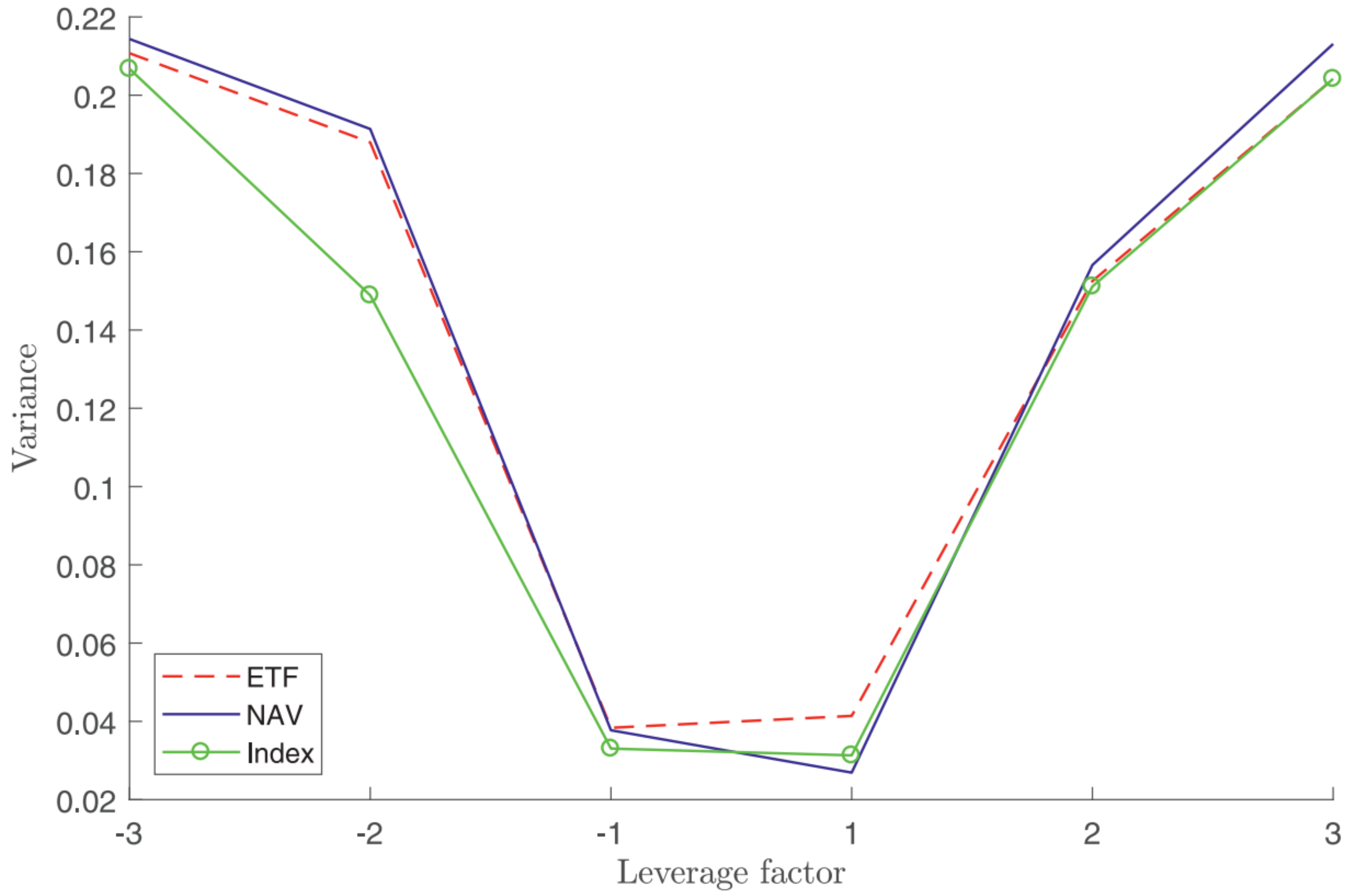

Fig. 9. Variance of exchange-traded (ETF) return, net asset value (NAV) return, and Index return by leverage. This figure illustrates the averages of ETF, NAV, and index return variance by leverage factors. The solid line represents NAV return variance; the dotted line, index return variance; and the dashed line, ETF return variance.

Fig. 9 illustrates the variance of the different return series by the degree of leverage.

Table 13
Non-trading probability and variance difference.

This table presents the summary statistics of variance, non-trading probability, and the expected no trading day of exchange-traded funds (ETFs). In addition, the first-order autocorrelation, the $AR(1)$ coefficient, and the sum of the autocorrelations from lag 1 to lag 10 for the underlying index returns are reported. All statistics are calculated from the daily return series for the entire sample period. σ_r^2 and σ_v^2 denote the variance of ETF returns and the variance of NAV returns, respectively. Non-trading probability, p, is the ratio of non-trading days to total trading days. $E(k)$ is calculated by $p/(1-p)$. ρ_i denotes the lag i autocorrelation. ϕ denotes the coefficient estimate of $AR(1)$ model for daily index returns.

Category	σ_r^2 (%)	σ_v^2 (%)	$\sigma_r^2 - \sigma_v^2$ (%)	p(%)	$E(k)day$	ρ_1(%)	ϕ(%)
1	10.96	10.63	0.33	0.00	0.00	1.76	1.77
2	17.68	18.14	−0.46	0.12	0.00	−1.25	−1.26
3	21.66	22.32	−0.66	0.27	0.00	1.89	1.88
4	14.49	14.65	−0.16	0.74	0.01	0.95	1.00
5	13.81	13.27	0.54	1.95	0.02	1.27	1.28
6	11.26	10.77	0.49	4.52	0.05	−0.36	−0.37
7	11.76	10.36	1.40	9.17	0.10	1.69	1.67
8	14.70	9.40	5.30	20.03	0.25	2.00	2.09
9	15.66	7.82	7.84	40.23	0.70	−0.51	−1.19
10	25.81	5.97	19.84	67.04	2.41	0.28	0.19

Table 13 provides average values for the ETF and NAV return variance classified by non-trading probability.

山西财经大学
Shanxi University of Finance and Economics

Table 14
Regression of variance difference on non-trading probability.
This table reports coefficient estimates of regressions of variance differences on non-trading probability. The dependent variable is the annual variance difference between exchange-traded fund (ETF) and net asset value (NAV) returns. Non-trading probability, p, is the ratio of non-trading days to trading days each year. ϕ is the coefficient of the $AR(1)$ for daily index returns each year. All independent variables are yearly averages of daily variables. All independent variables are yearly averages of daily variables. All daily variables are defined in Appendix B. All regressions include year fixed effects. t-statistics based on standard errors double-clustered at the fund and year level are in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

Variable	(1)	(2)	(3)	(4)	(5)
Non-trading Prob(p)	0.100***			0.101***	
	(10.21)			(10.39)	
$AR(1)$ Coefficient(ϕ)		0.016***	0.015***	0.023***	
		(3.04)	(2.82)	(5.32)	
$p*\phi$			0.023	0.009	
			(0.34)	(0.15)	
$p/(1-p)$					0.023***
					(6.76)
$p\phi/(1-p\phi)$					0.062
					(1.19)
Log(AUM)	−0.002	−0.004**	−0.004**	−0.002	−0.003
	(−1.09)	(−2.35)	(−2.35)	(−1.26)	(−1.61)
Log(Dollar Trading Volume)	−0.003***	−0.003***	−0.003***	−0.003***	−0.003***
	(−5.47)	(−4.33)	(−4.37)	(−5.20)	(−5.35)
Log(Shares Outstanding)	0.005***	0.003	0.003	0.005***	0.004**
	(2.96)	(1.47)	(1.47)	(3.03)	(2.39)
Shares Volatility	−0.015	−0.043***	−0.043***	−0.017	−0.022
	(−0.94)	(−2.59)	(−2.59)	(−1.07)	(−1.38)
Equity-Type ETF	0.004*	0.005**	0.005**	0.005**	0.004*
	(1.76)	(2.03)	(2.02)	(2.39)	(1.78)
Invested in US Assets	−0.013***	−0.011***	−0.011***	−0.011***	−0.012***
	(−10.33)	(−7.11)	(−7.10)	(−8.09)	(−9.64)
Swap-Based	0.008	0.004	0.004	0.007	0.007
	(0.94)	(0.41)	(0.43)	(0.80)	(0.76)
Derivatives-Based	−0.000	0.000	−0.000	0.001	−0.001
	(−0.02)	(0.02)	(−0.01)	(0.21)	(−0.10)
Leveraged Fund	−0.013*	−0.020**	−0.020**	−0.012	−0.016*
	(−1.70)	(−2.30)	(−2.29)	(−1.60)	(−1.93)
Futures Available	0.005***	0.014***	0.014***	0.005***	0.009***
	(3.52)	(7.44)	(7.43)	(3.63)	(5.80)
Options Available	0.001	−0.001	−0.001	0.001	0.000
	(1.09)	(−0.64)	(−0.69)	(1.21)	(0.10)
In-Kind	−0.005***	−0.009***	−0.009***	−0.005***	−0.007***
	(−3.10)	(−4.29)	(−4.29)	(−2.73)	(−3.82)
Optimized	−0.001	−0.003***	−0.003***	−0.002	−0.002*
	(−1.23)	(−2.75)	(−2.75)	(−1.43)	(−1.70)
Expense Ratio	−0.005	−0.008	−0.007	−0.006	−0.005
	(−1.35)	(−1.30)	(−1.27)	(−1.36)	(−1.11)
Year fixed effects	Yes	Yes	Yes	Yes	Yes
Number of observations	5,963	5,963	5,963	5,963	5,963
Adjusted R^2	0.215	0.118	0.118	0.219	0.201

Table 14 reports the panel regression results.

Part 6 Conclusion

- The ETF market has grown tremendously over the last two decades. ETFs in the US markets are one of the popular financial products that have emerged in recent years and,thus, have driven a passive investment era.
- This study investigates the effect of liquidity on ETF returns and tracking errors. **Our empirical analysis shows that illiquid ETFs tend to have large tracking errors.** We use the threshold list of ETFs as an instrumental variable to investigate the causal link between the ETF illiquidity and tracking errors. The results confirm that the instrumental variable approach shows a causal link from illiquidity to tracking errors. We also find that both underlying asset illiquidity and ETF illiquidity affect ETF tracking errors. More important, we find that tracking errors of ETFs holding illiquid underlying assets tend to be more sensitive to ETF illiquidity.
- **We show that liquidity is an important risk factor affecting the ETF returns, which is similar to the case of general common stocks.**Our empirical results support the LCAPM in that liquidity risks are priced in the US ETF market. An ETF’s required return depends on the covariances of its own liquidity and return with the market liquidity and return. Liquidity risk explains approximately 0.14% of the annual ETF returns. Although the magnitude is smaller than those of US or global common stocks, liquidity risk could be substantial for large institutional traders.
- **Our second set of empirical tests show that the lack of liquidity increases the ETF variance with respect to the NAV variance**. Extending the Lo and MacKinlay (1990) econometric model to consider the autocorrelation of the underlying index return, the ETF variance can be decomposed into the NAV variance and the terms related to the non-trading probability. Our finding implies that the variance of the ETF can increase when the ETF is traded infrequently. The calculated ETF variance is shown to be larger than the NAV variance. The regression analysis shows that the ETF variance is positively related to the non-trading probability.
- Our results suggest that ETF liquidity is an important aspect to consider when investors make investment decisions on ETFs.

Thanks！