
ETF Trading: Understanding the Equity ETF Primary Market

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May 2025

KEY TAKEAWAYS

- ▶ Traditional pro rata baskets reflect portfolio weights, while custom baskets allow for more selective inclusion of securities.
- ▶ Dimensional has placed a significant emphasis on the design and use of custom baskets in its active ETFs.
- ▶ This paper highlights the benefits active ETFs can achieve from the daily customization of their create and redeem baskets.

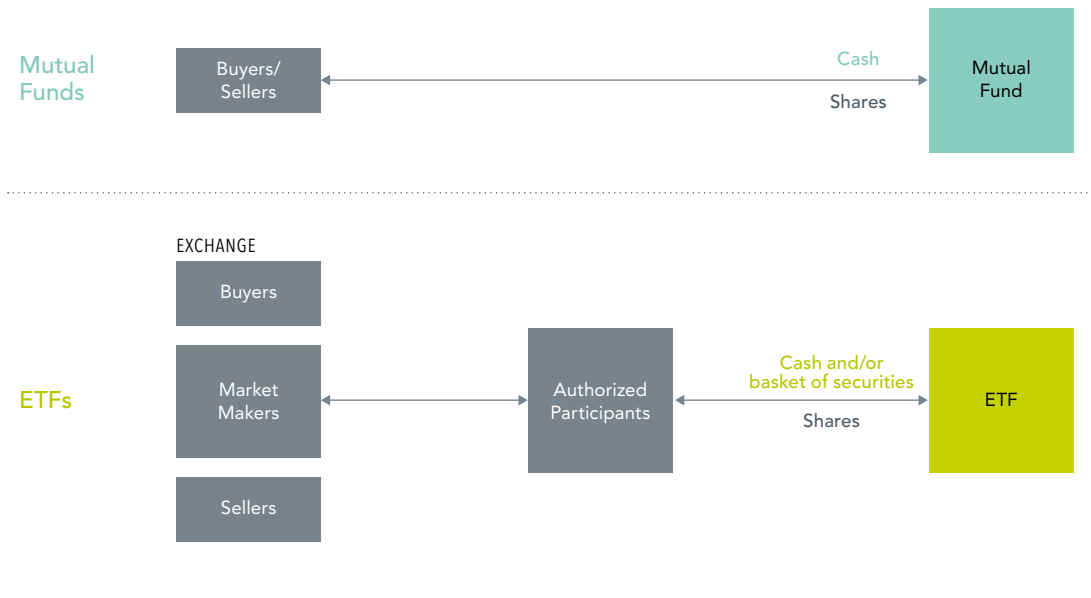
In 2024 investors poured a record \$1.1 trillion into US-domiciled ETFs, according to Morningstar. As a result, ETFs' total assets passed \$10 trillion. The growing popularity of ETFs makes it more important for investors to have a good knowledge of the markets in which ETFs trade. Retail investors buy and sell ETFs in the secondary market, and [our prior study](#) provided a deep dive into that market. The other market in the ETF ecosystem is called the primary market. This is the market where authorized participants create and redeem ETF shares directly with the ETF manager in exchange for baskets of cash and securities. In this paper, we provide a detailed analysis of the ETF primary market and highlight some of the benefits active ETFs can achieve by customizing their create and redeem baskets daily. To the best of our knowledge, this is the first paper to shed light on custom ETF baskets and their impact on ETF investors.

ETF Primary Market and Creation/Redemption Mechanism

ETFs differ in a few important aspects from other popular investment vehicles such as mutual funds. For example, ETFs can be traded throughout the day, whereas mutual funds can only be traded at the end of the day at their net asset value (NAV). The most significant difference between the two lies in how shares are created and redeemed (see Exhibit 1). Mutual fund investors generally exchange shares for cash based on the fund's NAV, and fund managers then use the cash to buy and sell securities on the market.¹ In contrast, ETFs involve an intermediary called an authorized participant (AP). Only APs, typically brokerage firms, can create or redeem ETF shares directly with the ETF manager in exchange for baskets of securities and cash.² APs may also act as market makers, facilitating the buying and selling of ETF shares with investors.

The marketplace where APs create and redeem ETF shares is referred to as the **primary market**, while the marketplace where APs trade ETF shares with investors is the **secondary market**.

EXHIBIT 1: Creation and Redemption Process for Mutual Fund and ETF Shares



1. The "40 Act" (Investment Company Act of 1940) permits a mutual fund to satisfy a redemption request in-kind by delivering a portion of its underlying portfolio securities directly to the redeeming investor rather than selling those assets for cash and then distributing the proceeds.

2. ETFs still do on-market trades but much less frequently than mutual funds. This can occur for portfolio rebalancing, utilizing cash from dividends and cash in lieu in basket creations, or raising cash for ETF distributions.

ETF Basket

The list of securities that an ETF manager is willing to exchange for ETF shares is known as the **basket**. This basket is published daily before the market opens. During the trading day, ETF shares are created or redeemed when an order is submitted by the AP and approved by the ETF manager.³ The ETF shares are delivered to the AP once the specified basket is transferred to the fund, usually on the contractual settlement date. The value of the securities in the basket, plus any cash adjustments, must match the value of the ETF shares created or redeemed, based on the ETF's NAV at the end of the trading day.

In this paper, we focus on baskets of equity ETFs.⁴ An equity ETF basket consists of a list of stocks, cash, and/or other assets designed by the ETF manager. In most cases, including index ETFs, the create and redeem baskets are proportional slices of the ETF's portfolio, referred to as **pro rata baskets**. However, in 2019, the SEC adopted Rule 6c-11, which allows ETFs that meet certain requirements to use daily baskets that don't necessarily reflect a proportional representation of the fund's portfolio. These are known as **custom baskets**.⁵

Since then, active ETFs' share of total ETF assets under management (AUM) in the US climbed from 2.5% in 2019 to 8.4% in 2024, with 26% of total ETF flows in 2024 going to active ETFs.⁶ Unlike index ETFs, active ETFs are not constrained by the need to track a specific index, which gives ETF managers more flexibility when "customizing" baskets. Factors considered in customizing a basket may include:

- Investment strategy (e.g., focus on size, value, profitability, investment, momentum, short-term reversal, and security lending fees)
- Liquidity usage (e.g., order size and depository receipts versus local shares)
- Tax optimization (e.g., embedded gains or losses at the tax lot level)
- Trading costs (e.g., fees and both explicit and implicit costs)

3. An ETF manager may put out a new basket during the trading day and use it for creations or redemptions. For example, this could happen when ETF flows exceed the manager's anticipated maximum for creations or redemptions.

4. Baskets of fixed income ETFs will be covered in our next paper.

5. For more details, see "[SEC Adopts New Rule to Modernize Regulation of Exchange-Traded Funds](#)," US Securities and Exchange Commission, September 2019.

6. Source: Morningstar Direct. US-domiciled ETFs only. Funds of funds are not included.

ETF Basket Data

Can customization provide benefits for ETF investors? To find out, we analyzed data from the [Depository Trust & Clearing Corporation \(DTCC\)](#) ETF historical portfolio composition file. This dataset records various types of baskets reported daily, including standard, create-only, redeem-only, and pricing baskets.⁷ The standard basket is the pro rata basket, which all ETFs are required to generate and report. However, using the standard basket for creations and redemptions is optional. The create-only and redeem-only baskets are designated for creations and redemptions, respectively. While generating these baskets is optional, custom baskets, when used, are reported as either create-only or redeem-only. The pricing basket provides a snapshot of the ETF's holdings, used to value the ETF throughout the trading day. Generating a pricing basket is optional, especially when the standard basket can represent a fund's holdings, as is often the case for index ETFs. The DTCC basket data consist of two types of records: portfolio header (information at the basket level) and component detail (detailed information about each basket component, including security identifiers, quantities, and cash-in-lieu indicators).

In this paper, we examine nearly 1,300 US-domiciled US equity and international equity ETFs as of December 31, 2024, covering the period from January to December 2024.⁸ The total AUM of those ETFs is over \$6 trillion in 2024. The set of ETFs, along with their asset class and investment style, is from Morningstar. **Exhibit 2** summarizes the dataset.⁹

7. Some special types of baskets, such as rebalance baskets, negotiated baskets, and restricted baskets, are not reported in the dataset. Standard basket data is available from November 2007, while create-only, redeem-only, and pricing basket data are available from July 2020.

8. Funds of funds, leveraged funds, inverse/short funds, and active nontransparent ETFs are excluded.

9. Additional statistics and an explanation of ETF basket terminology can be found in Appendix 1.

EXHIBIT 2: Summary Statistics of ETF Basket Data

	Number of ETFs	Total AUM	Average AUM	Average Number of Components	Average Weight Overlap to Holdings
US Equity					
Dimensional Fund Advisors					
Holdings	13	\$87B	\$6.7B	1,583	
Create Basket				319	60%
Redeem Basket				331	59%
Other Active ETFs					
Holdings	262	\$119B	\$0.5B	155	
Create Basket				140	98%
Redeem Basket				133	96%
Index ETFs					
Holdings	479	\$4,776B	\$10.0B	344	
Create Basket				341	99%
Redeem Basket				341	99%
International Equity					
Dimensional Fund Advisors					
Holdings	15	\$42B	\$2.8B	3,471	
Create Basket				669	50%
Redeem Basket				679	48%
Other Active ETFs					
Holdings	147	\$122B	\$0.8B	229	
Create Basket				156	96%
Redeem Basket				155	96%
Index ETFs					
Holdings	375	\$1,206B	\$3.2B	427	
Create Basket				420	99%
Redeem Basket				420	99%

Source: Dimensional using DICC ETF historical portfolio composition file and Morningstar data. January 1, 2024, to December 31, 2024. The universe includes US-domiciled US equity and international equity ETFs as of December 31, 2024. Holdings are based on pricing baskets. For index ETFs that do not report pricing baskets, their standard basket as of T-1 is used as a proxy. For ETFs that do not have designated create-only or redeem-only baskets, their standard basket is used as create or redeem baskets. All statistics are computed for each ETF at the daily frequency, then averaged across days. Cross-sectional averages are equally weighted.

Number of Components

The number of components in an ETF basket can range from a few to several thousand. Due to the use of custom baskets, Dimensional ETFs typically have far fewer components in their create and redeem baskets compared to their holdings. In contrast, index ETFs usually have baskets that closely mirror their holdings due to the need to maintain pro rata baskets. Interestingly, while labeled “active,” other active ETFs tend to have baskets with component counts closer to their holdings’ count, similar to index ETFs. Since the costs of in-kind creation and redemption are directly tied to the number of components in the baskets, basket customization allows Dimensional to offer the benefits of broad diversification in its ETFs while keeping costs relatively low by not forcing APs to create and redeem baskets full of thousands of stocks.

Weight Overlap to Holdings

To assess the overlap between the basket and the holdings, we calculate the overlap for each ETF as follows:

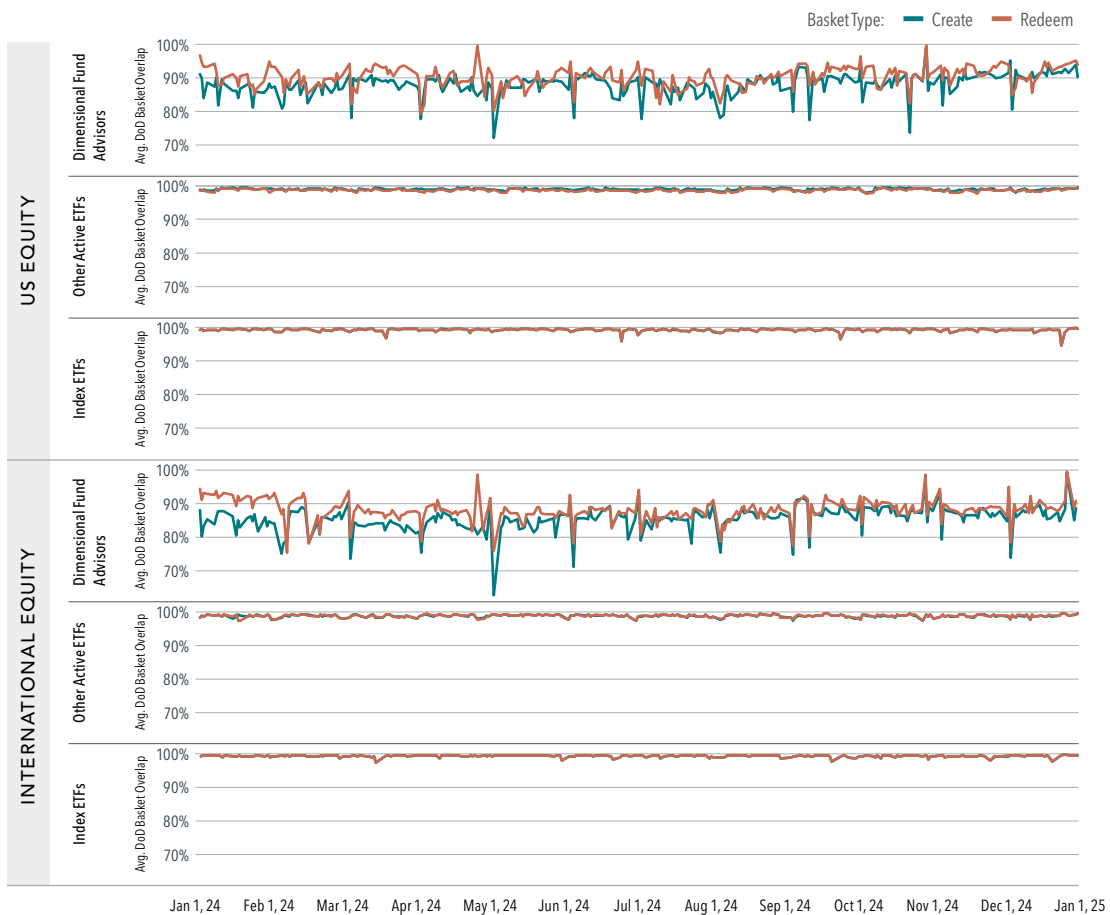
$$Overlap = 1 - \frac{\sum_i |WeightInBasket_i - WeightInHoldings_i|}{2} = \sum_i \min(WeightInBasket_i, WeightInHoldings_i),$$

where $WeightInBasket_i$ and $WeightInHoldings_i$ represent the weight of component i in the basket and holdings, respectively. We compute the average overlap for each ETF across trading days and then average across the ETFs in a group. As expected, for index ETFs, the average overlap between the create and redeem baskets and the holdings is 99%. For most active ETFs, the average overlap between the baskets and the holdings is also over 96%, which is quite surprising as it suggests that most active ETFs do not customize their baskets most of the time. Dimensional does customize its ETF baskets daily; as a result, our ETFs show a much lower overlap to holdings compared to both other active ETFs and index ETFs, between 48% and 60%. Basket customization allows Dimensional to use every creation and redemption order to efficiently rebalance the portfolio, saving investors unnecessary trading and tax costs. The next sections will explore these benefits in more detail.

ETF Basket Change over Time

Examining the overlap between an ETF’s basket and holdings is one way to determine if the basket is actively customized. Another way is by examining its evolution over time. **Exhibit 3** shows time-series plots of the day-over-day overlap for the same basket of an ETF, averaged across all ETFs in a group. For index ETFs, the day-over-day overlap is close to 100% most days, as changes in the basket are typically limited to scheduled rebalancing days. Similarly, for most active ETFs, the day-over-day overlap is also close to 100% most days, suggesting they change their baskets infrequently. When we look into individual ETF managers in Appendix 2, their baskets are typically changed once a week or less. However, Dimensional ETFs, which use custom baskets, change their baskets every day and exhibit more significant day-over-day variations compared to other ETFs. In summary, Dimensional ETFs use baskets that differ from the underlying holdings and change the composition of those baskets quite frequently.

EXHIBIT 3: Day-over-Day Basket Overlap

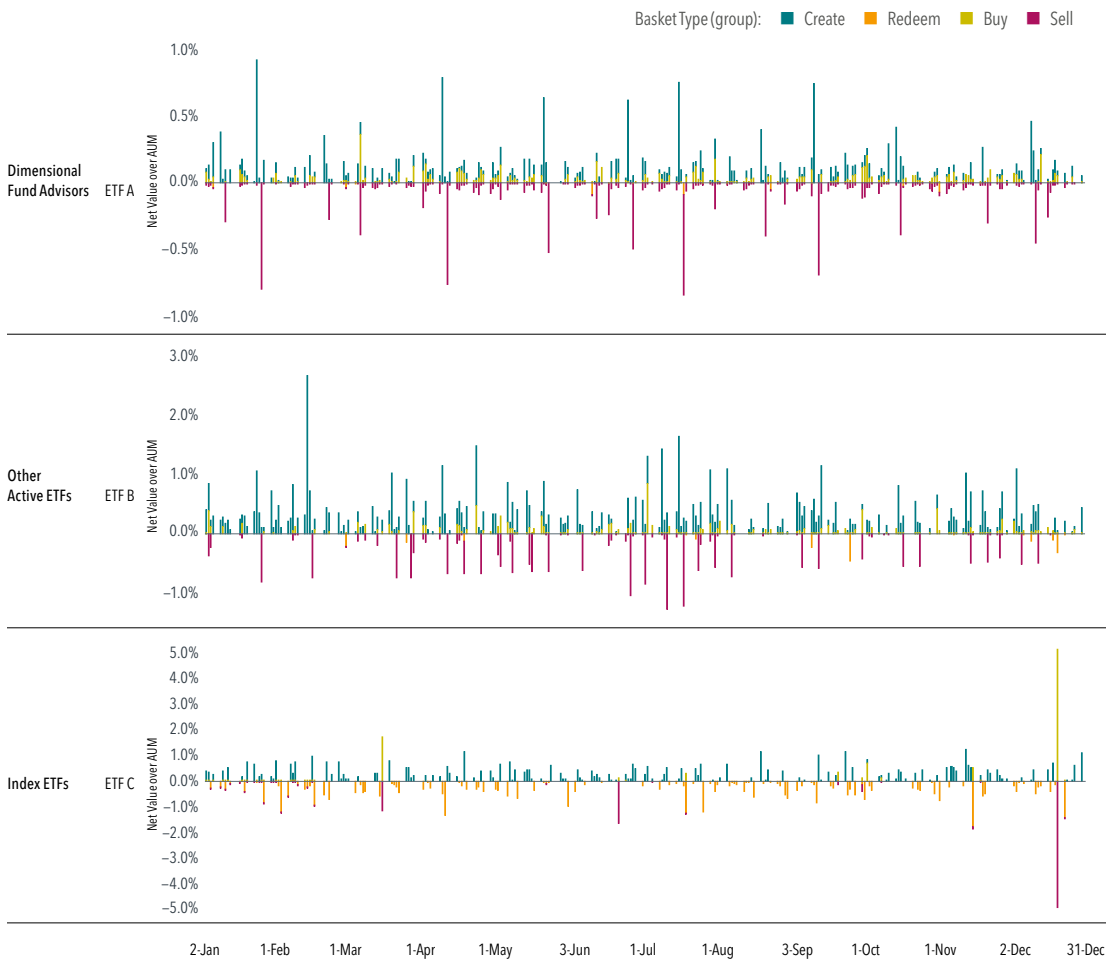


Source: Dimensional using DICC ETF historical portfolio composition file and Morningstar data. January 1, 2024, to December 31, 2024. The universe includes US-domiciled US equity and international equity ETFs as of December 31, 2024. For ETFs that do not have designated create-only or redeem-only baskets, their standard basket is used as create or redeem baskets. The day-over-day basket overlap is computed as the weight overlap of the same type of basket between two consecutive days for each ETF on each day; then we take equal-weighted averages cross-sectionally.

ETF Flow and Basket Usage

Now that we have examined how baskets are designed and adjusted, we explore how these baskets are applied in the creation/redemption process and how this impacts portfolio implementation. By computing the day-over-day change of ETF shares outstanding, the changes in holdings of each component, and their alignment with the ETF basket, we can estimate the extent to which the reported ETF baskets are used in the in-kind creation/redemption process. Appendix 3 provides a detailed explanation of the methodology, along with examples. Exhibit 4 illustrates the daily flow and basket usage for a few ETFs.

EXHIBIT 4: Examples of ETF Daily Flows and In-Kind Trades Using ETF Create/Redeem Baskets















Source: Dimensional using DICC ETF historical portfolio composition file and Morningstar data. January 1, 2024, to December 31, 2024. Includes US-domiciled US equity and international equity ETFs with pricing baskets reported. ETFs with largest AUM within each group are selected. Each day we compute the net portfolio traded value divided by fund's AUM. "Create" and "Redeem" represent the daily net traded value that can be explained by the in-kind trades using create and redeem baskets. "Buy" and "Sell" represent all other trades, which include on-market trades, in-kind trades using rebalance baskets, etc.

From Exhibit 4, we can see how much of the daily flow is attributed to regular in-kind trades compared to others. The blue and orange bars represent the size of in-kind trades using create and redeem baskets, respectively, while the lime green and red bars capture all other trade types that are not regular in-kind trades. Those could be in-kind creation and redemptions using rebalance baskets, which tend to be highly concentrated in fewer stocks, or on-market buys and sells.¹⁰ For example, in ETF A and B, many red bars appear two days after a similarly sized blue bar, suggesting they are likely the second leg of heartbeat trades, which would be the in-kind redemptions using rebalance baskets. In contrast, in ETF C, a lime green bar and a red bar of similar size appear on December 20, 2024, suggesting they are likely on-market buys and sells for the rebalance.

In Exhibit 5, we estimate the percentage of traded value for different ETF trade types and their contribution to portfolio weight changes across all studied ETFs. Although the total value of in-kind trades via create/redeem baskets is consistent across ETF groups—approximately 30%–50% of total traded value—these trades account for more than 30% of total portfolio weight adjustments in Dimensional ETFs, compared to just less than 2% in index ETFs and less than 8% in other active ETFs. This is not surprising given most ETFs post create and redeem baskets that mimic their holdings, so while a lot of trading happens via those baskets, it has little impact on the portfolio positioning.

EXHIBIT 5 : Traded Value by Different Basket Types and Their Contributions to Portfolio Weight Change

Traded Value by Different Basket Types			CREATE	REDEEM	OTHERS
US Equity	Dimensional Fund Advisors		49%	2%	49%
	Other Active ETFs		38%	8%	54%
	Index ETFs		28%	14%	59%
International Equity	Dimensional Fund Advisors		39%	1%	60%
	Other Active ETFs		27%	8%	65%
	Index ETFs		18%	16%	66%

Contribution to Portfolio Weight Change by Different Basket Types			CREATE	REDEEM	OTHERS
US Equity	Dimensional Fund Advisors		35%	1%	64%
	Other Active ETFs		4%	1%	94%
	Index ETFs		1%	1%	97%
International Equity	Dimensional Fund Advisors		27%	4%	68%
	Other Active ETFs		5%	2%	94%
	Index ETFs		1%	0%	98%

Source: Dimensional using DTCC ETF historical portfolio composition file and Morningstar data. January 1, 2024, to December 31, 2024. The universe includes US-domiciled US equity and international equity ETFs as of December 31, 2024. The top charts represent the percentage of total value of in-kind trades using create and redeem baskets and other trade types. The bottom charts represent the total contribution to the portfolio daily weight change of in-kind trades and other trade types, where the portfolio daily weight change is computed as the absolute value of the weight difference between the portfolio and the portfolio after being applied to the trades for each trading day. Cross-sectional averages are equally weighted.

10. Rebalance baskets are not reported in the DTCC data, making it impossible to explicitly identify in-kind trades using these baskets.

Quantifying the Potential Value-Add of Custom Baskets vs. Pro Rata Baskets

Dimensional ETFs use custom baskets for in-kind creation/redemption in daily order flows. In contrast, index ETFs and many other active ETFs use pro rata baskets. In fact, pro rata baskets are also generated daily by Dimensional ETFs. Given all the basket data and daily holdings data are available from DTCC, we can model how portfolios would evolve over time using pro rata baskets to achieve the same portfolio outcomes. To do this, we make the following assumptions:

- Daily inflows and outflows are consistent with actual flows.
- Pro rata baskets are used in daily flows to adjust the weights of portfolio constituents.
- Quarterly rebalances occur on the third Fridays of March, June, September, and December.
- Fund holdings align with actual holdings after each quarterly rebalance.

We then compare rebalance trade value, and create/redeem fees between the custom basket and pro rata basket approaches. The results are presented in **Exhibit 6**.

EXHIBIT 6: Comparison of Using Custom Baskets vs. Pro Rata Baskets in Dimensional ETFs

	Number of ETFs	In-Kind Creation from Ordinary Flow	In-Kind Redemption from Ordinary Flow	Rebalance Buy Value	Rebalance Sell Value	Rebalance Trade Value as a Percentage of AUM	Create / Redeem Fees
Dimensional US Equity ETFs							
Custom Baskets	12	\$1.5B	\$84M	\$1.1B	\$1.0B	29%	\$49K
Pro Rata Baskets				\$1.4B	\$1.4B	48%	\$225K
Dimensional International Equity ETFs							
Custom Baskets	13	\$1.0B	\$12M	\$0.6B	\$0.4B	37%	\$134K
Pro Rata Baskets				\$0.8B	\$0.8B	59%	\$941K

Source: Dimensional using data sourced from DTCC ETF historical portfolio composition file, funds' transfer agent, custodian, fund accountant, and London Stock Exchange Group (LSEG) Tick Data History data. January 1, 2024, to December 31, 2024. Only includes ETFs with inception dates before January 1, 2024. Cross-sectional averages are equally weighted.

Rebalance Trade

In both the custom basket and pro rata basket approaches, rebalancing is necessary to achieve the desired portfolio outcomes. We define rebalance trades as any trades that are not daily creation and redemption trades. Since daily creations and redemptions using pro rata baskets do not help with portfolio weight adjustment, ETFs using pro rata baskets require larger rebalance trades to reach their target portfolio weights. On average, the annual rebalance trade value, expressed as a percentage of ETF AUM, is approximately 20% higher when using pro rata baskets compared to custom baskets.

Create/Redeem Fee

The create/redeem fee is a fixed cost charged by the ETF manager to an AP per order. This fee is meant to compensate the ETF's custodian for the work it does to book the trades associated with basket activity. We estimate the create/redeem fee for each in-kind order based on the specific securities included in the basket and their historical fee schedules. Pro rata baskets, which include more securities, result in a higher create/redeem fee compared to custom baskets. The create/redeem fee in Dimensional's implementation of using custom baskets is on average 80% lower than if pro rata baskets are used, and the reduction could be as high as 90% for ETFs focused on emerging markets. Although these fee differences do not reflect directly into ETF NAV or performance, APs could pass those fees on to investors through the trading costs (e.g., ETF bid-ask spreads) in the secondary market.

ETF Market Quality

Overall, our analysis so far shows that basket customization can help reduce the sizes of designated rebalance trades and create/redeem fees for an ETF, which can improve net returns for ETF investors. However, lower overlap of the custom baskets with holdings may make it more difficult and expensive for APs to hedge against the ETF when creating and redeeming ETF shares. Does the benefit come at the cost of higher trading costs incurred by investors when buying and selling ETF shares? In Exhibit 7, we report several measures of ETF market quality for the different groups of ETFs.

EXHIBIT 7: Summary of ETF Market Quality Across Different ETF Managers

Equal-Weighted Cross-Sectional Averages								
	Number of ETFs	AUM	Daily Traded Value	Quoted Spread (bps)	Effective Spread (bps)	Absolute Premium/Discount to iNAV (bps)	Effective Spread to iNAV (bps)	ETF Spread-to-Basket Spread Ratio
US Equity								
Dimensional Fund Advisors	12	\$7.3B	\$16M	6.6	3.7	1.9	4.1	69%
Other Active ETFs	217	\$0.5B	\$5M	19.9	13.4	3.9	10.0	253%
Index ETFs	464	\$10.3B	\$160M	12.2	7.5	3.0	6.7	128%
International Equity								
Dimensional Fund Advisors	13	\$3.3B	\$13M	11.3	6.6	14.6	10.6	88%
Other Active ETFs	122	\$0.4B	\$2M	29.0	19.2	33.4	17.8	355%
Index ETFs	367	\$3.3B	\$33M	26.1	16.4	27.6	12.7	314%
Value-Weighted Cross-Sectional Averages								
	Number of ETFs	AUM	Daily Traded Value	Quoted Spread (bps)	Effective Spread (bps)	Absolute Premium/Discount to iNAV (bps)	Effective Spread to iNAV (bps)	ETF Spread-to-Basket Spread Ratio
US Equity								
Dimensional Fund Advisors	12	\$14.9B	\$28M	4.8	2.9	1.9	3.2	41%
Other Active ETFs	217	\$4.7B	\$53M	7.1	4.5	2.4	4.4	90%
Index ETFs	464	\$236.9B	\$5,347M	1.7	1.2	1.1	1.4	22%
International Equity								
Dimensional Fund Advisors	13	\$5.3B	\$20M	5.3	3.4	11.6	6.9	49%
Other Active ETFs	122	\$3.8B	\$16M	13.3	7.7	21.3	9.7	170%
Index ETFs	367	\$51.4B	\$302M	3.6	2.5	13.8	2.7	52%

Source: Dimensional using LSEG Tick History data and Morningstar data. January 1, 2024, to December 31, 2024. The universe includes US-domiciled US equity and international equity ETFs as of December 31, 2024. For each ETF, all statistics are computed on a daily basis. Then we take equally weighted averages across days. The first six months after ETF launch are excluded. The exhibit reports both equally weighted and value-weighted averages across ETFs, using average AUM in 2024 for the value weighting.

Quoted Spread and Effective Spread

The quoted spread and effective spread are two widely used measures of the transactions costs that investors pay to buy and sell ETFs in the secondary market. Higher values can indicate higher trading costs and lower market liquidity. The quoted spread is defined as the difference between bid and ask prices, while the effective spread is defined as the difference between execution price and midpoint price, multiplied by 2. The side of each execution is determined by the Lee-Ready algorithm (Lee and Ready 1991). Throughout the trading day, we calculate a time-weighted average for the quoted spread and a value-weighted average for the effective spread.

Across both US and international equity ETFs, the equally weighted average quoted and effective spreads for Dimensional ETFs are at least two times narrower than those of other active ETFs and index ETFs. While the value-weighted averages are much tighter for index ETFs, due to the narrow spreads associated with the largest index ETFs, Dimensional's ETFs remain very close to index ETFs.

Intraday Net Asset Value (iNAV)

The iNAV provides an intraday indicative value of an ETF based on the market values of its underlying holdings. The value is calculated by a contracted third-party data provider and then disseminated to the public a few times a minute. The ETF premium/discount to iNAV is computed as the difference between an ETF's midpoint price and the iNAV, measuring the price deviation between ETF market price and its underlying value. In Appendix 4, we further examine the premium/discount over time and intraday. Here we focus on the averages for different groups of ETFs. To obtain those averages, we calculate the absolute value of the premium/discount between the prevailing ETF midpoint price and the iNAV, and take an equal-weighted average over the trading day.

Another measure related to the iNAV is the effective spread. Instead of using the ETF's midpoint price as the estimation of the true value, we can replace it by the iNAV, then compute the difference to the execution price. We call this measure the effective spread to iNAV.

Again, Dimensional ETFs exhibit the lowest equal-weighted averages for both measures compared to those of other active ETFs and index ETFs, indicating minimal deviations of the iNAV from the midpoint price and execution price. While value-weighted averages show the lowest values for index ETFs, Dimensional ETFs remain much closer to index ETFs than other active ETFs.

Basket Spread

The basket spread is computed as the weighted average bid-ask spread of securities in the pricing basket (portfolio holdings), where the constituents and their weights in the pricing basket are as of December 31, 2024. This measure reflects the cost for APs to create or redeem ETF shares by trading underlying securities, which in turn influences the ETF bid-ask spread.

By taking the ratio of the ETF spread to the basket spread, we can assess how well the ETF is quoted relative to the weighted average spread of its constituents. Dimensional ETFs have the lowest equal-weighted average ratio among all groups. Notably, with ratios below 100%, this measure indicates that Dimensional ETFs exhibit tighter bid-ask spreads than their underlying securities.

Conclusion

An ETF's basket is one of the most important aspects in the ETF creation/redemption process. Its design and implementation are essential. Historically, most creations and redemptions have been executed through pro rata baskets, which mirror the portfolio's weights. In contrast, custom baskets can deviate from portfolio holdings and be more selective about the securities to include. Since 2019, the use of custom baskets has been approved for active transparent ETFs without requiring individual exemptions. Dimensional, as the largest active ETF manager in the US by AUM, has placed a significant emphasis on the design of custom baskets.¹¹ This approach integrates various daily investment considerations, resulting in reduced overlap with portfolio holdings and significant changes day to day. Our research indicates that the use of custom baskets can lower rebalance trade sizes, reduce fees, and potentially improve the overall quality of the ETF secondary market. In other words, one basket is not enough in the world of active ETFs.

References

Lee, C. M., and M. J. Ready. 1991. "Inferring Trade Direction from Intraday Data." *Journal of Finance* 46, no. 2: 733–746.

11. Source: Morningstar Direct. US-domiciled ETFs only. As of December 31, 2024.

Appendix 1 – Additional Statistics of DTCC ETF Basket Data

In Exhibit A1, we report the summary statistics of all fields reported in the DTCC ETF historical portfolio composition file.

EXHIBIT A1: Additional Statistics of ETF Basket Data

	Average Creation Unit Size (shares)	Average Net Asset Value Per Creation Unit	Average Estimated Cash Per Creation Unit	Average Actual Cash Per Creation Unit	Average Estimated Value of Cash-in-Lieu Components Per Creation Unit
US Equity					
Dimensional Fund Advisors					
Create Basket	47,692	\$2.0M	\$69K	\$69K	\$0K
Redeem Basket	47,692	\$2.0M	\$11K	\$11K	\$0K
Other Active ETFs					
Create Basket	23,123	\$0.8M	-\$21K	\$20K	\$11K
Redeem Basket	23,123	\$0.8M	\$13K	\$14K	\$5K
Index ETFs					
Create Basket	34,542	\$2.7M	\$22K	\$15K	\$3K
Redeem Basket	34,542	\$2.7M	\$22K	\$15K	\$3K
International Equity					
Dimensional Fund Advisors					
Create Basket	86,667	\$2.5M	\$122K	\$919K	\$802K
Redeem Basket	86,667	\$2.5M	\$88K	\$702K	\$619K
Other Active ETFs					
Create Basket	38,411	\$1.2M	\$71K	\$196K	\$256K
Redeem Basket	38,411	\$1.2M	\$67K	\$182K	\$248K
Index ETFs					
Create Basket	80,300	\$3.6M	\$72K	\$312K	\$452K
Redeem Basket	80,300	\$3.6M	\$72K	\$309K	\$449K

Source: Dimensional using DTCC ETF historical portfolio composition file and Morningstar data. January 1, 2024, to December 31, 2024. The universe includes US-domiciled US equity and international equity ETFs as of December 31, 2024. For ETFs that do not have designated create-only or redeem-only baskets, their standard basket is used as create or redeem baskets. All statistics are computed for each ETF at the daily frequency, then averaged across days. Cross-sectional averages are equally weighted.

Creation Unit Size

A **creation unit** refers to the minimum number of ETF shares that an AP can create or redeem with the ETF manager. Typically, the creation unit size is 50,000 shares, but it can range from 25,000 to 600,000 shares depending on the price and liquidity of the ETF.

Cash Component

Since it's nearly impossible to perfectly match the value of the securities in the basket with the ETF shares being created or redeemed, the cash component serves as an adjustment. This ensures the basket's value and the ETF's value match. This value can change throughout the trading day due to fluctuations in the value of the securities. **Estimated cash** is calculated using market prices at the time the basket is published (T-1 close), whereas **actual cash** is computed using the price at the end of trade date (T close).

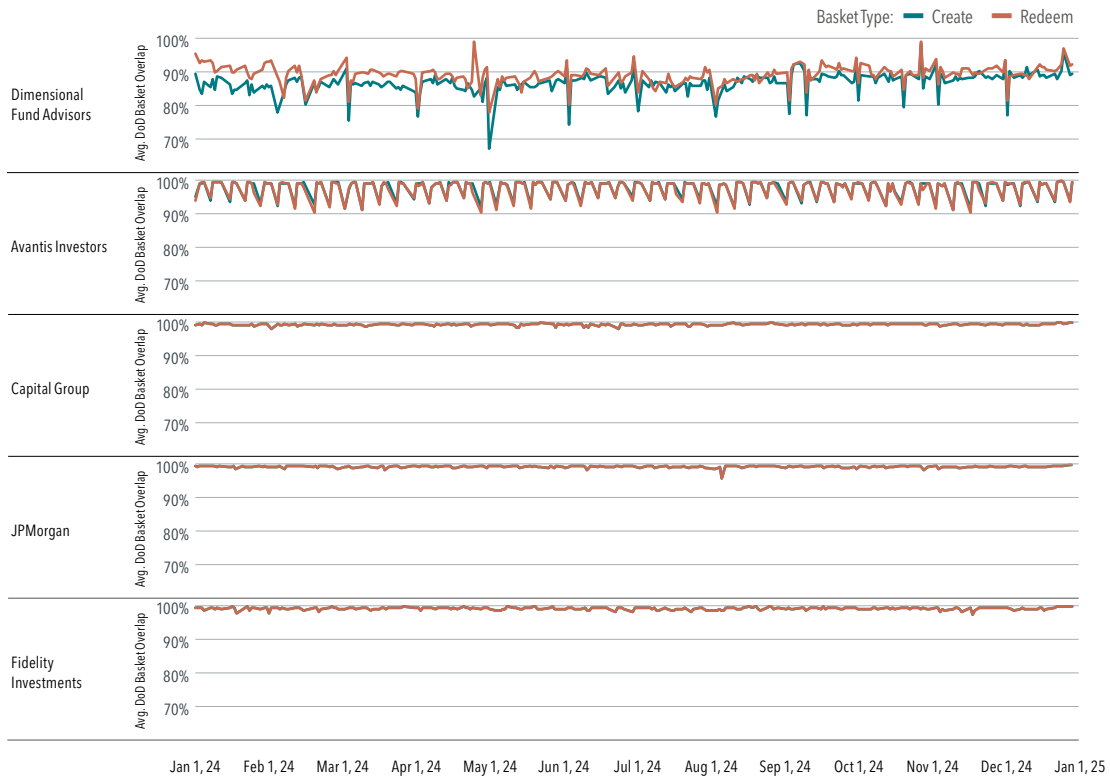
Cash-in-Lieu Component

Occasionally, the ETF may allow or require the AP to substitute cash for some or all of the securities in the basket (known as **cash in lieu**). This typically occurs when an instrument in the basket is difficult to obtain (e.g., low liquidity), in-kind transactions are not permissible in the local market (e.g., most emerging markets), or there are cost advantages to marking securities as cash (e.g., securities can be sourced more cheaply by the issuer than the AP). APs may also incur transaction fees (slippage) to offset any transaction cost to the ETF of buying or selling those securities on its own.

Appendix 2 – Day-over-Day Basket Overlap of Top Five Active ETF Managers

Similar to Exhibit 3, we calculate the day-over-day overlap for the same basket of an ETF, averaged across ETFs managed by the same firm. **Exhibit A2** presents the results for the top five active ETF managers by AUM in the US market as of December 31, 2024. The data shows that Dimensional changes its baskets daily, Avantis makes changes once a week, and the remaining managers change their basket far less frequently.

EXHIBIT A2: Day-over-Day Basket Overlap of Top Five Active ETF Managers



Source: Dimensional using DICC ETF historical portfolio composition file and Morningstar data. January 1, 2024, to December 31, 2024. The universe includes US-domiciled US equity and international equity active ETFs as of December 31, 2024. Top five active ETF managers by AUM are included, based on Morningstar data as of December 31, 2024. For ETFs that do not have designated create-only or redeem-only baskets, their standard basket is used as create or redeem baskets. The day-over-day basket overlap is computed as the weight overlap of the same type of basket between two consecutive days for each ETF on each day; then we take equal-weighted averages cross-sectionally.

Appendix 3 – Computation of Daily ETF Basket Usage

For an ETF on a given day, suppose the day-over-day change in ETF shares outstanding is x creation units. The change in shares of component i in the pricing basket (portfolio holdings), after adjusting for corporate actions such as merger & acquisition, share split, is ΔPR_i . The shares in create and redeem baskets are CR_i and RD_i , respectively. The net number of in-kind creation units x_{cr} and in-kind redemption units x_{rd} can then be determined by solving the following system of linear equations:

$$\begin{cases} x_{cr} + x_{rd} = x, \\ x_{cr} * CR_i + x_{rd} * RD_i = \Delta PR_i, \end{cases} \quad \text{for most } i.$$

Exhibit A3 provides an example.

EXHIBIT A3: Example of Computation of Daily ETF In-Kind Trade Usage

Component Symbol	Component Quantity (T)	Component Quantity (T-1)	Delta Component Quantity	Component Quantity (Create Basket)	Component Quantity (Redeem Basket)
AA	76,007	76,151	-144	0	18
AAN	614,798	614,246	552	92	0
AAOI	216,744	219,792	-3,048	0	381
ABCB	560,445	562,165	-1,720	0	215
ACCO	390,518	387,008	3,510	585	0
ACDC	158,357	158,159	198	33	0
ACIC	77,077	76,129	948	158	0
ACNB	72,030	72,222	-192	0	24
ACT	393,659	393,113	546	91	0
ACU	30,345	30,201	144	24	0
AEO	3,484,380	3,481,248	3,132	522	0
AGM	124,174	123,994	180	30	0
AGX	201,721	201,451	270	45	0
AL	2,101,946	2,111,634	-9,688	0	1,211
ALGT	333,352	332,992	360	60	0
ALK	1,203,116	1,205,540	-2,424	0	303
ALRS	157,359	158,975	-1,616	0	202
ALTG	35,231	34,631	600	100	0
AM	1,493,416	1,496,512	-3,096	0	387
AMAL	318,567	318,165	402	67	0
AMBC	585,526	584,896	630	105	0
AMCX	557,516	560,596	-3,080	0	385
AMKR	639,053	640,485	-1,432	0	179
AMPH	522,427	521,833	594	99	0
AMPY	44,588	44,096	492	82	0
AMR	255,902	255,758	144	24	0
AMSF	29,755	29,835	-80	0	10
AMTB	341,217	342,665	-1,448	0	181
ANDE	697,048	696,364	684	114	0
...
The day-over-day ETF share outstanding change in is -2 units; therefore the basket usage can be determined as :				6	-8

Appendix 4 – Premium/Discount of ETF Price to iNAV

In the paper [Understanding ETF Trading and Liquidity \(Part I\)](#), we examined the microstructure and liquidity of the ETF secondary market, where bid-ask spread and premium/discount are the two primary components of trading costs. The premium/discount is the difference between the ETF’s market price and the value of its underlying holdings, also referred to as the intraday net asset value (iNAV). 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 consist of:

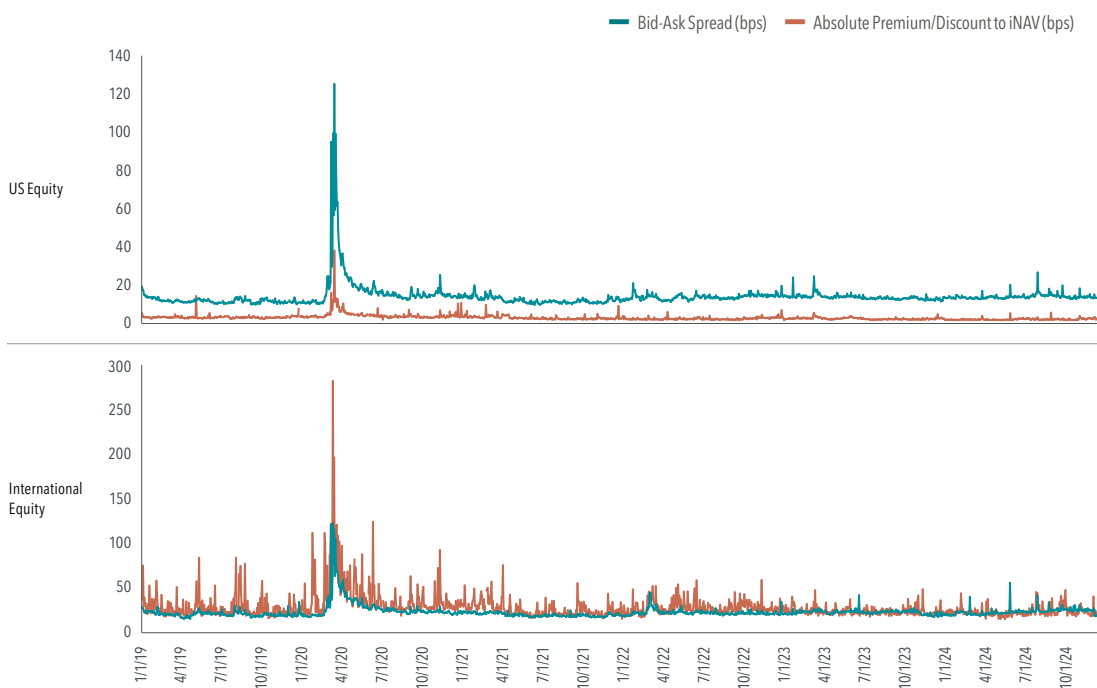
- Bid-ask spread: half of the spread = [trade price] – [midpoint price] = \$10.02 – \$10.01 = \$0.01
- ETF premium: [midpoint price] – [iNAV] = \$10.01 – \$10.005 = \$0.005

In Exhibit 7, we present cross-sectional statistics on the premium/discount. Next, we will study how it changed over time and throughout the trading day.

ETF Premium/Discount over Time

To see how the premium/discount has changed over time, **Exhibit A4** presents the time-series plots of the absolute premium/discount of ETF midpoint price to iNAV from January 2019 through December 2024. Similar to the bid-ask spread, the premium/discount spiked in March 2020, when the global equity markets tumbled due to the COVID-19 pandemic and market volatility reached an all-time high.

EXHIBIT A4: ETF Premium/Discount over Time, 2019–2024

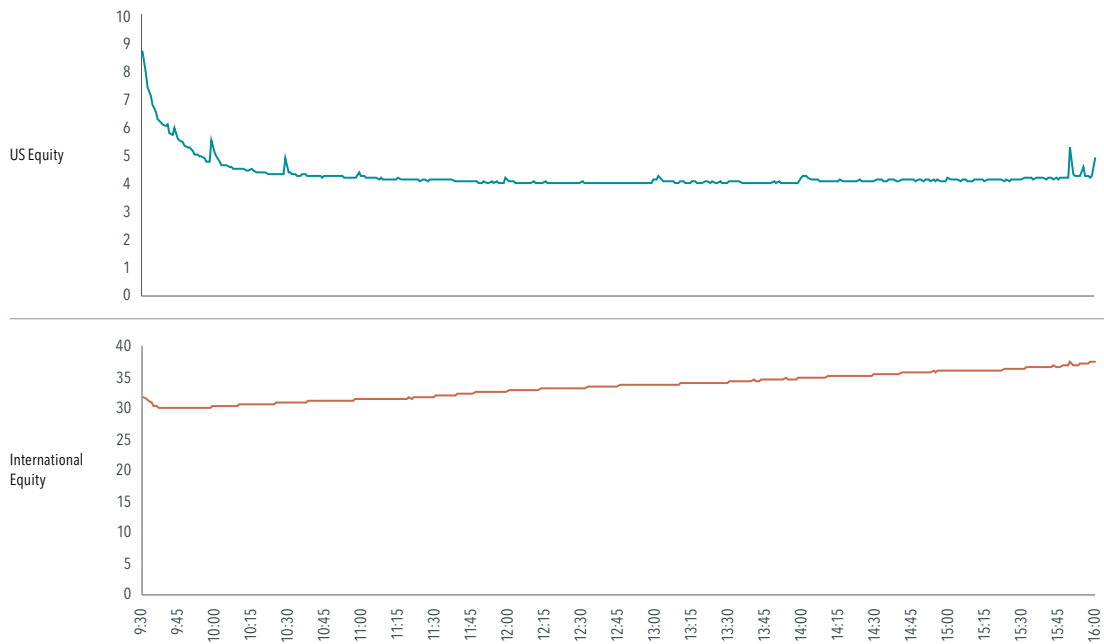


Source: Dimensional using LSEG Tick History data and Morningstar data. January 1, 2024, to December 31, 2024. The universe includes US-domiciled US equity and international equity ETFs as of December 31, 2024. For each day, cross-sectional averages are equally weighted.

Intraday ETF Premium/Discount

To examine how the ETF premium/discount changes throughout the trading day, we compute the absolute intraday premium/discount of ETF midpoint price to iNAV at each one-minute interval and then take equal-weighted averages across days and ETFs. Exhibit A5 presents the results. For US equity ETFs, the premium/discount is largest near market open, but drops significantly and becomes relatively stable 30 minutes after the open—a similar pattern to what we observed for the bid-ask spread. In contrast, for international equity ETFs, the premium/discount remains relatively small for the first few hours of trading while European markets are open. However, it gradually increases after the European market closes at 11:30 am ET in the US.

EXHIBIT A5: Intraday ETF Premium/Discount (bps), 2019-2024



Source: Dimensional using LSEG Tick History data and Morningstar data. January 1, 2019, to December 31, 2024. The universe includes US-domiciled US equity and international equity ETFs as of December 31, 2024. Statistics are computed for each 15-minute intraday interval. Statistics are then aggregated using equal-weighted averages cross-sectionally and over days.

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