Inefficiencies in the Pricing of Exchange-Traded Funds

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Abstract

The prices of exchange-traded funds can deviate significantly from their net asset values, on average fluctuating within a band of about 200 basis points, in spite of the arbitrage mechanism that allows authorized participants to create and redeem shares for the underlying portfolios. The deviations are larger in funds holding international or illiquid securities where net asset values are most difficult to determine in real time. To control for stale pricing of the underlying assets, I introduce a novel approach using the cross-section of prices on a group of similar ETFs. Nevertheless, the average pricing band remains economically significant at about 100 basis points, with even larger mispricings in some asset classes. Active trading strategies exploiting such inefficiencies produce substantial abnormal returns before transaction costs, providing further proof of short-term mean-reversion in ETF prices.

JEL classification: G10, G12, G14, G20, G23

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In the late fall of 2008, some investors spotted an attractive opportunity to buy muni bonds or junk bonds, as both types of bonds had declined dramatically in value in the immediate aftermath of the Lehman Brothers collapse, arguably more than could be justified by realistic expectations of future defaults. Exchange-traded funds (ETFs) provided a convenient new vehicle for investors to take advantage of this opportunity: any investor, including a retail investor, could easily buy a diversified portfolio of muni bonds or junk bonds, pay a low expense ratio, trade positions intraday, and use leverage to capitalize more aggressively on the opportunity. However, efficiently executing such trades with ETFs turns out to be more complicated.

Two muni bond funds, tickers PZA and MLN, both offered exposures to very similar portfolios of long-term muni bonds diversified across the entire U.S. But when comparing their pricing, one was sometimes trading at a premium relative to its net asset value (NAV) while the other was trading at a discount at exactly the same time. The difference in the end-of-day premium between the two funds varied from about +7% to -3% of NAV (Figure 1). Junk bond ETFs exhibited similar behavior, with the difference in premiums between JNK and HYG varying from +7% to -11% of NAV. The differences in premiums were driven by mean-reverting shocks to prices, which means that it was enormously important for an investor to correctly pick which fund to trade each day. Such pricing behavior is particularly surprising in the junk bond ETFs, given that each fund had several billion dollars in assets and traded large volumes every day with tight bid-ask spreads.

While the magnitudes in these examples are unusually large,[1] this paper provides empirical evidence that smaller inefficiencies in the pricing of ETFs are not limited to a few funds or a particular time period. In fact, the cross-section of ETFs routinely exhibits some economically significant differences between the ETF share price and the value of the underlying portfolio, especially in some asset classes, indicating that the unsophisticated investor may face an unexpected additional cost when trading ETFs.

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[1] One recent headline-grabbing episode occurred on August 24, 2015, when even very large funds like IVV with $70 billion in assets were briefly trading at around 20% discount to NAV.

Given the lack of attention ETF premiums have received from investors, many of them appear implicitly to assume that ETF prices stay extremely close to NAVs. This may be an understandable assumption because of the arbitrage mechanism that exists for ETFs: If the price is below the NAV, an arbitrageur can purchase ETF shares, redeem them for the underlying assets held in the ETF portfolio, and then sell the underlying assets at their prevailing market prices which add up to the NAV of the fund.[2] If the ETF price is higher than the NAV, an arbitrageur can do the reverse and create new ETF shares from the underlying assets. This generates a pure arbitrage profit, minus the transaction costs of buying or selling the underlying portfolio. The efficiency of ETF prices therefore would be expected to depend on the transaction costs and any other limits to arbitrage that might deter arbitrageurs from trying to profit from a mispricing.

Another issue complicating the arbitrage trade is that the officially published NAV may not fully reflect the current value of the ETF portfolio due to stale pricing. NAV is computed based on the latest closing prices for the underlying securities, or the latest bid prices in fixed-income markets (e.g., Gastineau (2010) and Tucker and Laipply (2010)). This can be a problem for illiquid securities such as high-yield bonds or for securities traded in international markets such as Japan where the trading day ends even before it begins in the U.S. Hence, estimating the true NAV, as distinct from the published NAV, becomes a more complicated task. Furthermore, in the case of international securities traded in different time zones, it may not even be possible to enter into simultaneous offsetting transactions involving ETF shares and the underlying portfolio. These concerns are likely to reduce the effectiveness of arbitrage and to allow for greater mispricings in ETFs.

[2] For purposes of illustration, we are assuming in these first few paragraphs that the NAV accurately reflects the market value of the underlying portfolio. However, the mutual fund literature has made it clear that this is not the case with some types of funds (e.g., Chalmers, Edelen, and Kadlec (2001), Goetzmann, Ivkovic, and Rouwenhorst (2001), and Zitzewitz (2003)).

A key research question in this paper is to provide comprehensive evidence of the magnitude of ETF premiums across all U.S.-listed ETFs, all underlying asset classes, and over time. An essential part of this objective is to determine the magnitude of the "true" ETF premiums when stale NAVs are accounted for. Furthermore, I want to understand what the premiums depend on and how investors should trade ETFs to avoid being adversely affected by the premiums.

I start by computing the premiums (positive or negative) of ETF midquote prices relative to NAVs on all categories of funds traded in the U.S. market. I also document their time-series evolution to see if the efficiency of the market has changed over time. Most importantly, I introduce a novel approach to address the stale pricing issue: I sort funds into groups with nearly identical underlying portfolios, and I use the average market price of the group as a real-time proxy for the true underlying value of funds. Any cross-sectional dispersion of an ETF price around its group mean is therefore likely to be explained by mispricing rather than stale pricing. Due to the dramatic growth of the ETF sector, I focus mostly on the data from January 2007 to December 2014, as older data may be a poor guide to the present situation in the ETF marketplace.

I find that the average premium across all funds has been only 6 basis points (bp), so on average ETFs are neither underpriced nor overpriced, in contrast to closed-end funds where the absence of share creation and redemption allows some funds to trade 10-20% or more below their NAVs. But the volatility of the ETF premium has been nontrivial at 49 bp. This means that with 95% probability a fund is trading at a premium from about -96 bp to +96 bp, or within a 192 bp band. The value-weighted numbers are only slightly smaller. This range is certainly economically significant and a potential source of concern for an ETF investor. Diversified U.S. equities and U.S. government bonds exhibit less volatile premiums, whereas international equities and municipal and corporate bonds exhibit volatilities of 40-140 bp around NAVs.

While stale pricing explains part of the premiums, it certainly does not explain all of it. To estimate this, we compute the volatility of the premium relative to the mean of a group of similar ETFs. This peer-group adjusted volatility is 26 bp, meaning that even after adjusting for stale pricing, the average ETF trades 95% of the time at a premium between -52 bp and +52 bp, or within a band of 104 bp. The numbers are again higher for some fund categories and twice that high for some international funds.

Bid-ask spreads cannot explain these premiums. I use the bid-ask midpoint price to measure all premiums, but spreads are relatively tight for commonly traded ETFs and thus these results are robust to using any price within the bid-ask spread.

The dollar amounts involved are also significant. Due to the large trading volume of ETFs, the historical premiums involved in actual ETF transactions amount to over $40 billion per year relative to NAVs and roughly $20 billion when adjusting for stale NAVs, which is a rather large amount of money to pay for trading at inefficient prices. This suggests that investors should not ignore these effects when trading ETFs.

Furthermore, an active trading strategy built to exploit these cross-sectional differences in ETF premiums generates attractive profits: on a simple unlevered long-short strategy trading at midquote prices (thus neither paying nor earning the bid-ask spread), the historical Carhart alpha is around 7% per year and the annualized information ratio is 4.8 using all the ETFs, and the alpha rises to 16% per year if we only use the categories that are most prone to mispricing. This provides another illustration of the inefficiencies that remain in the ETF market and the potential pitfalls for the average ETF investor.

Positive premiums on ETFs lead to more share creation, and vice versa for negative premiums, indicating that arbitrageurs are actively using the ETF share creation and redemption process to trade against these mispricings. Once new shares are created, there is downward price pressure on the same day and the subsequent two days which in turn pushes positive premiums back toward zero.

Over time, the cross-sectional dispersion in ETF premiums peaked during the financial crisis in late 2008, but it has remained at a nontrivial level through the end of 2014. It is correlated with the VIX index and TED spread which are proxies for the availability of arbitrage capital, as well as the average closed-end fund discount which can proxy for investor sentiment.

There is some but relatively little prior literature on the efficiency of ETFs as investment vehicles. Early references include Ackert and Tian (2000, 2008), Elton, Gruber, Comer, and Li (2002), Poterba and Shoven (2002), and Delcoure and Zhong (2007). Marshall, Nguyen, and Visaltanachoti (2010) look at the efficiency of intraday pricing of three S&P 500 index funds. In contrast, Sullivan and Xiong (2012), Wurgler (2011), and Ben-David, Franzoni, and Moussawi (2014) discuss the impact on ETF-induced trading on the efficiency of the underlying asset markets. The study perhaps closest to this paper is by Engle and Sarkar (2006) who analyze similar questions about ETF premiums and actually try to adjust for stale NAVs with an econometric model. However, all the studies above examine only a handful of ETFs; for example, Engle and Sarkar (2006) use a sample of 37 ETFs which ends in 2000 and Delcoure and Zhong have 20 ETFs until 2002, but since then the size of the ETF market has increased to over 1,400 live U.S.-traded ETFs with about two trillion dollars in assets at the end of 2014.[3] The only exception using a broad cross-section of ETFs is by Ben-David, Franzoni, and Moussawi (2014), but they focus on a different research question and they do not adjust for stale NAVs which is a key issue when investigating ETF premiums.

In contrast, this paper attempts to be the first comprehensive study of the pricing efficiency of all U.S.-listed ETFs after this dramatic surge in new products. To accomplish this objective, the paper shows a number of descriptive summary statistics for today's ETF market to provide the necessary context for researchers and investors. Very importantly, this paper also proposes a new and generally applicable methodology to deal with the stale pricing issue without having to make any assumptions about the price dynamics of the underlying portfolio. Besides ETFs, the same methodology could be helpful for fair-value pricing of closed-end funds or securities trading across different time zones.

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[3] Worldwide, the number of live ETFs, including exchange-traded notes and exchange-traded commodity funds, reached 5,428 with an estimated $2.8 trillion in assets in December 2014 (source: ETP Landscape 12/2014, BlackRock).

The paper proceeds as follows. Section I describes my data sources. Section II provides some preliminaries on ETFs and the dramatic growth of the ETF sector. Section III presents the results on ETF premiums relative to the funds' official NAVs. Section IV presents my approach to addressing the stale pricing issue and presents the results on remaining mispricings and their drivers cross-sectionally and over time, together with recommendations for ETF investors. Section V concludes.

I. Data

I combine six sources of ETF data. The first source is CRSP, which I use for daily prices and returns. CRSP covers all U.S.-listed live and dead ETFs, including commodity funds, but not exchange-traded notes (ETNs). The second source is Bloomberg, which covers daily NAV data for essentially all live funds as of April 2010 (the time of my first Bloomberg snapshot) or later, going back to the inception of each fund. Since 1995, the Bloomberg data include anywhere from about 60% to 100% of all ETFs and 90% to 100% of all ETF assets. The third source is iShares, covering daily NAV data for iShares funds from inception to 7/2009. The iShares funds used to account for over 50% of all ETFs until the end of 2005, and they generally account for about 50% of all assets since the beginning of 2005. The NAV data for any possibly remaining funds are from OpenTick, a data vendor which used to provide minute-by-minute estimates of NAVs throughout the trading day for a cross-section of funds from all fund families. The OpenTick data cover about 40-50% of funds between 10/2006 and 2/2009, and 30-50% of fund assets. Collectively, the three sources of NAV data cover about 87-99% of ETFs and 97-100% of ETF assets in 2007-2014, which is where I focus most of my analysis. I select data from Bloomberg, iShares, and OpenTick in that order, which means that the overwhelming majority of NAV data points come from Bloomberg.

The fifth data source is Morningstar, which I use for fund names as well as style categories and benchmark indices. Multiple snapshots were downloaded between 3/2010 and 6/2014 for live ETFs and then merged into one dataset, which accounts for 88-100% of my cumulative fund sample and at least 99.8% of ETF assets in 2007-2014.

Survivorship bias is not an issue here since I do not study the performance of individual ETFs.

The sixth data source is the consolidated NYSE TAQ data, which has been aggregated from individual transactions and quotes to five-minute intervals. I use it for intraday calculations, including bid-ask spreads, prices, and trading volume. The bulk of the analysis does not use intraday data – instead, I use it mostly as a robustness check to confirm that daily observations do not miss some relevant intraday behavior.

To mitigate concerns about illiquidity of the shares of smaller ETFs, I compute the end-of-day price as the average of the bid price and ask price at market close, instead of using the official closing price (i.e., the latest transaction price). I also compute all ETF returns from the bid-ask midpoint (plus dividends) rather than using the returns given in CRSP, following the recommendations of Engle and Sarkar (2006). In some parts of my analysis, I eliminate funds that have less than $10 million in assets or less than $100,000 in daily trading volume.

II. Background on ETFs

A. Growth of the ETF Sector

Before ETFs, most individual investors were effectively limited to investing in open-end and closed-end mutual funds or directly in individual stocks. Relative to mutual funds, ETFs have advertised several benefits to investors. Their fees are generally comparable to or even lower than those of the lowest-cost index funds. The ETF structure allows funds to minimize portfolio turnover, thus generating lower trading costs than comparable open-end index mutual funds. They can be more tax-efficient. They offer intraday trading, they can be sold short or bought on margin, and they can all be purchased conveniently on the investor's existing brokerage account. Investors have paid attention, and the sector has risen to become a very serious challenger to the existing mutual fund industry.

Figure 2 shows the explosive growth of the ETF sector in the last few years. The first ETF, the SPDR trust (ticker: SPY) from State Street, was launched in January

1993. Three years later in March 1996, the first competing firm (WEBS, later acquired by iShares) entered the field with 17 international single-country ETFs. The market experienced significant growth and reached 200 funds in October 2005, but then it started an even more explosive growth stage, reaching 1,435 live U.S.-traded funds with $1,969 billion in assets in December 2014. ETFs were among the few investment vehicles receiving broad inflows even throughout the financial crisis in 2008.

B. Cross-sectional ETF Characteristics

Table I describes my sample of ETFs in 2014, showing the whole distribution of some key characteristics. The median fund has $111 million in assets, but the distribution is heavily skewed in terms of asset size with the largest fund (SPY) accounting for $216 billion. Dollar trading volume is even more skewed, with the median fund trading $1.2 million per day and the most active fund (SPY) trading $21 billion per day. Relative to a fund's market capitalization, daily trading amounts to about 1.1% for the median fund, implying around 300% turnover per year, but the most active funds can even trade more than their market cap in a single day. The median ETF closing bid-ask spread is 15 bp, but it varies from as low as 1 bp for the most liquid funds to as high as several percent for the least liquid funds, reflecting the wide disparity in trading volume across funds. Unlike an individual stock where market makers have to post a large spread to offset the adverse selection problem they face (i.e., they may lose money trading with someone who has private information), an ETF is a diversified portfolio where idiosyncratic information has a smaller valuation impact, so ETF spreads should generally be lower than they would be for a stock with similar trading volume.

The median fund is generating a 26% annual turnover by its own trading. Some turnover is unavoidable even for passive funds because of changes in the underlying index. Especially funds holding front-month futures positions need to trade often as they roll over their positions regularly, whereas a diversified large-cap equity index requires little turnover if the fund uses only in-kind creations and redemptions. The annual expense ratio of a median fund stands at 50 bp of net assets, varying from 4 bp to 701 bp across funds.[4]

The table also shows the same statistics for two earlier snapshots in December 2010 and 2006. The distribution of ETF characteristics has stayed relatively similar over this eight-year period. However, in 2006 the median fund had slightly more assets, greater trading volume, and slightly lower bid-ask spread, reflecting the recent proliferation of ETFs and the testing of investor appetite with new products introduced in various niche categories.

C. *Share Creation and Redemption*

To create new ETF shares, an investor must be an "authorized participant" such as a broker-dealer who has entered into an agreement with the ETF trustee. ETF shares are created in "creation units" of usually 50,000 or 100,000 shares, with dollar values typically ranging from $300,000 to $10 million. Most creations occur as in-kind transactions: the investor submits a portfolio that matches the specifications given by the fund trustee before the end of the trading day, and new ETF shares are created for him at the end of the trading day. The trades are settled three days later.

The authorized participant must pay a fixed dollar fee, usually $500 to $3,000, for each creation transaction regardless of the number of creation units involved. For SPY, its fixed fee of $3,000 would currently amount to about 3 bp for a single creation unit worth about $10 million, or 1 bp for three creation units worth about $30 million. The process is similar for share redemptions, with identical fees. These transaction costs, combined with the costs of trading the underlying securities, would therefore be expected to set the boundaries of how much the ETF price can diverge from its NAV.

Some ETFs also allow investors to create and redeem creation units in cash. These transactions occur at the fund's published end-of-day NAV, much like purchases of open-end mutual funds, where the fund has the responsibility to use the new cash to

[4] A few highest-fee funds charge fixed dollar expenses, which can result in enormous percentage fees when they have only a very small amount of assets.

purchase more securities for its underlying portfolio. However, in ETFs the investor who creates new shares has to pay additional fees to cover the transaction costs incurred by the fund. These fees vary widely: for example, ProShares ETFs, based on relatively liquid underlying assets, charge only 0-3 bp additional fees for cash creation, whereas the iShares High Yield bond fund (ticker: HYG) may charge up to 3% for cash creations and 2% for redemptions, reflecting the higher transaction costs of the underlying assets.[5]

In-kind share creation exposes an arbitrageur to two risks: the timing risk due to non-simultaneous purchase and sale of the ETF shares and the underlying portfolio, and also the unpredictable transaction costs especially in illiquid assets. Cash creation eliminates these risks but it can be much more expensive and is not always available. As a result, even if arbitrageurs compete aggressively in this activity, their actions are likely to leave some nontrivial mispricings at least for the types of ETFs where the limits to arbitrage are most significant.

Table II shows some statistics on share creations and redemptions from 1/2007 to 12/2014. I compute the fraction of trading days when each ETF experienced share creations or redemptions, and then I compute the mean and median across all funds. On average, creations or redemptions occurred on 13% of all trading days. However, this measure is skewed by many small funds with little or no activity, as the median fund has such activity only on 6% of days.

The other columns in the table are all conditional on creations or redemptions taking place that day. The median number of shares created or redeemed was 100,000, which is a common size for one or two creation units, while the mean was 257,000 shares. The median dollar value of these transactions was $3.4 million, whereas the mean was again higher at $11.2 million. As a fraction of a fund's total assets, the median transaction accounted for 5%, while the mean accounted for 22%. Relative to the daily

[5] These fees represent the maximum possible cost for an authorized participant. If the actual transaction costs are lower, the authorized participant will typically have to pay only the smaller amount. If transaction costs are expected to be higher than these maximum amounts e.g. during a temporary lack of liquidity in the underlying market, the fund sponsor may refuse cash creations altogether.

ETF trading volume, these are much larger fractions, with the median and mean creation or redemption transaction accounting for 310% and 3,087% of daily volume, respectively.

Economically, these numbers indicate that the size of a creation unit is indeed large for a typical ETF. Even if an arbitrageur participates in every single trade in a fund and always on the same side, in most funds it would still need several days to accumulate a position that would be large enough to offset the creation or redemption of a single creation unit. This introduces timing risk which makes it harder to arbitrage small mispricings by using the ETF share creation and redemption process, thus making it less surprising if prices do not closely track NAVs for many funds. The fund categories most affected by infrequent creations and redemptions are the ones with the most difficult-to-trade underlying assets, including international equities (where differences in trading hours introduce timing risk even when the underlying assets are actively traded in each market within those hours) as well as corporate and muni bonds, whereas funds holding U.S. equities and U.S. government bonds experience more creation and redemption activity on average.

The bottom two panels of the table show the same statistics across funds sorted into quintiles by market cap and trading volume. The larger and more traded ETFs have much more frequent creations and redemptions. In spite of the larger size of creations for larger funds, such creations account for a much smaller fraction of daily trading volume, which makes arbitrage activity easier and more frequent in these funds. In contrast, creations for small and less liquid funds are often driven by investor flows, where a long-term investor buys the creation basket (which may have more liquidity) and works with the ETF sponsor's capital markets desk to immediately convert the basket into new ETF shares.

III. ETF Premiums Relative to NAVs

A. Sample and Methodology

I define the ETF price premium as the percentage deviation of the ETF price (closing midquote) from the NAV. For simplicity I call it a premium even if it is negative, i.e., when the ETF is trading at a discount. I weed out a handful of premiums greater than 20% in absolute value, as they are all due to data errors, but in general my data sources seem relatively clean.[6]

I focus on the premiums in the last eight years of the data, from 1/2007 to 12/2014, thus excluding the pre-2007 period, for two reasons. First, due to the dramatic growth of the ETF industry in the more recent years (see Figure 2), this is the only way I can get a broad cross-section of funds for the entire period. Second, it would be questionable to assume that the pricing of ETFs has not changed in any way while the business has undergone such an explosive period of growth, so the early years of the ETF market may not be informative about the current state of ETF pricing. Table III shows the ETF sample in the first columns. I have a cumulative total of 1,813 funds (including dead funds) over the sample period, with $1,969 billion in assets at the last available date of each fund. I have NAV data for 1,670 funds, extending across multiple fund families. The largest categories are equity funds, with $905 billion in diversified U.S. equity funds, $273 billion in sector funds, and $380 billion in international funds. Bond funds collectively have about $304 billion. Inverse ETFs are in the "Bear Market" category with $13 billion. Commodity funds have $51 billion, most of it in precious metals funds, particularly gold. The categories are from Morningstar, and they only apply to live funds, so dead funds are placed in their own category.[7]

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[6] In CRSP, I find 5 data points (out of about 600,000) where the daily ETF price is off by a nontrivial amount, and OpenTick has about 20 such data points. I cannot find similar errors in the iShares data. The cutoff cannot be set much lower than 20% because there are several legitimate data points where the premium is greater than 10%.

[7] Actually there are 1,435 live funds and 378 dead funds by 12/2014. Out of the dead funds, 100 died before my first Morningstar data snapshot in 3/2010, so they are placed in the "Dead before 2010" category; the

The statistics on the ETF premiums are computed as follows. First I calculate the average level and time-series volatility of the premium for each fund. Then I average across funds within each category to get the average premium and the average volatility of the premium. To compute value-weighted averages, I weight each fund by its average market capitalization over the time period.

B. Estimates of Premiums

The average premium is only 6 bp, which indicates that the typical fund is neither underpriced nor overpriced. However, the time-series volatility of that premium is 49 bp, which indicates that ETF prices fluctuate considerably around NAVs even if the average level is correct. The value-weighted average volatility is comparable at 40 bp, so the result is not limited to smaller funds.

Economically, the equal-weighted number tells us that the typical fund is trading in a range from -96 bp to +96 bp around its NAV with a 95% probability. Given that some funds are competing for cost-conscious investors by shaving a few basis points off their fees to bring them even below 10 bp per year, there is a risk that some investors are simultaneously overlooking a potentially much bigger cost due to an adverse premium on the transaction price. Conversely, transacting at an attractive price can offset the cost of investing in a higher-fee ETF.

The smallest premiums exist in diversified U.S. equities, U.S. government bonds, and shortest-maturity bonds in general. At the other end of the spectrum, international equities, international bonds, and illiquid U.S.-traded securities such as municipal bonds and high-yield bonds exhibit volatilities of up to 144 bp, which translates to a 95% confidence interval of almost 6%. This is qualitatively consistent with the limits to arbitrage hypothesis, since the securities with the highest transaction costs and the least transparent (and most stale) NAVs have the most volatile premiums. But can these

remaining 278 funds that died later during 2010-2014 have category data and thus are placed in the appropriate categories among live funds. The NAV data cover essentially all live funds (1,432 out of 1,435) and a majority of dead funds (238 out of 378).

costs really explain the entire magnitude of the premiums? One piece of evidence comes from sector funds: some sectors like real estate, technology, health care, and financials mostly contain U.S.-focused funds, which have liquid and transparent holdings, and yet these categories have premium volatilities up to 40 bp, which cannot be explained by stale pricing. For more general evidence we have to deal with the stale pricing issue directly, which is what I do in Section IV.

To give some idea of transaction costs in the ETFs themselves, the last two columns in the table show their bid-ask spreads. The equal-weighted average is 39 bp while the value-weighted average is only 5 bp, indicating the tremendous trading activity the larger ETFs have generated. The value-weighted numbers show the lowest bid-ask spreads of 2-5 bp for diversified U.S. equity funds, U.S. government bonds, and commodities, and 5-10 bp for most other categories with at least $1 billion in assets.

The column labeled "VW min" shows the value-weighted volatility of the premium controlling for the bid-ask spread. I set the price of the ETF between the bid and the ask price to minimize the absolute value of the premium, effectively assuming the market is maximally efficient within the bid-ask spread. By construction, the volatility of the premium goes down with such an extreme assumption, but only from 40 bp to 36 bp for value-weighted results.[8] Hence, transaction costs in ETF shares are unlikely to explain the premiums. This should perhaps not be surprising, given that the most liquid and actively traded securities in the equity market in recent years have in fact been ETFs.

How persistent are the premiums? I also compute autocorrelations of the premium for all categories of funds (not shown). The equal-weighted daily autocorrelation is only 0.30 across all funds, and the average half-life of the premium is 0.58 days. Hence, premiums relative to NAV are short-lived, which is perhaps what one might expect at least when the underlying assets have different trading hours than the

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[8] Since the value-weighted spreads are tighter than the equal-weighted spreads, the value-weighted results are more informative about potentially inefficient pricing in this case where we allow the "true" price to be anywhere within the spread.

ETF. Equity funds have premium half-lives of around 0.5 days, whereas non-Treasury bond funds have half-lives of 2-3 days.

Finally, premiums like the ones I compute here from closing midquote prices can potentially understate the true premiums paid by investors, even when NAVs are not stale.[9] ETF prospectuses are required by the SEC to disclose historical premiums computed from closing midquotes. This creates potential incentives for ETF providers to try to influence the closing quotes to get the midpoint more closely aligned with NAV. However, the actual price in the closing auction can differ from the midquote and does not get recorded in ETF prospectuses. Petajisto (2011) reports that premium volatility computed from closing prices, only including cases where actual transactions occurred within 15 minutes of market close, is indeed slightly higher: the averages are 53bp vs 49bp on an equal-weighted basis and 45bp vs. 43bp on a value-weighted basis in 2009-2010. Hence, investors should view the premiums reported in this paper as a lower bound, and in reality they may end up transacting at slightly more volatile premiums.

C. Premiums and Share Creations

Any material positive premium in an ETF can be exploited by a market maker (authorized participant) who sells shares in the market and then transacts with the ETF to create a corresponding number of creation units of shares at NAV, and vice versa for negative premiums. What do historical data suggest about how ETF market makers actually respond to premiums?

Table IV shows share creations on day t as a function of lagged end-of-day premium, with redemptions counted as negative creations. Creations are expressed as a fraction of the average daily trading volume during the same month. Standard errors are computed with double-clustered standard errors across both funds and time, and t-statistics based on them are reported in parentheses. This takes into account persistent fund-specific effects where one fund is trading at a persistent premium, e.g. due to strong

[9] I thank an anonymous referee for pointing this out.

inflows combined with illiquid underlying assets, and it also allows premiums to be correlated across similar funds within the same time period.

I find that past premiums positively predict future share creations up to about 10 daily lags (two weeks), with the strongest effect coming from the prior two days. A one-day premium of 1% on a fund would lead to a 4.9% increase in shares outstanding relative to the daily trading volume, and a more persistent one-week premium of 1% would increase shares outstanding by 8% of daily volume. The effect is statistically highly significant. This indicates that market makers indeed respond to nonzero premiums within 1-10 days by creating or redeeming ETF shares.

Within style categories, the coefficients are about twice as large for U.S. diversified equity funds, perhaps reflecting their more accurate NAV data. However, the accuracy of NAV data alone cannot explain differences across categories, because international bond funds have an even larger coefficient and international equity funds are about average. The significance of the results is very similar if I scale share creations by shares outstanding instead of average trading volume, or if I only include funds above $100M in assets.

Panel A of Table V shows how premiums respond to share creations and redemptions. Creations and redemptions in the same day immediately affect the premium, although by only a small amount: if a market maker creates enough new shares to match the daily trading volume (as we saw in Table II, the median creation is actually 3.1 times daily ETF volume), that reduces the premium by about 1 bp by the close of trading, which is statistically significant. Over the following two days, creations continue to reduce the premium by another 1 bp or so; subsequently they have no statistically significant effect on the premium. This suggests that market makers offload their newly created ETF shares in the secondary market immediately before and after the creation process, and thus the price pressure from the new shares arises contemporaneously within about one day of share creation. However, the relatively small size of the effect suggests that shares are created and redeemed for other reasons besides arbitrage: in particular, sometimes large investors trade directly in the underlying securities if the expected price impact there is less than in the ETF market, and in such cases the newly created or redeemed shares would not be traded at all in the secondary market and thus would not affect the premium on the ETF.

Panel B of Table V shows the long-term relationship between creations and the level of the premium. Creations in the prior three days all very significantly predict the level of the premium. In fact, the cumulative creations over the prior one, three, and six months all significantly predict the level of the premium. One explanation for this persistence in creations and premiums is that funds experiencing steady inflows trade at a premium; presumably investor demand pushes the ETF price to a premium, which then incentivizes market makers to create more ETF shares, but not so aggressively that they would eliminate the premium that is generating their own arbitrage profits. Similarly, the reason an ETF is shrinking is that a market maker is redeeming shares, which is a profitable trade only when it has first purchased those ETF shares in the public market at a discount.

IV. ETF Premiums Relative to Peer Groups

A. Methodology

To resolve the issue with staleness in published NAVs, Engle and Sarkar (2006) propose three econometric models that allow them to estimate the true NAV. This is certainly a reasonable approach, but such models always require assumptions about the price processes involved. In contrast, I use the information in the cross-section of ETFs, many of which track identical or nearly identical indices. Compared to earlier authors, I have the luxury of working with a much bigger cross-sectional sample of funds which makes my approach feasible.

I start by sorting ETFs into groups of similar funds, with each group having up to thirteen funds. For example, if a group has five funds that all track the MSCI EAFE index, the funds within the group should move very closely together, regardless of any staleness in their published NAVs. If four of the funds are up 1% and the fifth one is flat, it is likely that the fifth fund is now underpriced and will eventually rise back to the same level with its peers. I compute the deviation of each fund from its peer group mean, and I consider this the premium on the fund. This methodology captures any idiosyncratic mispricings on ETFs, but it does not capture a possible systematic mispricing for an entire fund group. It also may add some noise to the premium volatility if funds within a peer group track similar but not identical indices or if two funds within a group differ slightly in terms of how closely their portfolios replicate the index.

I include inverse ("Bear Market") and leveraged ETFs with regular ETFs that track the same indices, which requires me to de-lever their returns to get comparable return series where all funds have index betas equal to one. The de-levered fund return R_{del} can be written as a function of the levered fund return R_{lev}, leverage β, and risk-free return R_f:

$$R_{del} = R_f + \frac{R_{lev} - R_f}{\beta}. \tag{1}$$

To reduce the impact of the smallest funds on the results, I eliminate funds below \$10 million in assets, as well as funds with daily trading volume less than \$0.1 million. This reduces my sample size from 1,813 to 1,423 funds in 2007-2014. However, another 837 funds are dropped because I cannot find close enough substitutes for them (funds tracking the same or very highly correlated index) or because they only briefly exceed the aforementioned liquidity cutoffs, which leaves the total number of qualifying funds at 586. This still covers 87% of all ETF assets, so from an investment perspective the qualifying sample can be considered fairly comprehensive.

B. Estimates of Premiums

Table VI shows the volatility of the estimated price premiums on ETFs across the same Morningstar categories as before. To facilitate comparison, premiums are shown side-by-side using both NAV data and the cross-sectional peer group method because the sample is slightly different so the NAV premiums will not be identical to the ones in Table III. In other word, for both methods in Table VI, premiums will be computed for the same sample size of qualifying funds in peer groups, which also means the average fund is here larger than in Table III. The equal-weighted volatility of premium is now 26 bp, which is 30% lower than the 38 bp estimated from NAV data. The value-weighted volatility falls by around 50%, from 37 bp to 18 bp.

Compared with the NAV results, there are a few offsetting effects here: The premiums should be smaller because this new method is unaffected by staleness in reported NAVs. At the same time, this method can introduce new noise if the ETF groups contain some funds that are not perfect substitutes for each other in terms of their underlying holdings. Fortunately, one can approximate the magnitude of the noise term by comparing the cross-sectional premium volatilities for U.S. equities with the corresponding NAV premium volatilities, because U.S. equities (except perhaps small-caps) are not subject to stale pricing concerns. It turns out that the cross-sectional estimates are about 10 bp higher on an equal-weighted basis but only 2 bp higher on a value-weighted basis, which suggests that the noise due to inappropriate group assignment is rather small. Hence, the numbers in Table VI should be reasonable estimates of idiosyncratic mispricings in ETFs.

The biggest reductions in the volatility of the premium come from illiquid U.S. corporate and long-term muni bonds, international equities and bonds, and precious metals,[10] which are the categories most prone to stale pricing. Nevertheless, there is still nontrivial residual volatility within these ETF groups, with some international equity and bond groups exhibiting volatilities of 50-60 bp, implying 95% pricing bands of over 200 bp. Qualitatively it is not surprising that the harder and riskier the arbitrage for an authorized participant, the greater the mispricings that remain, but quantitatively the mispricings may still be surprisingly large.

It is interesting to note that there is no clear relationship between the secondary-market liquidity of the ETF and its premium volatility. For example, ETFs based on

[10] Precious metals suffer from stale pricing because NAVs are based on spot prices of gold and silver that are determined at 12pm or 3pm local time in London, which is 6-9 hours before the ETF market close at 4pm in New York.

high yield bonds, bank loans, and international equities can be very liquid as measured by low bid-ask spreads (see Table III) but still have fairly large premium volatilities, because the premiums are driven more by the liquidity of the underlying as well as other impediments to the creation/redemption arbitrage. Meanwhile, the ETF may be able to manufacture high secondary market liquidity even from illiquid underlying assets.

The persistence of the premiums goes up when stale NAVs are accounted for. Now the average autocorrelation rises to 0.70, and the average half-life rises to about two days. The differences across broad categories are surprisingly small, but the economic magnitude matters too: a half-life of 2 days for a tiny 2 bp mispricing in an S&P 500 fund is not very interesting, but for a 50 bp mispricing in a European equity fund it is interesting. Also within international equity, the "Foreign Large Blend" funds have a premium half-life of only 1 day, but the Chinese and Indian equity funds have premium half-lives of almost a week.

C. Economic Magnitude of Mispricings

How large are the dollar amounts involved in these mispricings? Panel A in Table VII shows the approximate dollar value of the premiums in actual trades, using both NAV-based premiums and peer-group premiums. I assume all trading takes place at the premium (using the bid-ask midpoint) at the close, which tends to be more efficient than intraday prices throughout the trading day.

The total premiums across all ETF trades add up to roughly \$38 billion per year just for the 586 funds in peer groups, or \$41 billion for all funds with NAV data. This arises partly from heavy trading volume of \$69 billion per day, corresponding to value-weighted ETF turnover of 9% or an average holding period of around two weeks, and partly from an average NAV premium of 22 bp per execution. Even the cross-sectional peer-group premiums add up to \$16 billion per year, which is economically very significant. In addition, the peer groups miss \$11 billion out of the total \$80 billion of daily ETF trading volume. If we assume these excluded funds are similarly mispriced as the funds in peer groups, which is an unrealistically low estimate because they are less liquid and harder to arbitrage, it still means the traded premiums add up to almost $20 billion per year across the entire U.S. ETF market. This is approximately how much investors are paying for suboptimal timing of their ETF trades, and conversely how much investors are earning from liquidity provision.[11] Of course the same investor may unwittingly end up doing both, but given the large amounts involved, the potential losses from trading with the crowd and the gains from smart liquidity provision still highlight the importance of being aware of these issues.

Panel B shows the average absolute market capitalization of premiums at the close. The average NAV premium within the ETF peer groups was slightly over $2 billion out of an average market capitalization of $991 billion. Adjusting for stale pricing with the peer-group method, the average market value of ETF premiums falls to $1 billion. But since the premiums can fluctuate rapidly, the more relevant metric is the dollar value of the premiums involved in actual trades.

D. Evolution of Mispricings over Time

One way to measure the efficiency of ETF prices at any point in time is to compute the cross-sectional standard deviation of ETF premiums. This is shown in Figure 3 as the bottom plot labeled “ETF spread.” In early 2007, the cross-sectional dispersion in premiums starts at about 20-25 bp. It first peaks during the quant crisis of August 2007, but it also generally increases afterwards, rising to 30-150 bp for most of 2008. After reaching its highest peak in September 2008, it declines again and remains at 30-90 bp for most of 2009. Starting in early 2010, the spread has hovered slightly below 30 bp on average, but there have been a number of significant spikes every year, even close to 100 bp or more. The spikes include things like the Flash Crash in May 2010, the U.S. debt downgrade in August 2011, the Taper tantrum of May-June 2013, and a few short-term mini-crashes in 2014. While the dispersion in premiums was widest during the

[11] Furthermore, an investor demanding liquidity may end up paying the bid-ask spread, i.e., buying at the ask and selling at the bid, which is another cost in addition to the ETF midquote being mispriced. Conversely, a patient liquidity provider may be able to earn part of the spread and thus benefit even more.

financial crisis in late 2008, it has remained interesting throughout the last five years of the sample. Going forward, it seems reasonable to assume that the cross-sectional dispersion in premiums will not fall below the present level for at least the next few years.

Why should the dispersion of premiums vary over time? Presumably, it should depend on two things: the trading volume in ETFs as investors move into or out of some funds, which generates price pressure for ETF shares, and the amount of arbitrage capital that is able and willing to accommodate that price pressure. Extreme market movements as indicated by the S&P 500 index and its volatility might serve as proxies for investors rebalancing needs. At the same time, the VIX index may serve as a proxy for the availability of arbitrage capital. Figure 3 suggests a link between the dispersion and the VIX index; interestingly, the wide dispersion in ETF premiums even preceded the extreme volatility in many key events like the quant crisis in August 2007, the Lehman bankruptcy in September 2008, the flash crash in May 2010, and the market jitters in late 2014.

Table VIII measures the relationship between the dispersion in ETF premiums and three different proxies of arbitrage capital: the VIX volatility index, the TED spread, and the average closed-end fund discount. The TED spread is defined as the difference between three-month LIBOR (or Eurodollar) and T-bill rates, which is the premium that a large financial institution would pay for unsecured lending over the true risk-free rate to finance its trading activity (e.g., Brunnermeier, Nagel, and Pedersen (2009)). The closed-end fund discount is computed at the end of each trading day as an equal-weighted average discount relative to NAV across all U.S.-listed closed-end funds. It has been used as a measure of investor sentiment (Baker and Wurgler (2006)), but it is also plausible that some of the same arbitrageurs operate in both ETF and closed-end fund markets, implying a potentially close relationship between the closed-end fund discount and the ETF premiums and discounts.

In Panel A, I find that all three measures are related to ETF premiums. In Panel B, I find that daily changes in each measure similarly explain daily changes in ETF premiums, although with slightly lower statistical significance. The most robust variables are the VIX index and the closed-end fund discount: Ten percentage point increase in VIX increases the dispersion in ETF premiums by 13 bp, and one percentage point increase in the closed-end fund discount increases it by 3 bp in univariate tests. Hence, the funding costs of arbitrageurs and the riskiness of the overall market environment do seem to matter for the efficiency of ETF prices. Furthermore, the efficiency of ETF prices is related to the deviations of closed-end fund values from their NAVs.

E. Profitability of Active Trading Strategies

If ETFs are never mispriced, then any attempt to trade on apparent mispricings will fail to produce a positive alpha even before transaction costs. Hence, the returns to an active trading strategy serve as a convenient summary statistic about the efficiency of market prices. The measurement of the cross-sectional price premium in the previous section naturally lends itself to an active trading strategy: buy funds trading at a discount relative to their peer group and short funds trading at a premium once the gap becomes sufficiently wide. I assume trading once at the end of each day using the bid-ask average price at the close.

Table IX shows the portfolio statistics for the trading strategy using data from 1/2007 to 12/2014. The percentage returns are reported for an "unlevered" portfolio that is \$100 long, \$100 short, and \$100 in cash for every \$100 in capital. The excess return on a strategy involving all U.S.-traded ETFs in my peer groups (above the liquidity cutoffs) is 7.00% (t = 13.14) with a very low volatility of 1.50% per year and a Sharpe ratio of 4.68. Controlling for the Carhart model, we see that the strategy is market neutral: it has zero loadings on market, size, value, and momentum, with a Carhart alpha of 6.84% (t = 13.60) per year and an information ratio of 4.81.

Investigating the trading more closely, I find that the profits tend to come from international funds and illiquid underlying securities, consistent with the results in Table VI, whereas diversified U.S. equities, U.S. Treasury bonds, short-term bonds, and commodities (mostly gold and silver) tend to produce very modest returns. Sector funds are somewhere in the middle, with some sectors priced more efficiently than others. When I drop diversified U.S. equities, Treasury bonds, and commodities,[12] the Carhart alpha rises to 10.33% (t = 14.44) per year, although volatility also rises slightly, while information ratio inches up to 5.10. Excluding also the sector funds, the Carhart alpha rises to 16.19% (t = 13.90) per year, again with a similar information ratio of 4.86. Economically, this means that my simple rule identifies mispriced ETFs that will converge to their fundamental values at a rate of 6.4 bp per day. As most positions are held for longer than a day, this implies that the level of mispricing can rise to a multiple of that.

These returns to active strategies seem extremely attractive. However, a real-life implementation of the strategy may potentially add a few complications: First, there may not be enough trading volume in some ETFs to make the strategy interesting. Second, even when trading volume is sufficiently high, it may occur at different times during the day for different funds, and this nonsynchronicity may introduce the false appearance of profitability. Third, the profits are sensitive to transaction costs, so the execution strategy plays a key role.

To address these concerns, I repeat the calculations with an intraday dataset using five-minute periods from 9:30am to 4:00pm. I construct a real-time signal based on currently observable prices and then trade subsequently based on that, which fully addresses potential issues with nonsynchronous trading. I also recompute trading profits assuming trading at actual transaction prices (five-minute volume-weighted average price) and with a maximum participation rate of 10%. This participation rate constraint on maximum trading volume implies that larger portfolios will be less profitable because there will not be enough volume to allow us to reach our ideal target position in some ETFs. I find that the strategy remains very profitable with intraday trading at actual transaction prices, but the capacity is somewhat limited: for example, the annual

[12] I also drop "Allocation" and "Miscellaneous" groups to keep things simple. However, levered and inverse funds in this case are grouped with their underlying asset class, not as part of the "Miscellaneous" category, so they are included in this trading strategy.

information ratio for a \$100M long-short portfolio falls to about two. Furthermore, the strategy should not be executed aggressively because paying the full bid-ask spread (buying at the ask, selling at the bid) each time would significantly reduce its profitability; instead, it should be run as a passive market-making strategy with constantly updated limit orders, which is feasible since it uses a broad cross-section of hundreds of ETFs, potentially trading in any of them at any point in time. In fact, being a liquidity provider could even enhance the profits of the strategy up to a certain dollar capacity.

Regardless of one's view on the exact level of information ratio after implementation costs, an important implication for market efficiency remains: these trading profits document that the actual prices faced by ETF investors can differ significantly from the true value of the portfolio, thus presenting a potentially large hidden cost for ETF investors.

F. How Investors Should Trade ETFs

The evidence in this paper indicates that trading U.S.-listed ETFs on diversified U.S. equity indices, nominal U.S. Treasury bonds, or precious metals is easy and generally harmless for the average investor. However, trading ETFs with non-Treasury bonds or international securities as the underlying assets does expose the investor to the risk of poor trade timing due to premiums. One approach is to compare the ETF's price to the Intraday Indicative Value (IIV), which is an intraday estimate of the ETF's NAV based on the latest prices of the ETF creation basket and published by the exchange every 15 seconds. However, when the underlying securities have not traded due to illiquidity or time-zone differences, the IIV can also be a stale measure of portfolio value. Some professional investors have developed their own proprietary IIV estimates e.g. using futures prices, and the peer group approach presented in this paper is another good way to check if a particular ETF has in recent days become cheap or expensive relative to its peers. An even simpler approach for longer-term investors is to look at the latest official premiums but trade only when markets have been flat for the last few days, because then even stale NAVs have had a chance to catch up with latest market prices of the underlying portfolio.

V. Conclusions

The dramatic growth of the ETF market since 2006 has brought these investment vehicles to a large fraction of relatively unsophisticated individual investors. It is easy for an investor to fall in the trap of focusing so much on the expense ratios of funds that the transaction price for ETF shares is overlooked. Given that U.S. ETF assets were about $2 trillion and growing in 2014, any nontrivial mispricing in ETFs has the potential to represent a considerable wealth transfer from less sophisticated individual investors to more sophisticated institutional investors.

In this paper I have provided new empirical evidence on the state of market efficiency in ETFs. Funds holding liquid domestic securities are priced relatively efficiently, whereas funds with international or illiquid holdings exhibit nontrivial premiums relative to NAVs, which is qualitatively consistent with the costs and uncertainty faced by arbitrageurs in these funds. More surprisingly, U.S. sector funds holding liquid domestic stocks can also exhibit nontrivial premiums.

I also propose a new approach to detect mispricings on ETFs: instead of comparing ETF prices with NAVs, measure them relative to the current market prices of a peer group of similar funds. This eliminates the problem of stale NAVs. I find that this adjustment reduces the premiums on funds with international or illiquid holdings but still leaves them fluctuating within a pricing band of 100-200 bp, which is economically significant, indicating that nontrivial mispricing remain. This is confirmed by tests that involve the creation of an active trading strategy to exploit these mispricings, as the strategy produces economically substantial profits before transaction costs with a high degree of statistical significance.

ETFs are convenient vehicles to access various market segments and generally come with many virtues such as low expense ratios, low turnover (implying low transaction costs paid by the fund), and high tax efficiency, so they have legitimately earned their place in the market. However, any cost-conscious individual investor should be aware of the potential to transact at a disadvantageous price and how to avoid it so that they can fully capture the benefits of these new investment vehicles.

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Appendix A: Intraday Trading

Figure 4 shows the total trading volume in all ETFs in five-minute periods throughout the day, averaged across all trading days in 2010, which is the last complete year in my intraday sample. ETFs exhibit the same type of clustering as other securities: most of the volume occurs at the beginning and end of the trading day. In the middle of the day, trading intensity is about 30-50% of the value near the beginning and end of day, but it is certainly still at an economically meaningful level. Anecdotal observations suggest that some ETFs tend to search for their efficient prices early in the trading day and then become more efficiently priced toward the close, but this does not seem to hinder overall trading activity in the morning, when trading is essentially just as intense as at the end of the day.

Before November 2008, many ETFs including SPY were trading on AMEX until 4:15pm, or 15 minutes longer than the equity securities on which the index values were based. Since then, exchange trading hours for ETFs have become standardized, starting at 9:30am and ending at 4:00pm EST, which presumably was driven by NYSE's acquisition of AMEX. Fixed-income ETFs still close at a different time than the underlying securities (4:00pm rather than 3:00pm for the bond market), and of course funds based on international securities will always close at different times than their underlying securities.

How liquid are ETFs in general? Figure 5 shows the average daily volume for all ETFs, plotted against their volume-weighted median intraday bid-ask spreads. To capture the liquidity that a typical investor would face, I specifically want to look at intraday spreads and not closing spreads,[13] and I compute the volume-weighted median for each fund to reflect the spreads at the time that actual trades are occurring. I find that all funds with bid-ask spreads below 10 bp also have at least $10M in daily trading volume; conversely, the dozen funds with over $1 billion in daily trading volume all have spreads at or below 10 bp. More surprisingly, among the funds with a median spread of

[13] Closing spreads would be about 20% lower than intraday spreads on average.

about 100 bp or above, there are still several funds with over \$1 million in trading volume; this spread seems rather large, given that these are fully transparent and passively managed investment vehicles. For the average investor, this also highlights the importance of efficient trade execution, especially if they have short average holding periods.

Table I. Sample Statistics of ETFs.

This table shows the cross-sectional distribution of various characteristics of U.S.-listed ETFs for three end-of-year snapshots in 2014, 2010, and 2006. Daily volume and turnover represent the trading by investors in ETF shares, and they are computed as the mean throughout the year. The bid-ask spread of an ETF is computed as the median end-of-day closing spread. Market capitalization is the last available month-end value that year. Fund turnover refers to annual turnover of securities within the ETF's portfolio (thus excluding in-kind creations and redemptions).

			Percentile							
Year	Variable	Mean	Min	5	25	50	75	95	Max	N
2014	Market cap ($M)	1,383	0.1	3.1	20	111	529	5,762	215,916	1,423
	Daily volume ($M)	46	0.0	0.0	0.2	1.2	6	112	21,113	1,435
	Daily turnover (%)	4	0.0	0.3	0.6	1.1	2	15	146	1,432
	Bid-ask spread (bp)	28	1	2	7	15	32	88	711	1,435
	Fund turnover (%)	47	1	4	11	26	52	146	1,335	1,014
	Expenses (bp)	56	4	12	32	50	75	95	701	1,194
2010	Market cap ($M)	1,023	1.2	3.7	20	92	428	4,328	90,965	968
	Daily volume ($M)	71	0.0	0.1	0.3	1.2	7	183	23,792	978
	Daily turnover (%)	6	0.1	0.5	0.9	1.7	4	29	147	977
	Bid-ask spread (bp)	19	1	3	8	14	23	57	453	978
	Fund turnover (%)	51	1	4	12	29	57	169	1,232	720
	Expenses (bp)	55	7	14	35	54	71	95	150	860
2006	Market cap ($M)	1,134	5.0	9.3	29	125	671	4,529	63,725	376
	Daily volume ($M)	72	0.0	0.1	0.4	1.6	9	112	9,160	376
	Daily turnover (%)	4	0.2	0.5	0.9	1.7	4	16	80	350
	Bid-ask spread (bp)	14	1	5	10	13	16	23	153	376

Table II. Share Creation and Redemption Activity.

The first two columns show the percentage of trading days when ETF shares were either created or redeemed by authorized participants transacting directly with the ETF. The next columns show the number of shares (in thousands) in each transaction, and the dollar value corresponding to it, conditional on a creation/redemption transaction taking place. The last columns show the size of the transaction relative to the total ETF shares outstanding and to the average daily trading volume that month. The median is computed first within a fund and then as another median across funds; the mean is similarly computed first within a fund and then across all funds. The time period is from 1/2007 to 12/2014.

Category	% of days		Shares ('000)		Value ($M)		% of all shares		% of volume	
	Mean	Median	Mean	Median	Mean	Median	Mean	Median	Mean	Median
U.S. Equity - Diversified	14	6	273	100	17.6	4.0	22	3	4,727	383
U.S. Equity - Sectors	16	9	244	100	8.9	2.8	15	4	1,987	218
U.S. Bonds - Government	15	9	217	100	16.2	5.2	17	3	1,346	255
U.S. Bonds - General	15	9	201	100	10.7	4.4	16	3	1,477	317
U.S. Bonds - Munis	8	5	124	100	4.6	2.5	12	3	3,584	512
International Equity	9	5	306	100	10.7	3.5	22	5	2,934	369
International Bonds	9	3	197	100	8.9	5.1	20	5	9,772	461
Allocation	6	3	763	50	15.2	1.7	68	13	13,327	890
Commodities	13	9	349	100	14.2	4.5	18	4	1,436	173
Miscellaneous	12	6	156	50	7.5	3.3	27	11	1,522	227
All	13	6	257	100	11.2	3.4	22	5	3,087	310

Fund size quintile	% of days		Shares ('000)		Value ($M)		% of all shares		% of volume	
	Mean	Median	Mean	Median	Mean	Median	Mean	Median	Mean	Median
Large	35	29	606	200	32.0	10.3	4	1	141	56
4	15	13	228	100	8.7	4.7	8	2	464	174
3	8	6	241	100	7.5	2.8	20	5	2,376	351
2	4	3	102	50	3.7	2.3	29	14	3,740	751
Small	1	1	70	50	2.2	1.5	52	50	9,947	1,559
All	13	6	257	100	11.2	3.4	22	5	3,087	310

Trading volume quintile	% of days		Shares ('000)		Value ($M)		% of all shares		% of volume	
	Mean	Median	Mean	Median	Mean	Median	Mean	Median	Mean	Median
Large	35	29	588	200	30.9	9.6	6	1	135	41
4	14	12	202	100	7.7	4.2	9	2	466	162
3	7	6	168	100	5.5	2.6	19	5	1,747	379
2	3	2	161	50	4.9	2.2	36	17	5,339	829
Small	1	1	83	50	2.7	1.9	52	50	11,092	2,148
All	13	6	257	100	11.2	3.4	22	5	3,087	310

Table III. ETF Price Premiums (and Discounts) Relative to NAV.

For all ETFs traded in the U.S., this table shows the number of ETFs and their last available market capitalization within each investment category. For the ETFs with available data on net asset values (NAVs), the table shows the equal-weighted average premium (or discount) of the ETF price relative to its NAV, as well as the equal-weighted and value-weighted time-series volatility of the premium. The market price is taken as the bid-ask average at the end of each trading day. Instead, the "VW min" column assumes the market price is any price within the bid and ask so that the distance to the NAV is minimized. The bid-ask spread is the cross-sectional average of the time-series median bid-ask spread for each ETF. The time period is 1/2007 to 12/2014. The premium and the bid-ask spread are expressed in basis points.

Category	Market	Number of funds		Average	Volatility of premium			Bid-Ask spread	
	cap ($M)	All	NAV	premium	EW	VW	VW min	EW	VW
U.S. Equity - Diversified	904,995	301	296	0	18	9	7	18	3
Large Blend	454,381	71	68	1	20	9	7	17	2
Large Growth	110,506	39	38	-1	20	8	6	19	3
Large Value	123,356	56	56	2	15	11	7	18	4
Mid-Cap Blend	70,995	29	29	-1	23	9	7	15	3
Mid-Cap Growth	16,693	19	18	2	26	10	6	16	6
Mid-Cap Value	35,209	23	23	1	14	10	7	15	5
Small Blend	62,292	28	28	0	15	11	9	19	3
Small Growth	14,622	17	17	-1	21	11	7	20	5
Small Value	16,941	19	19	0	12	12	8	19	6
All Equity - Sectors	273,067	343	328	2	42	19	15	32	7
Communications	2,153	14	12	2	47	25	18	40	12
Consumer Cyclical	19,222	23	22	-3	39	14	8	25	6
Consumer Defensive	16,651	17	17	3	40	13	8	38	6
Energy	22,549	33	32	1	36	13	10	32	5
Financial	36,706	42	41	3	41	25	21	31	7
Health	40,180	32	30	3	30	11	7	27	7
Industrials	17,210	29	29	-2	43	13	8	33	7
Miscellaneous Sector	4,770	24	24	1	51	44	31	28	18
Natural Resources	14,146	42	42	4	53	28	22	37	10
Precious Metals	7,378	10	10	18	62	39	37	51	6
Real Estate	43,117	18	18	2	34	21	17	19	4
Technology	36,051	43	36	1	38	11	7	35	7
Utilities	12,935	16	15	-1	36	10	6	36	5
U.S. Bonds - Government	52,556	42	42	4	17	16	14	12	3
Short Government	12,650	12	12	0	20	4	3	13	1
Intermediate Government	5,319	8	8	6	13	9	6	10	5
Long Government	15,116	10	10	7	21	17	15	14	3
Inflation-Protected Bond	19,471	12	12	6	13	24	22	9	4
U.S. Bonds - General	219,342	120	120	20	41	55	50	24	5
Ultrashort Bond	9,655	8	8	1	24	13	8	6	2
Short-Term Bond	40,639	15	15	29	28	45	42	15	3
Intermediate-Term Bond	68,087	16	16	8	45	32	28	23	3
Long-Term Bond	2,084	5	5	-5	55	48	42	22	13
Corporate Bond	37,710	33	33	31	42	70	66	29	6
High Yield Bond	34,494	19	19	31	43	98	92	14	4
Convertibles	2,860	2	2	6	61	70	36	101	13
Preferred Stock	16,461	10	10	16	47	63	51	27	8
Bank Loan	6,792	4	4	13	24	30	27	8	5
Nontraditional Bond	560	8	8	-2	57	38	23	56	38
U.S. Bonds - Munis	14,184	33	33	5	64	60	51	23	11
Muni Short	4,110	13	13	14	41	37	29	20	10
Muni Intermediate	5,828	8	8	19	84	71	62	26	10
Muni Long	2,359	9	9	-14	68	50	42	29	12
High Yield Muni	1,886	3	3	-17	95	116	102	14	12

Table III (continued).

Category	Market cap ($M)	Number of funds All	Number of funds NAV	Average premium	Volatility of premium EW	Volatility of premium VW	Volatility of premium VW min	Bid-Ask spread EW	Bid-Ask spread VW
International Equity	379,613	351	345	20	87	84	78	57	6
World Stock	17,574	22	22	19	62	49	38	37	11
Foreign Large Blend	109,051	28	27	27	59	71	67	35	4
Foreign Large Growth	1,991	6	5	15	59	87	76	39	11
Foreign Large Value	11,295	24	22	29	80	89	75	38	15
Foreign Small/Mid Blend	6,820	8	8	37	78	89	70	24	13
Foreign Small/Mid Growth		1	1	-1	24	24	12	30	30
Foreign Small/Mid Value	1,104	6	6	22	80	94	81	37	20
Latin America Stock	4,976	17	16	18	78	75	71	49	4
Europe Stock	32,847	15	14	29	87	62	55	31	9
Diversified Pacific/Asia	2,646	4	4	-4	89	30	23	404	15
Miscellaneous Region	29,061	77	77	16	91	105	98	88	9
Japan Stock	27,700	19	19	13	122	129	122	31	12
China Region	16,683	34	34	22	115	144	133	38	6
India Equity	3,804	7	7	17	107	119	112	26	10
Pacific/Asia ex-Japan Stk	6,870	13	13	12	92	116	106	42	8
Diversified Emerging Mkts	96,945	59	59	22	81	75	72	70	4
Global Real Estate	10,245	11	11	25	85	82	71	26	13
International Bonds	18,293	44	41	4	75	75	64	47	13
World Bond	7,986	25	25	-13	70	48	40	52	16
Emerging Markets Bond	10,307	19	16	31	83	94	81	40	10
Allocation	3,852	43	43	-11	67	42	22	51	26
Conservative Allocation	1,204	4	4	-40	99	36	13	45	14
Moderate Allocation	1,404	4	4	11	36	17	5	40	15
Aggressive Allocation	430	4	4	6	70	66	18	40	22
Target Date	116	14	14	-37	92	141	104	59	82
World Allocation	642	11	11	18	49	35	23	51	30
Tactical Allocation	56	6	6	-7	35	21	10	49	28
Commodities	51,159	45	45	1	98	98	94	43	4
Agriculture	1,197	7	7	-42	127	114	109	104	5
Broad Basket	6,014	6	6	17	55	107	101	15	7
Energy	2,492	11	11	9	82	114	59	16	7
Industrial Metals	224	3	3	-14	158	229	220	41	16
Precious Metals	41,232	18	18	9	102	94	94	45	3
Miscellaneous	51,469	491	377	1	39	35	21	50	8
Currency	2,691	23	23	0	53	45	40	24	7
Long-Short	620	11	10	4	102	34	23	40	24
Market Neutral	172	11	11	-11	51	34	17	56	33
Multialternative	1,658	3	3	5	15	18	7	15	14
Trading-Miscellaneous	1,093	11	11	-4	26	17	6	33	7
Volatility	992	4	4	-1	112	132	135	11	11
Managed Futures	213	2	2	24	62	15	9	32	16
Energy Limited Partnersh	9,897	8	8	8	18	8	5	23	8
Leveraged	16,618	81	81	-2	38	47	26	24	9
Bear Market	12,815	112	110	-2	33	33	17	27	6
(Dead before 2010)	5	100	0	0	0	0	0	121	0
(Inception in 2H2014)	4,418	110	109	9	32	19	13	26	16
(Unmatched)	278	15	5	-73	151	91	69	152	32
All	1,968,530	1813	1670	6	49	40	36	39	5

Table IV. Creations and Redemptions as a Function of Lagged ETF Premium.

The dependent variable is daily ETF shares created or redeemed, expressed as a fraction of the average daily trading volume of the ETF. The independent variables represent the premium (in percent) of the ETF price (closing bid-ask midpoint) over the NAV; a premium over multiple days is expressed as the sum of daily premiums (e.g., sum of five daily premiums from t-15 to t-11). The *t*-statistics (in parenthesis) are based on double-clustered standard errors across funds and time. The time period is from 1/2007 to 12/2014.

	(1)	(2)	(3)	(4)	(5)
Premium: t-1	0.0493***	0.0325***	0.0217***	0.0207***	0.0216***
	(12.17)	(9.46)	(8.58)	(9.76)	(10.52)
Premium: t-2		0.0348***	0.0225***	0.0213***	0.0222***
		(10.16)	(9.77)	(11.21)	(12.17)
Premium: t-5 to t-3			0.0131***	0.0116***	0.0123***
			(6.80)	(9.62)	(11.66)
Premium: t-10 to t-6				0.0021*	0.0032***
				(1.87)	(4.18)
Premium: t-15 to t-11					-0.0020**
					(-2.49)
N	1,842,629	1,840,087	1,833,016	1,821,317	1,808,922
R^2	0.4%	0.5%	0.6%	0.7%	0.7%

note: *** p<0.01, ** p<0.05, * p<0.1

Table V. ETF Premium as a Function of Lagged Creations and Redemptions.

The dependent variable in Panel A is the daily change in premium (in percent) of the ETF price (closing bid-ask midpoint) over the NAV, and in Panel B it is the level of the premium. The independent variables are the ETF shares created or redeemed in the previous three days, expressed as a fraction of the average daily trading volume of the ETF, as well as the cumulative ETF shares created or redeemed in the previous six months, expressed as a fraction of a fund's shares outstanding. The *t*-statistics (in parenthesis) are based on double-clustered standard errors across funds and time. The time period is from 1/2007 to 12/2014.

Panel A: Change in premium from t-1 to t				
	(1)	(2)	(3)	(3)
Creations: t	-0.0103***	-0.0101***	-0.0100***	-0.0099***
	(-6.61)	(-6.58)	(-6.61)	(-6.61)
Creations: t-1		-0.0047***	-0.0046***	-0.0044***
		(-3.64)	(-3.61)	(-3.55)
Creations: t-2			-0.0026**	-0.0025**
			(-2.16)	(-2.12)
Creations: t-3				-0.0021*
				(-1.84)
N	1,841,318	1,838,621	1,835,945	1,833,303
R^2	0.0%	0.0%	0.0%	0.0%

Panel B: Level of premium at time t				
	(1)	(2)	(3)	(3)
Creations: t-1	0.0598***	0.0432***	0.0436***	0.0436***
	(20.74)	(18.11)	(18.40)	(18.33)
Creations: t-2	0.0563***	0.0403***	0.0403***	0.0404***
	(20.54)	(18.03)	(18.24)	(18.18)
Creations: t-3	0.0532***	0.0373***	0.0372***	0.0372***
	(20.53)	(17.63)	(17.87)	(17.91)
Creations: prior 1 mo		0.3046***	0.1457***	0.1590***
		(16.99)	(11.09)	(11.37)
Creations: prior 3 mos			0.0845***	0.0466***
			(12.26)	(6.57)
Creations: prior 6 mos				0.0222***
				(7.25)
N	1,835,178	1,819,207	1,771,856	1,701,115
R^2	0.6%	1.2%	1.4%	1.4%

note: *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table VI. Cross-sectional Volatility of Premiums on ETFs.

For all ETFs traded in the U.S., this table shows the number of ETFs and their last available market capitalization within each investment category. From this sample, funds are further assigned to peer groups of 2-13 funds tracking the same or very similar underlying index. For the funds that have a close match and therefore have been assigned to groups, the table shows the equal-weighted ("E group") and value-weighted ("V group") volatility of the deviation of the fund price from its group mean, averaged across funds within a category. For comparison, the volatility of the NAV premium for the same fund-dates is shown in adjacent columns ("E NAV" and "V NAV"). The market price is taken as the bid-ask average at the end of each trading day. The time period is 1/2007 to 12/2014. The volatility of premium is expressed in basis points.

Category	Market Cap		Number of funds		Volatility of premium			
	All ($M)	Groups ($M)	All	In groups	E NAV	E group	V NAV	V group
U.S. Equity - Diversified	904,995	846,478	301	128	12	22	9	12
Large Blend	454,381	445,912	71	33	13	22	9	9
Large Growth	110,506	103,306	39	13	12	17	7	9
Large Value	123,356	111,660	56	27	10	24	9	20
Mid-Cap Blend	70,995	64,348	29	13	10	18	9	9
Mid-Cap Growth	16,693	13,867	19	6	8	15	8	14
Mid-Cap Value	35,209	16,493	23	8	10	33	9	37
Small Blend	62,292	60,393	28	13	16	23	12	14
Small Growth	14,622	14,154	17	7	9	18	11	18
Small Value	16,941	16,345	19	8	13	26	13	26
All Equity - Sectors	273,067	216,895	343	90	18	35	14	29
Communications	2,153	1,354	14	4	57	35	22	26
Consumer Cyclical	19,222	11,949	23	4	8	12	10	17
Consumer Defensive	16,651	13,073	17	3	9	9	9	10
Energy	22,549	18,130	33	7	6	18	9	21
Financial	36,706	27,812	42	9	18	46	24	42
Health	40,180	30,077	32	13	13	32	8	26
Industrials	17,210	15,596	29	8	7	33	8	28
Miscellaneous Sector	4,770	2,838	24	6	52	76	51	72
Natural Resources	14,146	4,980	42	7	15	27	9	23
Precious Metals	7,378	7,135	10	4	53	51	39	50
Real Estate	43,117	41,276	18	9	14	24	21	22
Technology	36,051	30,886	43	11	8	50	8	39
Utilities	12,935	11,790	16	5	6	21	7	21
U.S. Bonds - Government	52,556	45,840	42	25	11	15	15	6
Short Government	12,650	9,482	12	4	2	2	2	1
Intermediate Government	5,319	5,058	8	7	9	9	8	8
Long Government	15,116	14,516	10	7	16	38	16	8
Inflation-Protected Bond	19,471	16,784	12	7	13	5	23	7
U.S. Bonds - General	219,342	183,110	120	50	39	25	52	27
Ultrashort Bond	9,655	0	8	0				
Short-Term Bond	40,639	23,869	15	3	15	11	16	11
Intermediate-Term Bond	68,087	65,511	16	10	29	15	33	16
Long-Term Bond	2,084	2,084	5	5	53	26	40	22
Corporate Bond	37,710	36,398	33	18	38	24	68	34
High Yield Bond	34,494	33,137	19	8	48	26	99	36
Convertibles	2,860	0	2	0				
Preferred Stock	16,461	15,521	10	3	83	86	68	73
Bank Loan	6,792	6,591	4	3	17	12	18	13
Nontraditional Bond	560	0	8	0				
U.S. Bonds - Munis	14,184	11,225	33	20	72	39	70	39
Muni Short	4,110	1,611	13	6	40	24	56	25
Muni Intermediate	5,828	5,489	8	4	95	58	74	47
Muni Long	2,359	2,320	9	8	74	44	50	38
High Yield Muni	1,886	1,804	3	2	113	28	96	28

Table VI (continued).

Category	Market Cap		Number of funds		Volatility of premium			
	All ($M)	Groups ($M)	All	In groups	E NAV	E group	V NAV	V group
International Equity	379,613	307,861	351	107	83	38	82	24
World Stock	17,574	15,365	22	8	49	40	47	39
Foreign Large Blend	109,051	104,875	28	13	56	26	72	13
Foreign Large Growth	1,991	0	6	0				
Foreign Large Value	11,295	5,226	24	10	71	31	88	39
Foreign Small/Mid Blend	6,820	4,712	8	5	87	50	98	45
Foreign Small/Mid Growth			1	0				
Foreign Small/Mid Value	1,104	0	6	0				
Latin America Stock	4,976	4,786	17	4	49	24	66	8
Europe Stock	32,847	25,373	15	5	76	51	53	28
Diversified Pacific/Asia	2,646	0	4	0				
Miscellaneous Region	29,061	5,682	77	18	94	44	113	48
Japan Stock	27,700	27,518	19	10	118	33	120	28
China Region	16,683	9,767	34	9	115	49	158	51
India Equity	3,804	2,668	7	2	117	51	125	56
Pacific/Asia ex-Japan Stk	6,870	6,463	13	6	98	44	108	41
Diversified Emerging Mkts	96,945	86,396	59	11	85	35	76	23
Global Real Estate	10,245	9,028	11	6	57	29	62	31
International Bonds	18,293	9,249	44	8	75	42	108	62
World Bond	7,986	507	25	2	36	29	36	29
Emerging Markets Bond	10,307	8,741	19	6	88	46	111	63
Allocation	3,852	631	43	9	59	36	48	33
Conservative Allocation	1,204	553	4	2	18	23	18	23
Moderate Allocation	1,404	0	4	0				
Aggressive Allocation	430	0	4	0				
Target Date	116	78	14	7	71	40	90	46
World Allocation	642	0	11	0				
Tactical Allocation	56	0	6	0				
Commodities	51,159	41,526	45	9	86	35	92	9
Agriculture	1,197	0	7	0				
Broad Basket	6,014	0	6	0				
Energy	2,492	1,946	11	3	44	83	37	75
Industrial Metals	224	0	3	0				
Precious Metals	41,232	39,580	18	6	107	11	94	5
Miscellaneous	51,469	41,264	491	140	33	14	33	13
Currency	2,691	1,538	23	4	24	9	18	10
Long-Short	620	0	11	0				
Market Neutral	172	0	11	0				
Multialternative	1,658	0	3	0				
Trading-Miscellaneous	1,093	1,053	11	4	10	4	8	3
Volatility	992	458	4	2	130	16	141	16
Managed Futures	213	0	2	0				
Energy Limited Partnership	9,897	9,402	8	3	11	18	8	16
Leveraged	16,618	16,253	81	59	34	16	46	16
Bear Market	12,815	12,560	112	67	31	14	33	11
(Dead before 2010)	5	0	100	1		9		
(Inception in 2H2014)	4,418	0	110	0				
(Unmatched)	278	0	15	0				
All	1,968,530	1,704,080	1813	586	38	26	37	18

Table VII. Dollar Premiums on ETFs: Trading Volume and Market Capitalization.

All ETFs traded in the U.S. ("All") are assigned to peer groups of 2-13 funds tracking the same or very similar underlying index ("In groups"). For the funds that have a close match and therefore have been assigned to groups, Panel A shows the value-weighted average daily turnover of ETF shares, total average daily dollar trading volume, and total absolute dollar premium involved in actual trades each year. The total traded premium is computed using either the official price premium relative to NAV for all funds ("All NAV"), premium relative to NAV for only funds in groups ("Grp NAV"), and the peer-group adjusted price premium for funds in groups ("Group"). Panel B shows the sum of average market cap across funds and the total absolute average dollar premium, where the latter is computed again using either the NAV premium for all funds, NAV premium for in-group funds, and peer-group adjusted premium. The time period is 1/2007 to 12/2014.

Panel A: Historical ETF premium in actual trades

Category	Number of funds		Turnover (%)		Volume ($M/day)		Traded premium ($M/yr)		
	All	In groups	All	In groups	All	In groups	All NAV	Grp NAV	Group
U.S. Equity - Diversified	296	128	12	12	38,269	38,026	5,284	5,232	3,373
All Equity - Sectors	328	90	10	9	11,224	7,891	2,491	2,118	4,871
U.S. Bonds - Government	42	25	3	3	1,225	1,162	445	437	128
U.S. Bonds - General	120	50	1	1	1,352	1,127	1,117	1,033	456
U.S. Bonds - Munis	33	20	1	1	69	53	77	71	33
International Equity	345	107	4	4	8,982	7,833	17,274	15,138	2,939
International Bonds	41	8	1	1	155	87	170	104	39
Allocation	43	9	2	1	20	3	10	1	1
Commodities	45	9	4	4	2,693	2,525	5,836	5,654	845
Miscellaneous	377	140	26	28	16,038	10,393	8,658	8,454	3,745
Leveraged	81	59	44	45	4,350	4,303	3,217	3,176	1,341
Bear Market	110	67	29	30	5,502	5,480	4,085	4,070	2,288
All	1670	586	8	9	80,026	69,100	41,361	38,243	16,431

Panel B: Historical market capitalization of ETF premium

Category	Number of funds		Market cap ($M)		Premium cap ($M)		
	All	In groups	All	In groups	All NAV	Grp NAV	Group
U.S. Equity - Diversified	296	128	441,869	414,093	158	143	246
All Equity - Sectors	328	90	143,244	103,435	113	59	194
U.S. Bonds - Government	42	25	43,977	39,277	39	37	15
U.S. Bonds - General	120	50	126,305	106,390	318	291	139
U.S. Bonds - Munis	33	20	8,335	6,322	27	25	12
International Equity	345	107	266,515	217,900	1,401	1,137	314
International Bonds	41	8	12,999	5,929	50	26	10
Allocation	43	9	2,185	406	5	1	1
Commodities	45	9	69,757	58,391	389	350	33
Miscellaneous	377	140	48,238	39,258	94	74	33
Leveraged	81	59	12,046	11,671	31	30	10
Bear Market	110	67	17,728	17,283	35	34	12
All	1670	586	1,163,424	991,402	2,594	2,143	998

Table VIII. Cross-sectional Dispersion of Premium and Limits of Arbitrage.

The dependent variable in Panel A is the cross-sectional standard deviation of the premium across all large ETFs at the end of each trading day. Large funds are defined as having at least $100 million in assets. The premium is computed relative to a peer group mean to eliminate any effects from stale pricing. The explanatory variables are the CBOE VIX volatility index, the spread between three-month LIBOR and T-bill rates, and the average equal-weighted discount (relative to NAV) on all U.S.-traded closed-end funds. Panel B shows similar regressions, except that both the dependent and independent variables are expressed as changes from the previous day. The *t*-statistics (in parenthesis) are based on Newey-West standard errors with five lags. The time period is 1/2007 to 12/2014.

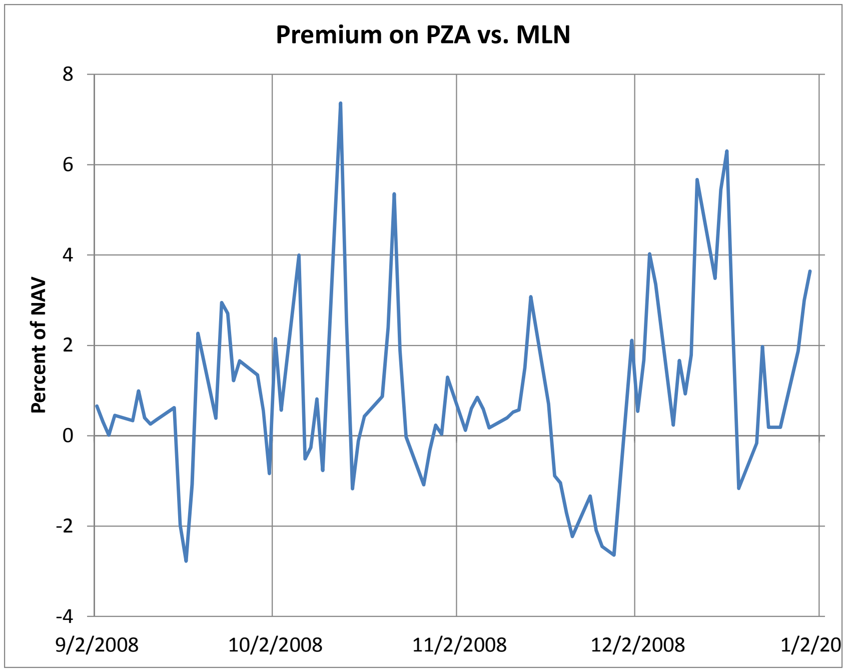
Panel A: Cross-sectional dispersion of premium				
	(1)	(2)	(3)	(4)
VIX index	0.0133***			0.0100***
	(16.83)			(13.79)
TED spread		0.1917***		0.0487***
		(9.93)		(3.18)
CEF discount			0.0322***	0.0100***
			(9.37)	(6.61)
N	1,975	1,967	1,975	1,967

Panel B: Daily change in cross-sectional dispersion of premium				
	(1)	(2)	(3)	(4)
Δ(VIX index)	0.0097***			0.0065***
	(13.64)			(8.17)
Δ(TED spread)		0.1496***		0.0837***
		(6.77)		(3.88)
Δ(CEF discount)			0.0381***	0.0244***
			(13.78)	(6.98)
N	1,974	1,958	1,974	1,958

Table IX. Profitability of Trading against ETF Mispricings.

This table shows the returns on a fully invested but unlevered long-short portfolio which takes positions against the estimated mispricings. The time period is 1/2007 to 12/2014. The intercept (alpha) and residual volatility are expressed in percent per year, and the information ratio (Sharpe ratio for "None") is also annualized. T-statistics (in parentheses) are based on White's standard errors. For these calculations, levered and inverse funds are counted as part of their underlying style, so they are included with other funds that track the same index (and not excluded with the "miscellaneous" category).

Excluded funds	Model	Intercept	Info ratio	Volatility (residual)	Beta				df	R^2
					MktRf	SMB	HML	UMD		
None	None	7.00	4.68	1.50					1973	0.0%
		(13.14)								
	CAPM	6.84	4.76	1.44	0.02				1972	7.9%
		(13.58)			(4.90)					
	FF	6.84	4.81	1.42	0.02	-0.02	-0.01		1970	9.9%
		(13.62)			(4.80)	(-2.33)	(-1.04)			
	Carhart	6.84	4.81	1.42	0.02	-0.02	-0.01	0.00	1969	9.9%
		(13.60)			(4.92)	(-2.33)	(-0.90)	(0.31)		
Diversified US	None	10.50	5.00	2.10					1973	0.0%
equity, US		(14.05)								
government	CAPM	10.32	5.06	2.04	0.02				1972	5.9%
bonds,		(14.43)			(4.50)					
commodity,	FF	10.33	5.10	2.03	0.03	-0.03	-0.01		1970	7.2%
miscellaneous		(14.46)			(3.91)	(-2.08)	(-0.39)			
	Carhart	10.33	5.10	2.03	0.03	-0.03	-0.01	0.00	1969	7.3%
		(14.44)			(3.90)	(-2.06)	(-0.51)	(-0.56)		
Diversified US	None	16.41	4.82	3.40					1973	0.0%
equity, US		(13.55)								
government	CAPM	16.19	4.83	3.35	0.03				1972	3.2%
bonds,		(13.86)			(3.05)					
sector funds,	FF	16.18	4.86	3.33	0.03	-0.04	-0.02		1970	4.4%
commodity,		(13.91)			(2.73)	(-1.85)	(-0.72)			
miscellaneous	Carhart	16.19	4.86	3.33	0.03	-0.04	-0.02	-0.01	1969	4.5%
		(13.90)			(2.70)	(-1.84)	(-0.85)	(-0.74)		



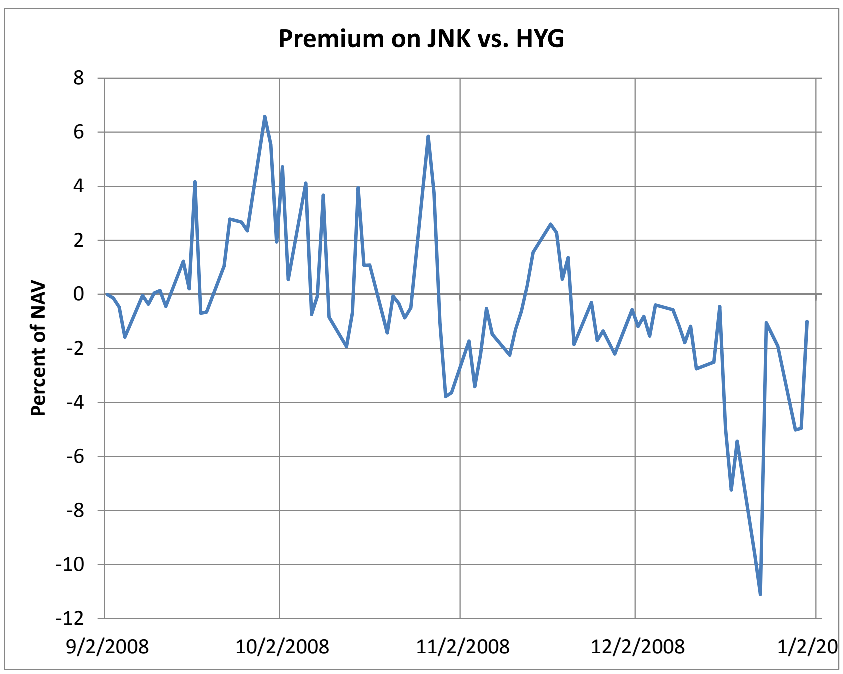


Figure 1. Premiums on similar ETFs.

The top panel computes the end-of-day price premiums on two similar muni bond funds, PZA and MLN, relative to their NAVs, and shows the difference in the two premiums over time. The bottom panel shows the difference in premiums for two similar junk bond ETFs, JNK and HYG.

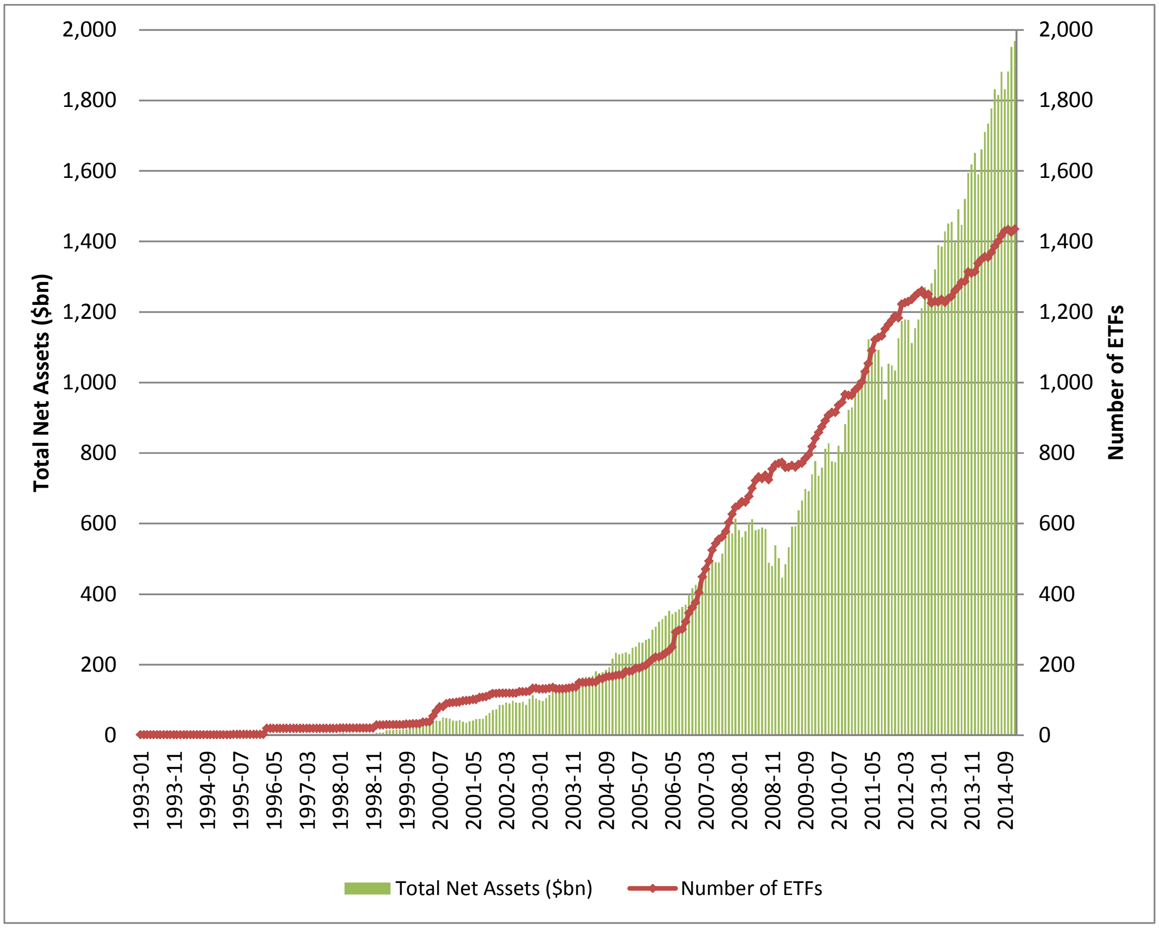


Figure 2. The size of the ETF sector in the U.S.

For all ETFs traded in the U.S., this figure shows the number of ETFs and their total market capitalization from the inception of the first ETF in 1/1993 to 12/2014. ETNs are excluded from the sample, but all ETFs including commodity and currency funds are included.

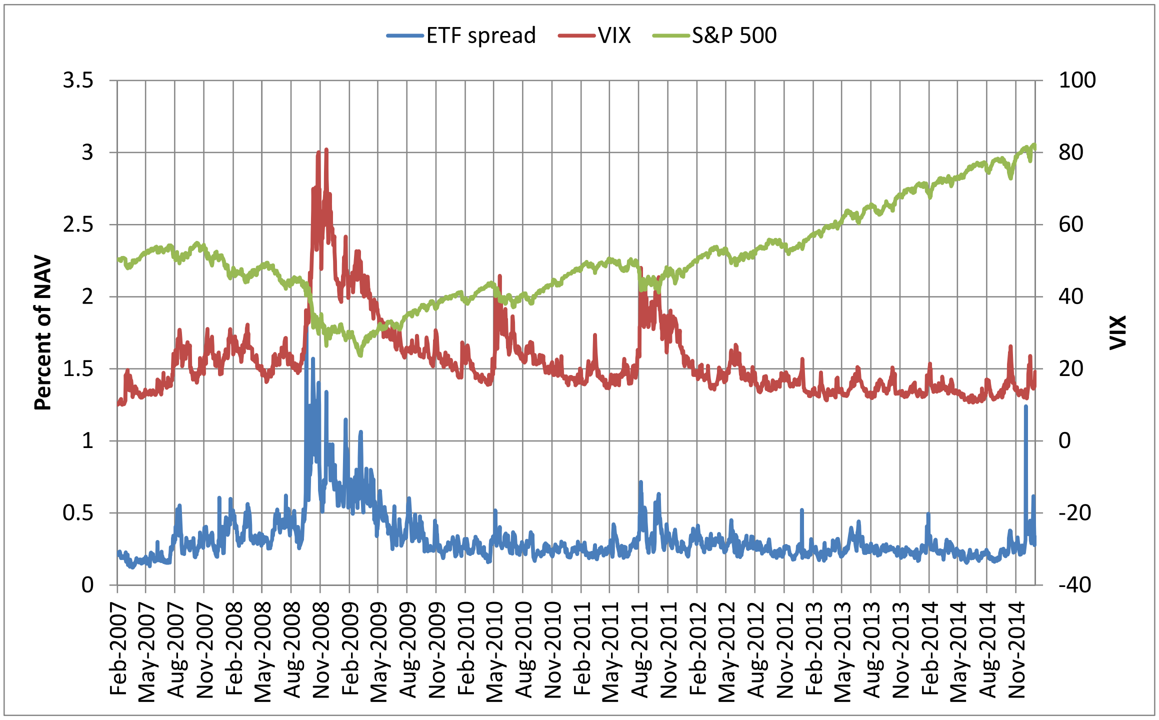


Figure 3. Cross-sectional dispersion of premium.

The figure shows the cross-sectional standard deviation of the premium across all ETFs at the end of each trading day. The premium is computed relative to a peer group mean to eliminate any effects from stale pricing. The other plotted time series are the CBOE VIX volatility index, and the cumulative return on the S&P 500 index.

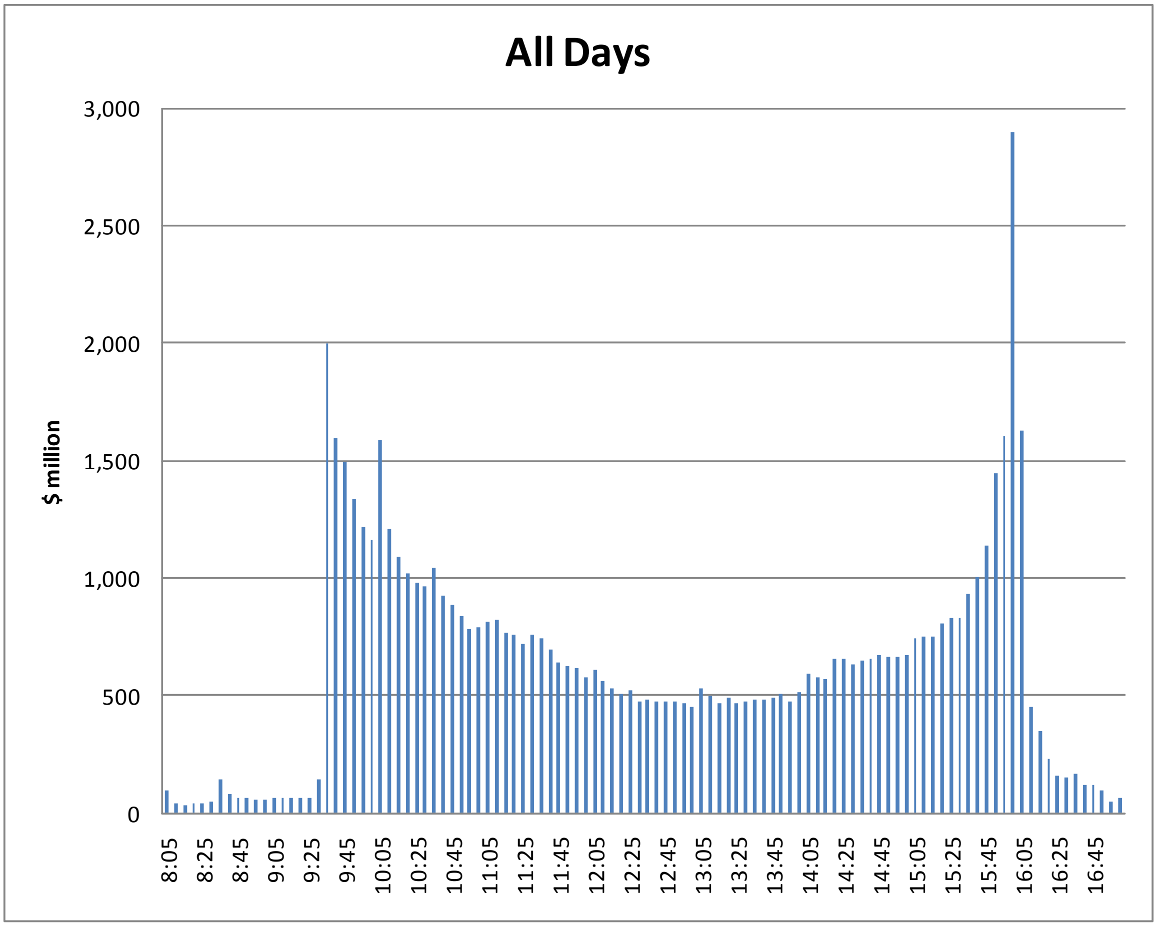


Figure 4. Daily trading volume in 2010.

The total trading volume (in $ millions) is computed across all U.S.-listed ETFs for each five-minute interval during the day. The figure shows the average across all trading days in 2010.

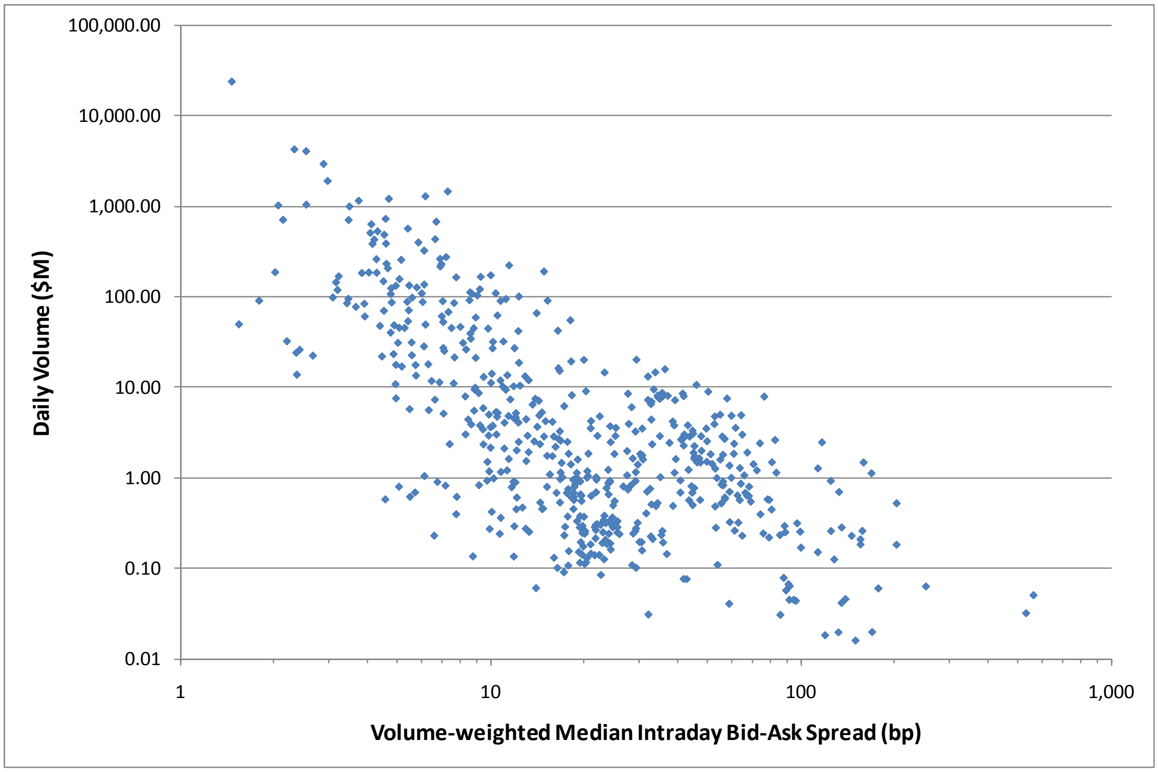


Figure 5. Trading volume and median intraday bid-ask spread.

The figure shows the mean daily trading volume plotted against the volume-weighted median bid-ask spread for all U.S.-listed ETFs in 2010. The numbers are based on intraday five-minute periods from 9:30am to 4:00pm. Both axes are in log scale.