
Understanding ETF Trading and Liquidity (Part I)

Jerry Liu, PhD
Senior Researcher and VP

July 2023

The marketplace where investors trade existing ETF shares is called the secondary market. In this paper, we study how liquidity in the ETF secondary market changes throughout the day, over time, and across ETFs.

Introduction

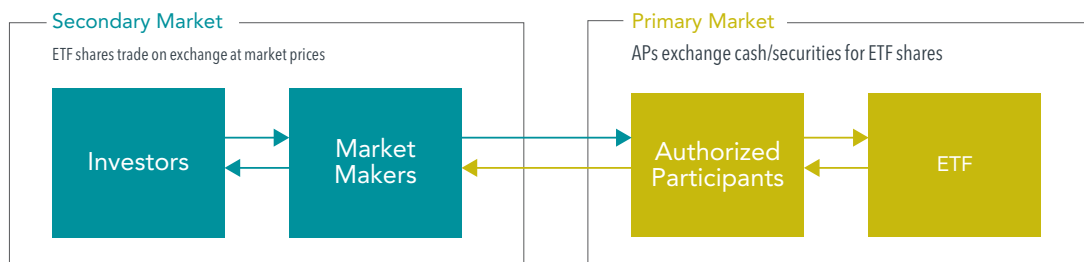
ETFs (exchange-traded funds) have gained popularity in the last two decades due to their low fees, tax efficiency, liquidity, and transparency. Unlike mutual funds, ETFs can be traded throughout the day in the secondary market.¹ In this paper, we take a deep dive into the liquidity of the ETF secondary market using data on the ETFs listed in the US market from 2019 through 2022. Our analysis provides a few important takeaways about ETF liquidity intraday, over time and cross-sectionally.

ETF Secondary Market

The marketplace where investors buy and sell existing ETF shares is called the secondary market. Just like the market for trading individual stocks, the secondary market for trading ETFs consists of centralized exchanges like the New York Stock Exchange (NYSE) and Nasdaq, as well as off-exchange venues such as dark pools.² These exchanges and venues maintain a record of outstanding limit orders called the limit order book, where traders can buy or sell against pre-existing orders or add/remove/modify orders during market hours. For most investors, “on-screen” ETF liquidity they see (volume and quotes) and ETF trades they make on their brokerage trading platforms occur in the secondary market.

One unique aspect of the ETF secondary market trading is that it is supported by an additional layer of liquidity that lives in the primary market. The primary market is where authorized participants (APs), often brokerage firms, can create and redeem ETF shares directly from the ETF issuer in exchange for baskets of cash and securities, as shown in **Exhibit 1**. If liquidity in the secondary market cannot meet demand or the ETF price deviates from the value of its underlying securities, APs may be incentivized to create or redeem ETF shares to provide more liquidity or take advantage of the arbitrage opportunity.

EXHIBIT 1: ETF Market Mechanics



ETF liquidity in the secondary market is supported by the liquidity in the primary market, through ETF share creation and redemption activity between APs and an ETF sponsor. This is unlike an individual stock, which generally has a fixed supply of shares in the secondary market. An AP may request to create or redeem ETF shares in order to provide liquidity to large ETF orders or to help balance supply and demand for ETF shares on the secondary market.

1. The ETF secondary market is the marketplace where investors can trade ETF shares that already exist.
2. A dark pool is a privately organized financial forum or exchange for trading securities. Dark pools allow investors to trade without exposure until after the trade has been executed and reported.

ETF Trading Costs

Trading costs include explicit costs and implicit costs. Explicit costs are the direct costs of trading. Generally, they include broker commissions, transaction taxes, stamp duties, and exchange fees. For investors buying and selling ETFs, explicit costs tend to be negligible.³ Implicit costs are the indirect costs of trading. One implicit cost for investors trading ETFs on the secondary market is the discrepancy between the trade price of the ETF and the value of its underlying holdings. This cost can be broken down into two components: bid-ask spread and premium/discount.

The bid-ask spread is the difference between the most competitive (highest) bid price and the most competitive (lowest) ask price in the limit order book of the ETF secondary market. It can be thought of as the execution price difference between supplying and demanding immediacy and is one component of the trading costs incurred by traders who demand immediacy (for example, trading with market orders). In most cases, the wider the spread, the higher the trading costs.⁴

The premium/discount is the difference between the ETF price in the secondary market and the value of the ETF's underlying holdings, which is also known as the intraday net asset value (iNAV⁵). Both the bid-ask spread and premium/discount are mostly driven by the costs that APs face when they create/redeem ETF shares: the costs to buy the securities in the create basket or sell the securities in the redeem basket, creation/redemption fees for the ETFs, hedging and financing costs.

For example, if an ETF is quoted at \$10.00 bid / \$10.02 ask and the iNAV is \$10.005, the trading costs for a market order buying at \$10.02 are as follows:

- Bid-ask spread: half of the spread = [trade price] – [midpoint price] = \$10.02 – \$10.01 = \$0.01
- ETF premium: [midpoint price] – [iNAV] = \$10.01 – \$10.005 = \$0.005

We will explore in detail ETF premium/discount in the second part of our study, which will focus on the creation and redemption of ETFs in the primary market. In this paper, we focus on the bid-ask spread. To shed light on market impact (another implicit cost), we also study trading volume in the ETF secondary market.

3 The explicit costs are generally low but will vary based on the platform they are traded through. As of December 2022, major retail custodians in the US such as Schwab, TD Ameritrade, and Fidelity offer zero commission trading on most ETF trades. However, for daily trades exceeding 10,000 shares in one investment account, Fidelity imposes a \$0.01/share fee on each share above the first 10,000. Schwab and TD Ameritrade, in contrast, charge a Trading Activity Fee of \$.000145 per share on sells of equities and ETFs.

4 Although under certain circumstances orders are allowed to be executed outside quoted bid-ask spreads, traders that send their ETF orders through ETF capital market desks of their brokers can often get executions within the quoted bid-ask spread due to the ability of APs to create/redeem daily and to the fact that many market makers might have inventory but not post quotes.

5 iNAV provides an intraday indicative value of an ETF based on the market values of its underlying holdings. The value is calculated by the listing exchange and then disseminated to the public a few times a minute.

Data Description and Microstructure Statistics

To analyze the market microstructure of ETFs, we compile a comprehensive data set of tick-by-tick trade and quote data for over 1,500 US equity, international equity, and fixed income ETFs listed in the US market as of December 31, 2022.⁶ The set of ETFs, along with their asset class and investment style, is from Morningstar. The intraday tick data is from Refinitiv. We use this data to compute several key microstructure statistics for the period 2019 to 2022, which are summarized in **Exhibit 2**.

EXHIBIT 2: Summary Statistics of ETF Market Microstructure, 2019-2022

ETF Group	Actively Managed ETF	Number of ETFs	Average Price (USD)	Average AUM (USD)	Average Bid-Ask Spread (bps)	Average Daily Dollar Volume (USD)	Average % of Open Auction Volume	Average % of Closing Auction Volume
US Equity	Y	173	\$32	\$408M	24.3	\$5M	2.2%	0.5%
	N	426	\$68	\$5,764M	16.1	\$147M	2.8%	0.6%
	Subtotal	599	\$58	\$4,217M	18.5	\$106M	2.6%	0.6%
International Equity	Y	78	\$32	\$328M	29.5	\$3M	3.4%	1.7%
	N	376	\$37	\$2,125M	33.8	\$40M	4.0%	2.1%
	Subtotal	454	\$36	\$1,816M	33.1	\$33M	3.9%	2.1%
Fixed Income	Y	173	\$40	\$616M	22.1	\$6M	2.3%	1.5%
	N	305	\$45	\$2,895M	15.6	\$53M	3.0%	1.3%
	Subtotal	478	\$43	\$2,070M	18.0	\$36M	2.7%	1.4%
Grand Total		1,531	\$47	\$2,835M	22.6	\$63M	3.1%	1.3%

Source: Dimensional using Refinitiv Tick History data and Morningstar data. 01/01/2019 to 12/31/2022. The universe includes all US equity, international equity, and fixed income ETFs listed in the US market as of 12/31/2022. Price, AUM, bid-ask spread, dollar volume, and % of open/close auction volume are computed for each ETF at the daily frequency, then averaged across days. Cross-sectional averages are equal weighted.

Bid-Ask Spread

For each ETF on each day, we compute the time-weighted average intraday bid-ask spread in basis points (bps). We then take a simple average across all trading days in 2019 through 2022 for each ETF, and take equal-weighted averages across ETFs. Our analysis shows that US equity ETFs and fixed income ETFs have smaller average spreads (18.5 bps and 18.0 bps, respectively) than international equity ETFs (33.1 bps).

Dollar Volume

Trading volume is another important metric for market liquidity. We compute the average daily dollar volume for each ETF across all available trading days in the sample. Then we take the equal-weighted average across ETFs in the same asset class and with the same investment style. Among the three asset classes, US equity ETFs demonstrate the highest average daily volume. Also, index ETFs exhibit a much higher volume than actively managed ETFs.

⁶ Funds of funds, leveraged funds, and inverse/short funds are excluded.

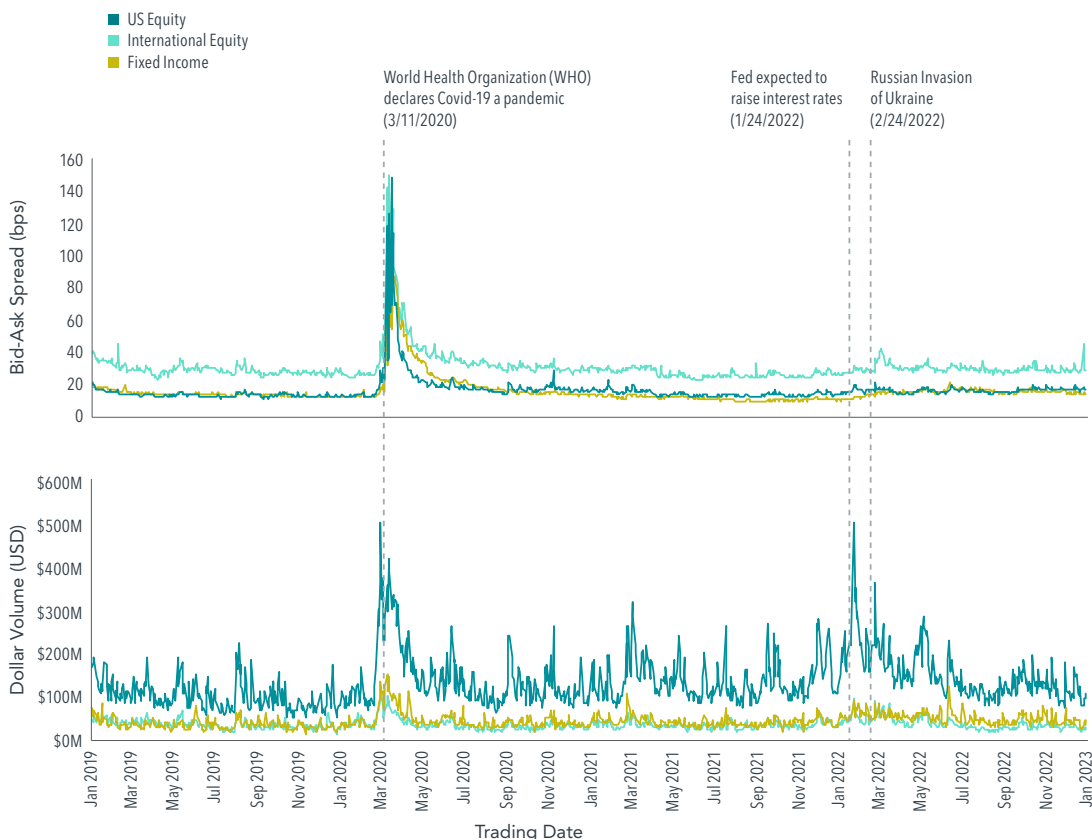
Open and Closing Auction Volume

Open auction and closing auction are mechanisms on stock exchanges to determine securities' opening and closing prices each trading day. For ETFs, open auction and closing auction trades account for 3.1% and 1.3% of the daily total volume, respectively. The closing auction size for ETFs is much smaller than that for individual stocks (which is around 10% for US stocks). **In fact, 75% of ETFs regularly see no volume at all in the closing auctions, with fewer than half of their trading days seeing a closing auction trade.**

ETF Bid-Ask Spread and Volume over Time

To see how the market microstructure has changed over time, **Exhibit 3** presents the time-series plots of the bid-ask spread and dollar volume from January 2019 through December 2022. During March 2020, the global equity markets tumbled due to the COVID-19 pandemic and market volatility reached an all-time high. As a result, the bid-ask spread and dollar volume of the ETF market also peaked. We observe similar patterns in January and February 2022, due to the expectations of the US Federal Reserve's raising interest rates and the start of the Russian invasion of Ukraine.

EXHIBIT 3: ETF Bid-Ask Spread and Dollar Volume over Time, 2019-2022



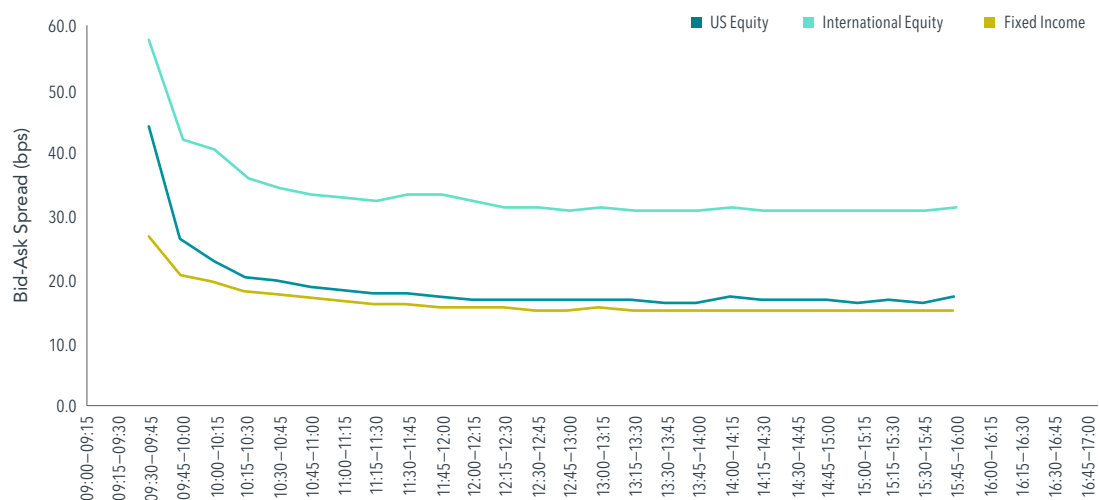
Source: Dimensional using Refinitiv Tick History data and Morningstar data. 01/01/2019 to 12/31/2022. Universe includes all US equity, international equity, and fixed income ETFs listed in the US market as of 12/31/2022. For each day, cross-sectional bid-ask spread and dollar volume are computed using equal-weighted averages.

To further examine the factors that affect ETF bid-ask spread and trading volume over time, we conducted multivariate regression analysis in the Appendix. Our findings suggest that the ETF bid-ask spread and daily dollar volume do not reliably differ by day of the week, and are not significantly impacted by special trading days, such as Russell rebalance days, triple witching days, or third Fridays. One exception is the first trading day of the month, when all three asset classes of ETFs experience about 13% higher turnover. Also, while the daily average bid-ask spread is not reliably higher on Federal Open Market Committee (FOMC)⁷ announcement days, during such days the spread does widen around the announcement time. We discuss that in detail in the next section.

Intraday ETF Bid-Ask Spread and Volume

Many investors trading ETFs wonder when to place an order to minimize trading costs. Typically, lower trading costs are associated with a tighter bid-ask spread and higher trading volume. To examine how the spread and volume change throughout the day, we compute the intraday bid-ask and volume for each 15-minute interval, and then take equal-weighted averages across days and ETFs. **Exhibit 4** shows the intraday plots of ETF bid-ask spread and distributions of trading volume. The spread tends to be wider near market open, but drops significantly and becomes relatively stable 30 minutes after the open. The wider spread near market open may be due to greater pricing risk for APs and dealers making markets in an ETF when the underlying securities' market is incorporating information from overnight and international markets and has a wider spread. In contrast, the intraday ETF volume displays a U-shape, with higher trading volume right after market open, followed by a drop and a relatively stable period throughout the day, before gradually increasing toward market close. The period from 3:45 pm to 4:00 pm ET tends to be the most liquid trading time for ETFs. However, as we mentioned before, we observe low trading volume for ETFs in the closing auction despite the high trading volume near market close.

EXHIBIT 4: Intraday ETF Bid-Ask Spread and Distribution of Trading Volume, 2019-2022



⁷ The Federal Open Market Committee is a committee within the Federal Reserve System that is charged under United States law with overseeing the nation's open market operations.

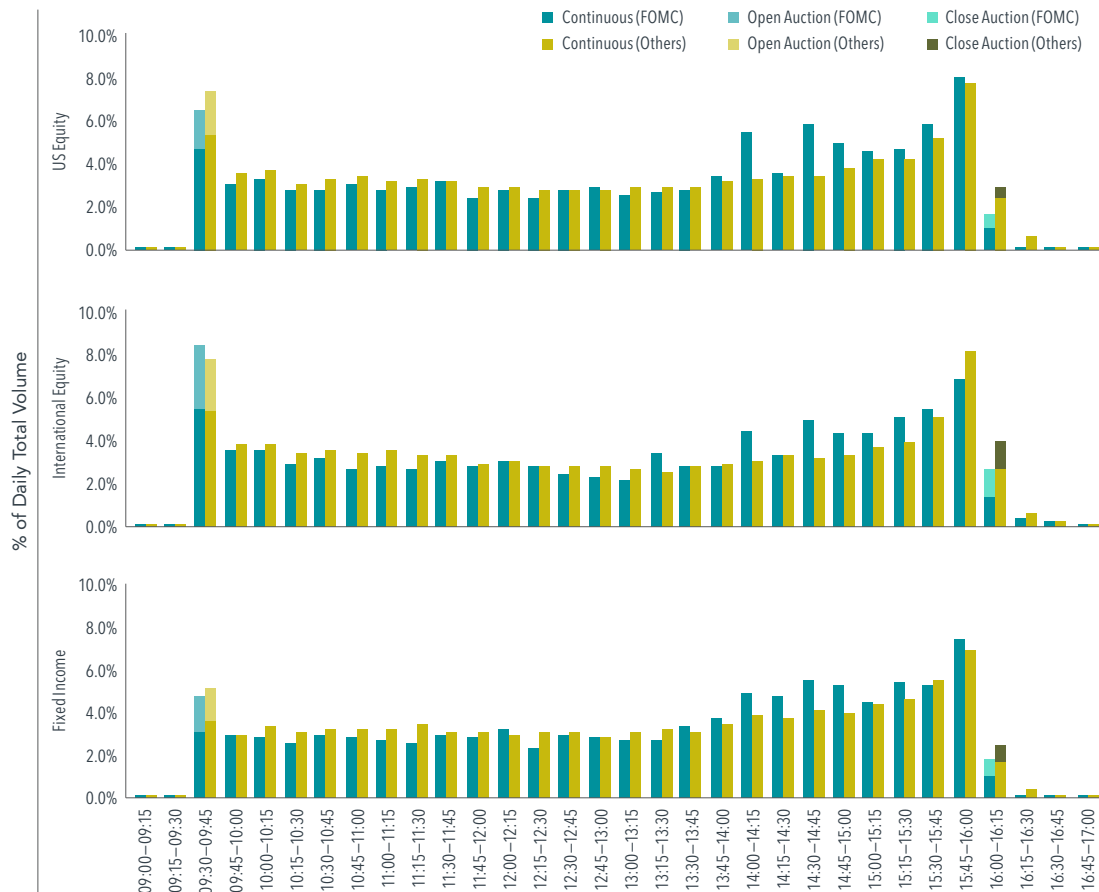
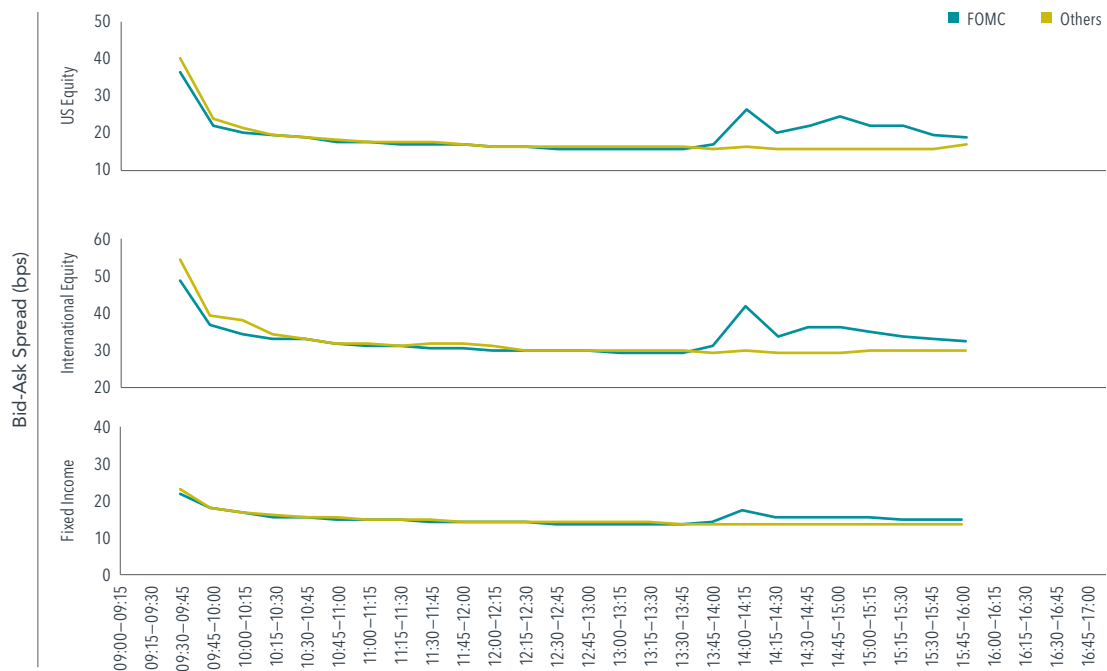
EXHIBIT 4: Intraday ETF Bid-Ask Spread and Distribution of Trading Volume, 2019–2022 (continued)



Source: Dimensional using Refinitiv Tick History data and Morningstar data. 01/01/2019 to 12/31/2022. Universe includes all US equity, international equity, and fixed income ETFs listed in the US market as of 12/31/2022. Statistics are computed for each 15-minute intraday interval. Statistics are then aggregated using equal-weighted averages cross-sectionally and over days.

Exhibit 5 illustrates a comparison between the intraday bid-ask spread and trading volume on the FOMC announcement days and other trading days. On the FOMC announcement days, we find the intraday bid-ask spread and trading volume increase at 2 pm ET, the time when the FOMC releases its statement and the Federal Reserve chair speaks. The bid-ask spread and trading volume tend to stay higher for the remainder of the trading session. Hence, investors might consider this when placing market ETF orders at and after 2 pm ET on such days.

EXHIBIT 5: Intraday ETF Bid-Ask Spread and Distribution of Trading Volume on FOMC Announcement Days, 2019-2022



Source: Dimensional using Refinitiv Tick History data and Morningstar data. 01/01/2019 to 12/31/2022. March 2020 is excluded due to being an extreme outlier in terms of bid-ask spreads on FOMC days. Universe includes all US equity, international equity, and fixed income ETFs listed in the US market as of 12/31/2022. Statistics are computed for each 15-minute intraday interval. Statistics are then aggregated using equal-weighted averages cross-sectionally and over days.

ETF Bid-Ask Spread and Volume across ETFs

The bid-ask spread of an ETF is affected by both its underlying securities and the ETF itself as a security. On one hand, the ETF is a basket of securities, and the ETF bid-ask spread is impacted by the liquidity of these underlying securities. The costs for the AP to create and redeem shares, such as the bid-ask spread of underlying securities, hedging costs, commissions, and other fees, are reflected in the ETF bid-ask spread.

On the other hand, the ETF is traded in the open market as a standalone security, and its bid-ask spread can be impacted by its own characteristics. For example, when an ETF is large and highly liquid in the secondary market, it becomes less necessary for APs to create and redeem shares in the primary market in response to buying or selling pressure. In such cases, the liquidity in the secondary market is sufficient to meet these pressures. **Exhibit 6** compares the bid-ask spreads for several pairs of ETFs, where each pair consists of the two largest ETFs, ranked by AUM, that track the same index.

EXHIBIT 6: Microstructure Statistics for Several Pairs of ETFs that Track the Same Index, 2019–2022

Benchmark Index	ETF	Bid-Ask Spread (bps)	Price (USD)	AUM (USD)	Daily Dollar Volume	% of Open Auction Volume	% of Closing Auction Volume
S&P 500 Index	A	0.4	\$362	\$327.4B	\$30,380M	0.3%	1.9%
	B	0.9	\$363	\$242.6B	\$1,838M	0.8%	4.1%
S&P MidCap 400 Index	C	2.4	\$224	\$54.8B	\$292M	1.2%	1.7%
	D	2.6	\$409	\$18.5B	\$441M	0.4%	2.3%
S&P SmallCap 600 Index	E	1.6	\$90	\$55.6B	\$386M	1.3%	1.9%
	F	7.1	\$35	\$3.0B	\$22M	1.4%	0.2%
Russell 1000 Index	G	2.3	\$202	\$25.0B	\$188M	0.9%	2.2%
	H	3.8	\$167	\$2.0B	\$13M	2.1%	0.3%
Russell 2000 Index	I	0.7	\$179	\$51.9B	\$4,893M	0.3%	2.1%
	J	4.0	\$109	\$3.7B	\$68M	1.4%	0.7%

Source: Dimensional using Refinitiv Tick History data and Morningstar data.. 01/01/2019 to 12/31/2022. The set of ETFs is sourced from Morningstar, under the category "Index ETF" and with "Primary Prospectus Benchmark" specified in the "Benchmark Index" column. To provide a clearer comparison, the dataset includes only the two ETFs with highest AUM for each index, as of December 2022. The actual ETF tickers and names are masked. Price, AUM, bid-ask spread, dollar volume, % of open/close auction volume are computed for each ETF at the daily frequency then averaged across days.

To gain a deeper understanding of the factors that affect the bid-ask spread and trading volume of an ETF, we run several cross-sectional regressions. The detailed results are reported in the Appendix. **Exhibit 7** presents the key findings. The ETF bid-ask spread does appear to be impacted by the underlying securities. For equity ETFs, there is a reliably positive relation between the bid-ask spread of the ETF and the average bid-ask spread of the underlying stocks. For fixed income ETFs, the bid-ask spread is reliably higher for ETFs holding lower quality bonds, longer duration bonds, and non-USD bonds. Additionally, the bid-ask spread is impacted by the ETF itself. ETFs with larger AUM, higher trading volume, and higher prices tend to have narrower spreads, much like individual stocks. For the ETF trading volume, it appears to be impacted by AUM only.

EXHIBIT 7: Reliable Drivers of Differences in Bid-Ask Spreads and Volumes across ETFs

Panel A: Bid-Ask Spread Differences				
	AUM	Trading Volume	ETF Price	Underlying Securities
US Equity ETF	-	-	-	+ (via average bid-ask spread of pricing basket)
International Equity ETF	-	-	-	+ (via average bid-ask spread of pricing basket)
Fixed Income ETF	-	-	-	+ (via fund's average credit rating, average duration, currency exposure)

Panel B: Volume Differences			
	AUM	ETF Price	Underlying Securities
US Equity ETF	+	no	no
International Equity ETF	+	-	no
Fixed Income ETF	+	no	no

The "+" symbol means positively correlated; "-" means negatively correlated; "no" means not reliably correlated.

Conclusion

ETFs offer investors the ability to trade in the open market during market hours. Understanding ETF liquidity can help investors achieve better trading outcomes. Through our analysis of the ETF market in the US, we demonstrate how ETF trading volume and bid-ask spread change throughout the day and over time. Our research also shows the ETF bid-ask spread is impacted by the liquidity of both the underlying securities and the ETF itself.

Appendix

Descriptive Statistics

The tables below provide metrics describing the data set used for the regression analysis. For each ETF on each day, we compute several statistics—ETF spread is the time-weighted average bid-ask spread in basis points from market open to close; daily AUM is computed by multiplying the NAV by outstanding shares; basket spread is the weighted average bid-ask spread of stocks in the pricing basket, where the constituents and their weights in the price basket are as of 12/30/2022; daily price is the ETF's closing price; daily dollar volume is computed by multiplying daily trading volume by the closing price; % of open (closing) auction volume is the open (closing) auction size as a percentage of daily total volume.

EXHIBIT A1: Descriptive Statistics for the ETFs Included in the Regression Analysis

	Number of ETFs	Number of ETF x Day	5th Percentile	10th Percentile	Median	90th Percentile	95th Percentile	Mean	Std. Dev
US Equity									
ETF Spread (bps)	599	461,066	1.8	2.7	12.5	34.5	45.6	17.1	25.5
Daily AUM	599	460,770	\$5M	\$10M	\$216M	\$9,097M	\$21,897M	\$5,398M	\$25,736M
Basket Spread (bps)	521	420,458	3.1	3.5	6.8	25.4	32.0	11.0	10.3
Daily Price	599	460,711	\$21.17	\$24.14	\$43.56	\$140.43	\$185.95	\$65.98	\$59.84
Daily Dollar Volume	599	460,711	\$2K	\$12K	\$760K	\$53M	\$153M	\$138M	\$1,756M
% of Open Auction Volume	599	452,069	0.0%	0.0%	0.6%	6.5%	11.7%	2.7%	6.9%
% of Closing Auction Volume	599	452,069	0.0%	0.0%	0.0%	1.1%	2.5%	0.6%	3.3%
International Equity									
ETF Spread (bps)	454	393,972	2.2	3.3	21.1	69.5	106.8	33.2	47.9
Daily AUM	454	394,000	\$4M	\$8M	\$109M	\$3,669M	\$6,812M	\$2,047M	\$8,801M
Basket Spread (bps)	382	273,125	3.7	4.3	7.8	19.7	24.1	10.5	10.8
Daily Price	454	393,925	\$15.45	\$18.70	\$30.16	\$63.64	\$75.88	\$36.86	\$20.35
Daily Dollar Volume	454	393,925	\$1K	\$8K	\$388K	\$45M	\$153M	\$38M	\$199M
% of Open Auction Volume	454	386,415	0.0%	0.0%	0.3%	9.9%	20.4%	3.9%	10.6%
% of Closing Auction Volume	454	386,415	0.0%	0.0%	0.0%	3.4%	7.9%	1.9%	8.4%
Fixed Income									
ETF Spread (bps)	478	364,849	1.2	2.0	9.1	37.3	53.5	17.0	33.4
Daily AUM	478	365,529	\$10M	\$19M	\$224M	\$6,236M	\$15,130M	\$2,675M	\$7,780M
Daily Price	478	365,516	\$20.04	\$21.70	\$36.77	\$89.59	\$105.38	\$44.54	\$26.86
Daily Dollar Volume	478	365,516	\$1K	\$13K	\$1M	\$71M	\$171M	\$46M	\$234M
% of Open Auction Volume	478	356,620	0.0%	0.0%	0.5%	5.6%	10.9%	2.6%	7.6%
% of Closing Auction Volume	478	356,620	0.0%	0.0%	0.0%	1.4%	3.8%	0.9%	5.0%

Determinants of ETF Bid-Ask Spread and Volume in the Time Series

The bid-ask spread (Panel A) and dollar volume (Panel B) for each ETF each day are regressed on explanatory variables for trade dates. Independent variables include a categorical variable (Weekday) to indicate the day of week, and binary variables to indicate Russell index rebalancing dates (R2RebDay), FOMC announcement dates (FOMCDay), third Friday of each month (ThirdFridayDay), triple witching days (TripleWitching), first day of each month (FirstDayOfMonth), last day of each month (LastDayOfMonth) and last day of each quarter (LastDayOfQuarter). We introduce two types of fixed effects—ETF FE (on ETF level) and Calendar Month FE (on month of year level). Standard errors are shown below the coefficient estimates. Standard errors are double clustered by ETF and trade date.

EXHIBIT A2: Regression Analysis of ETF Bid-Ask Spread and Trading Volume over Time

Panel A: ETF Bid-Ask Spread	Dependent Variable Is ETF Bid-Ask Spread (bps)			
	US Equity (1)	International Equity (2)	Fixed Income (3)	All (4)
Weekday: Tuesday	-1.172 (1.001)	-1.006 (1.035)	-0.672 (0.903)	-0.969 (0.952)
Weekday: Wednesday	-1.296 (1.132)	-1.077 (1.195)	-1.049 (1.089)	-1.152 (1.110)
Weekday: Thursday	-0.454 (1.110)	-0.090 (1.175)	-0.111 (1.063)	-0.234 (1.092)
Weekday: Friday	-1.016 (1.016)	-0.215 (1.139)	-0.612 (0.965)	-0.635 (1.007)
R2 Reb Day	0.295 (1.599)	0.046 (1.805)	0.297 (2.424)	0.215 (1.897)
FOMC Day	3.701* (2.234)	4.168* (2.250)	4.283 (2.686)	4.030* (2.343)
Third Friday	-0.237 (0.627)	-0.881 (1.038)	-0.196 (1.087)	-0.434 (0.875)
Triple Witching	1.378 (2.875)	1.637 (3.517)	2.313 (4.136)	1.743 (3.437)
First Day of Month	-0.252 (0.833)	0.234 (1.236)	0.012 (1.264)	-0.015 (1.070)
Last Day of Month	0.327 (0.599)	0.099 (0.949)	-0.266 (0.862)	0.077 (0.757)
Last Day of Quarter	-2.033 (1.662)	-1.208 (2.311)	0.489 (2.612)	-1.013 (2.044)
Calendar Month FE	Yes	Yes	Yes	Yes
ETF FE	Yes	Yes	Yes	Yes
SE CL	Day+ETF	Day+ETF	Day+ETF	Day+ETF
Observations	461,066	393,972	364,849	1,219,887
Adjusted R ²	0.287	0.446	0.257	0.394

Note: *p<0.1; **p<0.05; ***p<0.01

EXHIBIT A2: Regression Analysis of ETF Bid-Ask Spread and Trading Volume over Time (continued)

Panel B: ETF Trading Volume	Dependent Variable Is Log(Daily Dollar Volume + 1)			
	US Equity (1)	International Equity (2)	Fixed Income (3)	All (4)
Weekday: Tuesday	-0.022 (0.041)	-0.015 (0.035)	0.027 (0.059)	-0.005 (0.042)
Weekday: Wednesday	-0.042 (0.041)	-0.070* (0.036)	0.015 (0.061)	-0.034 (0.043)
Weekday: Thursday	-0.055 (0.041)	-0.058 (0.036)	-0.015 (0.061)	-0.044 (0.043)
Weekday: Friday	-0.105** (0.045)	-0.115*** (0.038)	-0.056 (0.067)	-0.094** (0.047)
R2 Reb Day	0.032 (0.155)	-0.023 (0.155)	-0.076 (0.296)	-0.018 (0.196)
FOMC Day	0.016 (0.067)	0.028 (0.059)	0.029 (0.105)	0.024 (0.072)
Third Friday	-0.066 (0.085)	-0.058 (0.067)	-0.060 (0.118)	-0.062 (0.084)
Triple Witching	0.137 (0.126)	0.124 (0.101)	0.041 (0.187)	0.104 (0.129)
First Day of Month	0.134** (0.057)	0.147*** (0.044)	0.178** (0.076)	0.151*** (0.054)
Last Day of Month	0.123* (0.069)	0.178*** (0.067)	0.132 (0.113)	0.143* (0.077)
Last Day of Quarter	-0.101 (0.120)	-0.176 (0.112)	-0.028 (0.187)	-0.103 (0.132)
Calendar Month FE	Yes	Yes	Yes	Yes
ETF FE	Yes	Yes	Yes	Yes
SE CL	Day+ETF	Day+ETF	Day+ETF	Day+ETF
Observations	460,711	393,925	365,516	1,220,152
Adjusted R ²	0.799	0.763	0.749	0.773

Note: *p<0.1; **p<0.05; ***p<0.01

Determinants of ETF Bid-Ask Spread in the Cross Section

The bid-ask spread (Panels A1–A3) and dollar volume (Panels B1–B3) for each ETF each day are regressed on explanatory variables for ETFs. Panels A1 and B1 show the results for US equity ETFs. Panels A2 and B2 show the results for international equity ETFs. Panels A3 and B3 show the results for fixed income ETFs. Independent variables are as follows. ActiveETF is a categorical variable with a value of 1 for actively managed ETF and 0 for index ETF. Log(DailyAUM) is the natural logarithm of an ETF’s AUM (assets under management) in USD as the end of each day. BasketSpread is the weighted average bid-ask spread of securities in the pricing basket, where the constituents and their weights in the price basket are as of 12/30/2022. Log(DailyPrice) is the natural logarithm of an ETF’s closing price. Log(DailyDollarVolume+1) is the natural logarithm of ETF daily dollar volume. PctOpenAuctionVolume and PctCloseAuctionVolume are the open and closing auction volumes as a percentage of ETF daily trading volume. We also include the interaction term between Log(DailyAUM) and Log(DailyDollarVolume+1). In Panel C, we

introduce three variables for fixed income ETFs: CreditRating (break down into AAA-AA, A-BB, BB and below, and not rated), CurrencyExposure (0 for USD and 1 for non-USD) and Duration (in years). All three variables for fixed income ETFs are sourced from Morningstar as of 12/30/2022. We introduce fixed effects for trade date (Day FE). Standard errors are shown below the coefficient estimates. Standard errors are double clustered by ETF and trade date.

EXHIBIT A3: Regression Analysis of ETF Bid-Ask Spread and Trading Volume Cross-Sectionally

Panel A1: US Equity ETFs	Dependent Variable Is ETF Bid-Ask Spread (bps)—US Equity ETFs						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Active ETF		2.548* (1.470)	1.747 (1.443)	1.532 (1.457)	1.512 (1.457)	1.481 (1.461)	1.481 (1.468)
log (Daily AUM)	-3.606*** (0.190)	-3.474*** (0.177)	-3.326*** (0.171)	-3.117*** (0.206)	-2.948*** (0.254)	-3.285*** (0.637)	-3.532*** (0.673)
Basket Spread			0.217*** (0.043)	0.222*** (0.043)	0.223*** (0.043)	0.225*** (0.043)	0.232*** (0.043)
log (Daily Price)				-1.175* (0.676)	-1.182* (0.674)	-1.264* (0.687)	-1.349** (0.680)
log (Daily Dollar Volume + 1)					-0.137 (0.118)	-0.484 (0.559)	-1.471** (0.682)
Pct Open Auction Volume							5.548** (2.677)
Pct Close Auction Volume							4.192 (2.704)
log (Daily AUM)* log (Daily Dollar Volume +1)						0.020 (0.032)	0.057 (0.036)
Day FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
SE CL	Day+ETF	Day+ETF	Day+ETF	Day+ETF	Day+ETF	Day+ETF	Day+ETF
Observations	460,709	460,709	420,093	420,028	420,028	420,028	412,994
Adjusted R ²	0.256	0.257	0.262	0.263	0.263	0.263	0.263

Note: *p<0.1; **p<0.05; ***p<0.01

EXHIBIT A3: Regression Analysis of ETF Bid-Ask Spread and Trading Volume Cross-Sectionally (continued)

Panel A2: International Equity ETFs							
	Dependent Variable Is ETF Bid-Ask Spread (bps) International Equity ETFs						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Active ETF		-9.983*** (3.319)	-7.210** (3.511)	-7.056** (3.446)	-7.213** (3.458)	-7.085** (3.456)	-6.492* (3.394)
log (Daily AUM)	-8.709*** (0.626)	-8.865*** (0.641)	-7.345*** (0.580)	-6.799*** (0.580)	-5.837*** (0.639)	-6.961*** (2.229)	-8.146*** (2.385)
Basket Spread			0.263*** (0.100)	0.234** (0.095)	0.246** (0.098)	0.248** (0.098)	0.255*** (0.098)
log (Daily Price)				-5.856*** (2.231)	-6.144*** (2.225)	-6.105*** (2.208)	-6.297*** (2.164)
log (Daily Dollar Volume + 1)					-0.705** (0.293)	-1.945 (2.248)	-5.361** (2.595)
Pct Open Auction Volume							9.781*** (2.923)
Pct Close Auction Volume							-14.961*** (4.749)
log (Daily AUM)* log (Daily Dollar Volume + 1)						0.071 (0.122)	0.212 (0.136)
Day FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
SE CL	Day+ETF	Day+ETF	Day+ETF	Day+ETF	Day+ETF	Day+ETF	Day+ETF
Observations	460,709	460,709	420,093	420,028	420,028	420,028	412,994
Adjusted R ²	0.256	0.257	0.262	0.263	0.263	0.263	0.263

Panel A3: Fixed Income ETFs							
	Dependent Variable Is ETF Bid-Ask Spread (bps) Fixed Income ETFs						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
CreditRating: A-BBB		2.838** (1.220)	2.267* (1.179)	1.892 (1.219)	1.771 (1.206)	1.862 (1.187)	1.783 (1.149)
CreditRating: BB and below		6.054*** (1.751)	6.308*** (1.728)	5.984*** (1.675)	6.183*** (1.670)	5.950*** (1.595)	5.671*** (1.530)
CreditRating: Not Rated		11.211** (5.276)	9.518* (5.626)	9.233 (5.639)	9.407* (5.605)	8.899 (5.457)	9.019 (5.525)
CurrencyExposure		7.085* (3.796)	8.129** (3.634)	7.884** (3.661)	8.100** (3.649)	8.552** (3.652)	8.700** (3.599)
Duration		0.492*** (0.124)	0.578*** (0.127)	0.627*** (0.135)	0.629*** (0.135)	0.641*** (0.135)	0.644*** (0.132)
ActiveETF			3.899** (1.552)	4.214*** (1.529)	3.750** (1.536)	4.404*** (1.500)	4.339*** (1.468)
log(DailyAUM)	-4.804*** (0.331)	-4.366*** (0.305)	-4.232*** (0.307)	-3.926*** (0.349)	-2.950*** (0.402)	-6.647*** (1.571)	-7.529*** (1.546)
log(DailyPrice)				-2.965** (1.314)	-2.970** (1.306)	-3.645*** (1.357)	-3.645*** (1.293)
log(DailyDollarVolume+1)					-0.694*** (0.198)	-4.399*** (1.443)	-6.391*** (1.643)
PctOpenAuctionVolume							5.364* (2.844)
PctCloseAuctionVolume							-0.694 (2.273)
log(DailyAUM)*log(DailyDollarVolume+1)						0.215*** (0.081)	0.299*** (0.086)
Day FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
SE CL	Day+ETF	Day+ETF	Day+ETF	Day+ETF	Day+ETF	Day+ETF	Day+ETF
Observations	364,665	341,499	341,499	341,483	341,483	341,483	333,533
Adjusted R ²	0.188	0.196	0.199	0.200	0.202	0.205	0.250

Note: *p<0.1; **p<0.05; ***p<0.01

EXHIBIT A3: Regression Analysis of ETF Bid-Ask Spread and Trading Volume Cross-Sectionally (continued)

Panel B1: US Equity ETFs					
	Dependent Variable Is Log(Daily Dollar Volume + 1) US Equity ETFs				
	(1)	(2)	(3)	(4)	(5)
ActiveETF		-0.158 (0.144)	-0.136 (0.147)	-0.146 (0.147)	-0.155 (0.114)
log(DailyAUM)	1.241*** (0.021)	1.233*** (0.022)	1.226*** (0.023)	1.235*** (0.028)	1.126*** (0.021)
BasketSpread			0.004 (0.004)	0.004 (0.004)	0.003 (0.003)
log(DailyPrice)				-0.052 (0.084)	0.044 (0.077)
PctOpenAuctionVolume					0.108 (0.155)
PctCloseAuctionVolume					0.286 (0.551)
Day FE	Yes	Yes	Yes	Yes	Yes
SE CL	Day+ETF	Day+ETF	Day+ETF	Day+ETF	Day+ETF
Observations	460,703	460,703	420,078	420,078	413,043
Adjusted R ²	0.725	0.726	0.736	0.736	0.792

Panel B2: International Equity ETFs					
	Dependent Variable Is Log(Daily Dollar Volume + 1) International Equity ETFs				
	(1)	(2)	(3)	(4)	(5)
ActiveETF		-0.196 (0.209)	-0.231 (0.207)	-0.222 (0.212)	-0.134 (0.142)
log(DailyAUM)	1.327*** (0.026)	1.324*** (0.025)	1.326*** (0.027)	1.362*** (0.031)	1.280*** (0.026)
BasketSpread			0.018* (0.009)	0.016* (0.009)	0.012* (0.007)
log(DailyPrice)				-0.397*** (0.141)	-0.337*** (0.116)
PctOpenAuctionVolume					-0.513*** (0.167)
PctCloseAuctionVolume					-0.488* (0.249)
Day FE	Yes	Yes	Yes	Yes	Yes
SE CL	Day+ETF	Day+ETF	Day+ETF	Day+ETF	Day+ETF
Observations	393,923	393,923	272,926	272,926	268,595
Adjusted R ²	0.676	0.677	0.691	0.693	0.756

Note: *p<0.1; **p<0.05; ***p<0.01

EXHIBIT A3: Regression Analysis of ETF Bid-Ask Spread and Trading Volume Cross-Sectionally (continued)

Panel B3: Fixed Income ETFs					
	Dependent Variable Is Log(Daily Dollar Volume + 1) Fixed Income ETFs				
	(1)	(2)	(3)	(4)	(5)
CreditRating: A-BBB		-0.279* (0.145)	-0.178 (0.143)	-0.181 (0.148)	-0.031 (0.100)
CreditRating: BB and below		0.319* (0.162)	0.275* (0.150)	0.272* (0.150)	0.270** (0.128)
CreditRating: Not Rated		-0.037 (0.309)	0.262 (0.313)	0.259 (0.314)	0.348* (0.180)
CurrencyExposure		0.504** (0.240)	0.319 (0.229)	0.317 (0.226)	0.115 (0.167)
Duration		0.018 (0.016)	0.003 (0.017)	0.003 (0.017)	0.007 (0.013)
ActiveETF			-0.687*** (0.159)	-0.684*** (0.160)	-0.510*** (0.114)
log(DailyAUM)	1.420*** (0.026)	1.433*** (0.027)	1.410*** (0.026)	1.413*** (0.033)	1.266*** (0.021)
log(DailyPrice)				-0.027 (0.156)	0.172* (0.097)
PctOpenAuctionVolume					-0.321** (0.149)
PctCloseAuctionVolume					-0.768** (0.313)
Day FE	Yes	Yes	Yes	Yes	Yes
SE CL	Day+ETF	Day+ETF	Day+ETF	Day+ETF	Day+ETF
Observations	365,512	342,249	342,249	342,249	334,091
Adjusted R ²	0.661	0.671	0.676	0.677	0.766

Note: *p<0.1; **p<0.05; ***p<0.01

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