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Abstract

In the light of standard theories of financial innovation, levered ETFs are unusual in that although they are largely marketed to retail investors, they increase, rather than decrease, information sensitivity. How does this affect market liquidity? Controlling for the underlying index, the turnover in the levered ETF market is several times higher than that in the regular ETF market. However, this does not imply that the levered ETF market is more liquid, as we also find that levered ETFs have significantly higher bid-ask spreads and lower liquidity ratios. One interpretation is that levered ETFs appeal certain type of investors who are interested in short-term levered speculation or hedging. In aggregate, the total cost levered ETF investors incur is around 5% of the market capitalization, or around $1 billion, each year. Moreover, levered and regular ETF investors appear trade differently: For levered (regular) ETFs, monthly fund flows are strongly negatively (positively) correlated with both current and past month returns. Finally, due to limits of arbitrage, ETF prices converge to their fundamental values, but only gradually.

JEL Classification Numbers: G11, G23.

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1 Introduction

Exchange-traded funds (ETFs) are becoming increasingly popular in the last two decades. One interesting recent development is the emergence of levered ETFs. Levered long ETFs attempt to provide daily returns that are 2 or 3 times of the returns of their benchmark indices, while levered short ETFs, or inverse levered ETFs, attempt to generate daily returns that are –2 or –3 times of their index returns. Since the introduction of levered ETFs in June 2006, the total market capitalization of all levered ETFs quickly grew to over $24 billion in 2009.

The levered ETF market offers an interesting setup to study a number of issues. For example, one important theory of financial innovation emphasizes the motive to create information insensitive securities to address the adverse selection problem and enhance market liquidity.[1] However, although levered ETFs are mostly marketed to retail investors, who are presumably less informed, levered ETFs appear to aim for the opposite: they increase information sensitivity through embedded leverage. How does this affect market liquidity? What is the cost investors incur to access this innovation? Moreover, through redemption and creation, the total supply of ETFs can easily adjust over time. This makes it possible to analyze both prices and quantities. How do investors, in aggregate, respond to past returns? When an underlying index increases, do investors move to the long or the short side of levered ETFs? How do ETF prices track their fundamental values—net asset values (NAVs)—over time? Our paper attempts to address the above questions and the main findings are the following.

First, the embedded leverage has multifaceted impacts on market liquidity. Judging from turnover, for example, levered ETFs appear more liquid than those without embedded leverage: Holding underlying indices constant, the average turnover is 2.69 times per month for 1-time ETFs (i.e., those without embedded leverage), but is 7.73 times per month for 2-time levered ETFs, and 10.07 times per month for 3-time levered ETFs; the t-statistics for the differences across the three types are well above 3. However, other popular liquidity measures, such as bid-

[1] See, e.g., Gorton and Pennacchi (1990), DeMarzo and Duffie (1999).

ask spread and liquidity ratio, suggest the opposite. For example, holding underlying indices constant, the average bid-ask spread is 7 basis points for 1-time ETFs, but is 12 and 34 basis points for 2- and 3-time levered ETFs, respectively. Similarly, the average liquidity ratio is 31.6, 12.1, and 4.0 for 1-, 2-, and 3-time levered ETFs, respectively. Hence, the levered ETF market is not as liquid as the heavy turnover implies. Our evidence suggests that, despite their high bid-ask spreads and low liquidity ratios, levered ETFs seem appealing to some investors who are interested in short-term levered speculation, or hedging. This is consistent with some recent studies that emphasize the role of financial innovation in facilitating speculation or hedging.[2]

Second, in aggregate, levered ETF investors appear to be contrarian while regular ETF investors appear to be momentum traders. On average, a one percent increase in the underlying index return is accompanied by a 1.08% ($t = 3.73$) outflow in the current month and 0.30% ($t = 1.70$) outflow next month for the levered long ETFs on this index; but is accompanied by inflows of 0.93% ($t = 2.86$) in the current month and 0.82% next month for the levered short ETFs on this index. That is, investors appear to be betting on the reversal of the index return. However, this contrarian trading is not justified by future returns. If anything, our evidence suggests that investors, in aggregate, trade in the "wrong" direction: fund flows appear to be negatively correlated with the future returns. It is interesting to contrast the behavior of levered ETF investors to that of regular ETF investors. Unlike levered ETF investors, regular ETF investors appear to be momentum traders: A one percent increase in the underlying index return is accompanied by inflows of 0.14% ($t = 2.16$) in the current month and 0.24% ($t = 4.3$) in next month.

Third, the total cost that levered ETF investors incur is over 5%, or more than $1 billion dollars per year. Sponsors of levered ETFs usually issue pairs of ETFs for each index: one ETF aims to provide x-time ($x = 2, 3$) daily return of the index, while the other aims to provide $-x$-time daily return of the same index. This offers an easy way to assess costs. Consider a portfolio which invests $1 in each ETF, and re-balances daily to keep the same exposure to the

[2] See, e.g., Frazzini and Pedersen, (2012), Simsek (2012) and Shen, Yan and Zhang (2012).

two ETFs. For convenience, we refer to this portfolio as a "long-long" portfolio. If the two ETFs deliver the returns they are designed to generate, the long-long portfolio return should be zero regardless of the underlying index return. Therefore, the realized returns of long-long portfolios provide a measure of the cost to investors in levered ETFs. In our sample from 2006 to 2012, the average return of the long-long portfolio is -20.9 basis points per month (or -2.51% per year), with a t-statistic of 2.00. Hence, one can interpret this as levered ETF investors facing a cost of 2.51% a year. Note that this cost measure does not include the transaction costs investors face when they frequently trade levered ETFs in the secondary market. In our sample, the median turnover of levered ETFs is around 2.14 times per month. Hence, a bid-ask spread of 10 basis points implies a transaction cost of roughly 2.57% ($= 2.14 \times 12 \times 10$ b.p.) per year. Therefore, the total cost that levered ETF investors incur is about 5.08% (=2.51%+2.57%) per year. Based on the market size of $20 billion, this amounts to over $1 billion dollars per year. As a comparison, French (2008) finds that "investors spend 0.67% of the aggregate value of the market each year searching for superior returns."

Fourth, we calculate the long-long portfolio returns based on NAVs. That is, we treat NAVs as if they were ETF prices when calculating the long-long portfolio return. For convenience, we refer to this hypothetical return as "NAV return". If ETF prices closely track their NAVs, this NAV return should be similar to the long-long portfolio return that we obtained earlier. Surprisingly, although the average premium (i.e., the difference between the price of an ETF and its NAV) in our sample is less than one basis point, the difference between the NAV return and the long-long portfolio return is substantial. For example, in contrast to the -20.9 basis points return from the long-long strategy, the NAV return is 1.4 basis points per month. The difference between the two returns, which we refer to as "GAP", is highly significant, with a t-statistics of 2.6.

Fifth, GAP arises due to the combination of two factors. 1) ETF returns appear to under-react to NAV-implied returns. Specifically, when the NAV of an ETF increases (or decreases) by 1%, the ETF price increases (or decreases), on average, by only 94 to 95 basis points. 2) The daily rebalance in the long-long strategy is contrarian in nature: It moves investment out of the winner of the ETF pair, and into the loser of the pair. It is the combination of under-reaction and contrarian trading that leads to the under-performance of the long-long strategy relative to NAV returns: Suppose, for instance, an index increases by 1% today, the 2-time long ETF on this index tends to increase by only 190 basis points (rather than 200 basis points that it is designed to deliver) and so become underpriced relative to its NAV. Similarly the 2-time short ETF on this index tends to decrease by only 190 basis points and so become overpriced relative to its NAV. Then, the daily rebalance means moving investment from the under-priced long ETF to the over-priced short ETF. Therefore, as the ETF prices converge to their corresponding NAVs, the future returns of the long-long strategy tend to be lower than the NAV returns.

The average premium in our sample is less than one basis point, suggesting that arbitrage forces are effective in bringing ETF prices towards their NAVs and that there is no mispricing on average. However, the arbitrage force does not perfectly peg an ETF price to its NAV. Rather, NAV is the "moving target", to which arbitrage forces *partially* push the ETF price. This is a sensible strategy when arbitrageurs face costs when setting up their trades, similar to the intuition in the literature of optimal portfolio choice with transaction costs. For example, Garleanu and Pedersen (2012) find that in an environment with predictable return and transaction costs, the optimal strategy is to "trade partially towards the current aim". The above interpretation implies that GAP returns should be higher when NAVs are more volatile, and so can only be tracked less closely by ETF prices. Consistent with this implication, we find that the GAP return is -28.5 basis points per month for 3-time ETFs, and is -12.1 for 2-time ETFs. Moreover, if we sort ETFs based on their underlying indices' past month volatility, the GAP return for the top half ETFs is -29.8 basis points per month, but is only -6.8 basis points per month for the bottom half.

Our paper is related to the literature that emphasizes the role of financial innovation in facilitating speculation or hedging. In particular, we document the poor performances of levered ETFs. This is related to Frazzini and Pedersen (2012), who show that, across many asset classes, due to the demand pressure from leverage-constrained investors, instruments with embedded leverage tend to be priced higher related their unlevered counterparts. One difference is that, our analysis is not a comparison between levered versus unlevered instruments. Rather, it is an examination of whether the sum of a "zero-sum game" is actually zero. Moreover, our evidence highlights that levered ETF investors appear to be willing to pay a very large cost for trading in this market, shedding light on the speculative motivation for some financial innovations (Shen, Yan and Zhang (2012), Simsek (2012)). Our paper is also related to the study of regular ETFs. Petajisto (2011) examines the efficiency of ETF pricing. Ben-David, Franzoni and Moussawi (2012) analyze the role of ETF is propagating shock across markets. Lu, Wang, and Zhang (2009) studies the long term returns of levered ETFs. More broadly, our paper also adds to the large literature on limits of arbitrage (Shleifer and Vishny (1997)) and investors' trading behavior (Odean (1998)). The rest of the paper is as follows. Section 2 describes the data, the main analysis is in Section 3 and Section 4 concludes.

2 Data

From Bloomberg, we obtain the full list of ETFs traded in U.S., which includes funds that have been liquidated. Hence, our analysis is not subject to survivorship bias. The list contains basic information of each ETF, including ticker, inception date, benchmark index, leverage, asset type, geographic focus and the ETF sponsor. According to this list, the first ETF, "SPDR S&P 500 ETF Trus" (SPY), was created on January 22nd, 1993. Levered ETFs were invented much later. On June 19th, 2006, ProShares issued the first four pairs of levered ETFs. At the end of our sample, Feburary 29 2012, there are 1011 regular ETFs and 184 levered ETFs. We merge ETF tickers with CRSP and obtain daily trading variables, including closing price, closing bid and ask prices, trading volume. We also obtain the daily observations of NAV, benchmark index return, and the number of shares outstanding for each ETF.[3] Institutional ownership are obtained from

[3]Both CRSP and Bloomberg contain data on total number of shares outstanding, but CRSP data updat weekly or bi-monthly while Bloomberg has daily updates.

Thomson Reuters Institutional Holdings dataset (13f filing to SEC).

We form ETF pairs by matching a long ETF with a short ETF on the same benchmark index, with the same leverage ratio. For each pair, we make sure the two ETFs have exactly the same ticker for the benchmark index. Then we manually check each ETF's official prospectus to make sure both indices have the same adjustment to dividends. This rules out pairs of regular (i.e., one-time long) ETFs and one time short ETFs, because regular ETFs are designed to deliver the total return of benchmark indices (i.e., including dividends) but one time short ETFs are designed to deliver minus index return, excluding dividend. Hence, the underlying indices do not match even though they both use the same index as the benchmark. In the end, we obtain 77 pairs of levered ETFs, including 53 2-time levered pairs and 24 3-time levered ones, from July 2006 to February 2012.

Panel A of Table 1 reports the number of ETFs and the total market capitalization of levered ETFs at the end of each year. The levered ETF market started with 8 ETFs in 2006 and grew into 155 in 2011. The total market capitalization grows to $24.64 billion in 2011. Panel B reports the summary statistics of some key variables in our analysis. *Return* refers to the monthly return of levered ETFs, including distributions. The average returns of all ETFs is –88 basis points per month (or 10.56% per year), with a standard deviation of 12%. *NAV Return* refers to the monthly returns calculated based on NAVs of levered ETFs. It is interesting to note that the mean *NAV Return* is 10 basis points lower than the mean of *Return*. We will return to this point later in Section 3.5. *Spread* is the closing bid-ask spread, the closing ask price minus the closing bid price divided by the average of the bid and ask prices. The *Spread* for levered ETFs has a mean of 41 basis points and its standard deviation is 54 basis points. *Turnover*, the monthly turnover, has a mean of 4.74 times per month and a standard deviation of 5.53. *Flow* denotes the monthly capital inflow. It has a mean of 15.6%, suggesting that the levered ETFs market have been growing quickly during our sample period. *Cap* is the total market capitalization. It shows that the median size of levered ETFs is only $30 million and the mean is $190 million. It also shows that levered ETF investors are predominantly retail investors, as median the institutional ownership, *IO*, is only 20.6%. *Premium* is the ratio of ETF price and NAV minus 1 measured at the end of each month for each ETF. Both the mean and the median are 0, suggesting that there is no premium or discount on average. Finally, due to the concern that extreme outliers are caused by erroneous data, we winsorized *Turnover*, *Spread*, *Flow* and *Premium* at both 1% and 99% for each cross-section of all ETFs.

3 Empirical Analysis

3.1 Embedded leverage and the market liquidity

One important theory of financial innovation emphasizes the motive to create information insensitive securities to address the adverse selection problem and to enhance market liquidity (e.g., Gorton and Pennacchi (1990), DeMarzo and Duffie (1999)). However, although levered ETFs are mostly marketed to retail investors, who are presumably less informed, levered ETFs appear to aim for the opposite: they increase information sensitivity through embedded leverage. This unusual feature makes levered ETFs an interesting setup to analyze market liquidity.

Table 2 compares standard market liquidity measures, turnover, bid-ask spread, and liquidity ratio as in Amihud(2002), of ETFs with different embedded leverage. In order to control for the underlying indices, Panel A restricts our sample to the indices on which there are both regular ETFs and 2-time levered ETFs, while Panel B restricts the sample to the indices on which there are 1-time, 2-time, and 3-time levered ETFs. As shown in Panel A, the average turnover of 1-time ETFs is 2.37 times per month. In contrast, the turnover of 2-time levered ETFs is 5.7 times per month. The difference in turnover is highly significant, with a t-statistic of 5.25. Panel B shows that the comparison between 2-time levered ETFs and 3-time levered ETFs is similar. Holding the underlying index constant, the turnover is 7.73 times per month for 2-time levered ETFs but is 10.07 time per month for 3-time levered ones. The difference is highly statistically significant, with a t-statistic of 3.61.

The above evidence suggests that levered ETF market has higher turnovers. However, this does not imply that levered ETF market is more liquid. In fact, other liquidity measures imply the opposite. Panel A shows that, holding the underlying indices constant, the average bid-ask spread at market close is 13 basis points for regular ETFs, and 30 basis points for 2-time levered ones. The difference is highly significant ($t = 5.69$). Similarly, Panel B shows that the bid-ask spreads for 3-time levered ETFs are significantly higher than those for 2-time ones. Similar results are obtained based on liquidity ratio, which is measured as the sum of the stocks trading volume over one month divided by the sum of the stocks absolute daily returns over that month. So a high liquidity ratio indicates that the market is more liquid. Panel A shows that holding the underlying indices constant, the liquidity ratio is 54.24 for 1-time ETFs and 9.07 for 2-time ETFs. Similarly, in Panel B where there are both 2-time and 3-time ETFs on the underlying indices, the liquidity ratio is 12.13 for 2-time ETFs and 4.01 for 2-time ETFs. The t-statistics for both differences are well above 3.

It is interesting to note that the turnover of 2-time levered ETFs in Panel B is much higher than the turnover of 2-time levered ETFs in Panel A, suggesting that 3-time levered ETFs are more likely to be introduced on indices on which regular ETFs and 2-time levered ETFs have higher turnover. Perhaps the high turnover in the ETFs on a certain index is an indicator that if one introduces ETFs with higher embedded leverage on this index, investors would also be interested in trading them. We further explore this conjecture in Panels C and D. Panel C reports the liquidity measures of 1-time ETFs (regular ETFs and one time short ETFs). The first row is for those 1-time ETFs on the indices on which are no 2-time levered ETFs. Their average turnover is 0.61 time per month. In contrast, if indices have both 1-time and 2-time ETFs, the average turnover for these 1-time ETFs is 2.32, significantly higher that of the 1-time ETFs on the indices on which are no 2-time levered ETFs. Column 2 shows that the average bid-ask spread is 43 basis points if the underlying indices don't have 2-time levered ETFs, but is only 13 basis points if the underlying indices do have 2-time levered ETFs. Similarly, column 3 shows that the average liquidity ratio is only 3.31 for the sample where the underlying indices don't have 2-time levered ETFs, but increases to 53 for the sample where the underlying indices do have 2-time levered ETFs.

That is, the above evidence shows that 2-time levered ETFs are more likely to be introduced on indices on which 1-time ETFs have higher turnovers, lower bid-ask spreads and higher liquidity ratios. Perhaps the low bid-ask spread and high liquidity ratio of the ETFs on a certain index is an indicator that if one introduced 2-time levered ETFs on this index, they won't be prohibitively illiquid. Similarly, Panel D shows that 3-time levered ETFs are more likely to be introduced on indices on which 2-time ETFs have higher turnovers, lower bid-ask spreads and higher liquidity ratios.

In summary, the levered ETF market is not as liquid as the heavy turnover implies. The high bid-ask spreads and low liquidity ratios mean that it is quite costly to trade in this market. The overall evidence shows that, despite their iliquidity, levered ETFs seem appealing to some investors who have very short investment horizons. This is consistent with some recent studies that emphasize the role of financial innovation in facilitating speculation or hedging (e.g., Frazzini and Pedersen, (2012), Simsek (2012) and Shen, Yan and Zhang (2012)).

3.2 Investor Behavior

We noted in Table 1 that the median institutional ownership of levered ETFs is merely 20.6% in our sample. That is, the levered ETF market is dominated by individual investors. How do levered ETF investors trade in aggregate? Table 3 suggests that in aggregate, levered ETF investors appear to be contrarian: Monthly fund flows to levered ETFs are strongly negatively correlated with both their contemporaneous and past month returns. The first column of Panel A, for example, reports the result from a panel regression of monthly flows to levered long ETFs on contemporaneous and past month returns of the underlying indices. It shows that a one percent increase in the underlying index return is accompanied by a 1.08% outflow in the current month ($t = 3.73$), and a 0.3% outflow in the next month ($t = 1.70$). Similar results are in columns two and three, where the past month index return is replaced by the past quarter and past year return, respectively. For example, a one percent increase in the quarterly underlying index return is associated with 0.18% outflow from the levered long ETF in the next month ($t = 1.95$). The last three columns of Panel A are for levered short ETFs and also implies a contrarian aggregate behavior. For instance, column four implies that a one percent increase in the underlying index return (i.e., a negative 2 or 3 percent return on the ETF) is associated with a 0.93% inflow in the current month ($t = 2.86$), and a 0.82% inflow in the next month ($t = 2.02$).

Panel B shows that this contrarian aggregate trading behavior is not justified by future returns. It reports the results from the regression of future index returns on past flows to levered ETFs. For levered long ETFs, a one percent increase of inflow last month is associated with 1.9 basis points decrease in the underlying index return next month. For levered short ETFs, an increase of inflow in he past month is associated with an increase in index return (a decrease in the return of the levered short ETF) next month, although the coefficient is not significant. Hence, our evidence suggests that, if anything, investors in aggregate trade to the "wrong" direction: an increase in fund flow appears to be negatively correlated with the future ETF returns.

Panel C shows that a one standard deviation increase in the volatility of the underlying index increases next month turnover by 1.25 times ($= 0.5\% \times 250.3$) for levered long ETFS, and 2.76 times for levered short ETFs. There is also some evidence that past index volatility increases future fund flows to both the long and short ETFs on the index. Columns one and four in Panel A shows that a one standard deviation increase in index volatility increases the next month fund inflow by 1.8% for levered long ETFs, and by 2.2% for levered short ETFs.

It is interesting to contrast the behavior of levered ETF investors to that of regular ETF investors. Panel D shows that unlike levered ETF investors, regular ETF investors appear to be momentum trader: Monthly fund flows to regular ETFs are strongly positively correlated with both their contemporaneous and past month returns. In column one, for example, a one percent increase in the underlying index return is associated with a 0.14% inflow in the current month

($t = 2.16$), and a 0.24% inflow in the next month ($t = 4.3$). Columns 2 and 3 show similar results when we replace the past month return by the past quarter return and past year return, respectively. Naturally, the coefficient for the past return decreases when the horizon increases from one month to one quarter and one year. Finally, similar to the behavior of levered ETF investors, fund flow is negatively associated with future index return (column 4) and past month volatility strongly increases the turnover in the next month (column 5).

3.3 Cost Measure

The heavy trading in the levered ETF market, despite the large bid-ask spreads and low liquidity ratios, implies that investors might incur a large cost, which we try to quantify in this section. The special structure of ETF pairs offers a nice way to make cost assessment. ETF sponsors usually issue levered ETF pairs for each index: one ETF aims to provide x-time ($x = 2, 3$) daily return of the index, while the other aims to provide $-x$-time daily return of the same index. Consider a portfolio which invests \$1 in each ETF, and re-balances daily to keep the same exposure to the two ETFs. For convenience, we refer to this portfolio as a "long-long" portfolio. If the two ETFs deliver the returns they are designed to provide, the return of the long-long portfolio should be zero regardless of the underlying index return. That is, it is a zero-sum game between the investor of the x-time ETF and that of the $-x$-time ETF. Perhaps due to market frictions, the realized returns of the long-long portfolio can differ from 0, and so provide a measure of the cost to investors in levered ETFs.

Table 4 reports the returns of this long-long portfolio. The first column of Panel A shows that during our sample from 2007 to 2012, the average return of the long-long portfolio is -20.9 basis points per month (or -2.51% per year), with a t-statistic of 2.00. Hence, one can interpret this as levered ETF investors facing a cost of 2.51% a year. Note that this cost measure does not include the transaction costs investors face when they frequently trade levered ETFs in the secondary market. In our sample, the median turnover of levered ETFs is 2.14 times per month. Hence, a bid-ask spread of 10 basis points implies a transaction cost of roughly 2.57%

($= 2.14 \times 12 \times 10$ b.p.) per year. Therefore, the total cost that levered ETF investors incur is about 5.08% (=2.51%+2.57%) per year. Based on the market size of $20 billion, this amounts to over $1 billion dollars per year.

Panel B reports the long-long strategy returns for the two subsample periods. In the first half of the sample 2006-2009, the average long-long return is somewhat closer to 0, -14.3 basis points per month, and perhaps due to the high volatility during the finanical crisis, the estimate is noisier, as the t-stat drops to 0.71. In the second half of the sample 2009-2012, however, the average long-long strategy loss becomes larger, -27.4 basis points per month, and the t-stat increases to 7.84. As noted earlier in Table 1, the total market capitalization for levered ETFs is much larger in the latter half of the sample, suggesting that the true cost should be larger than the estimate based on the overall sample in Panel A.

Panel C analyzes the long-long portfolio returns by the categories of the underlying indices. What stands out is that the cost estimates are much larger for ETFs on commodity and international indices, 69.3 and 42.1 basis points per month, respectively. The cost for the ETFs on stock and bond indices is about the same as the estimate based on the overall sample, while the cost for the ETFs on currency indices is significantly smaller.

One implicit assumption behind the above cost measure is that the total market capitalization for the x-time ETF is the same as that for the $-x$-time ETF, while in reality the sizes of the two ETFs are often imbalanced. To examine if this violation meaningfully affects the cost measure, we make the following adjustment. We calculate the long-long strategy return for each pair of ETFs as the average return of the pair, weighted by each ETF's market capitalization on the previous day. We then take an average of the long-long strategy returns across all pairs, weighted by the total market cap of each pair. As shown by the first column of Panel D, this adjustment only slightly changes the cost measure we obtained in Panel A.

In a recent study, Brunnermeier, Simsek, and Xiong (2011) show that due to the deadweight cost for speculation, there may exist a belief-neutral criteria to evaluate the welfare in the economy. Our empirical evidence suggests that the deadweight loss for trading in the levered ETF market is indeed substantial, and so providing useful information for evaluating the welfare implications of the levered ETF market.

3.4 The determinants of the long-long strategy return

What determines the long-long strategy return? First, levered ETFs attempt to track *daily* returns of underlying indices with x-time leverage ($x = \pm 2, 3$). Thus, they must adjust their underlying portfolio at a relative high frequency to keep their leverage ratios fixed. The transaction costs associated with the adjustments erode the net asset values (NAVs), and contribute to the low return from teh long-long strategy. Following this intuition, we would expect that the long-long strategy loss to be larger for 3-time levered ETF pairs, and for the pairs based on more volatile indices. The idea is that more re-balancing is needed for 3-time levered ETFs, or for ETFs on more volatile indices, leading to larger long-long strategy loss returns for them. As shown in Panel A of Table 5, the average long-long strategy return is −49.1 basis points per month for 3-time ETF pairs and is −27.6 basis points per month for 2-time pairs. Moreover, we sort ETFs based on the past month volatility of their underlying indices into two groups. The average long-long strategy return is −34.4 basis points per month for ETF pairs in the high group, and is only −8.9 basis points for the low group. In both cases, the cross-sectional differences are highly significant, both statistically and in economic terms.

Second, part of the long-long could be due to the overpricing of levered ETFs relative to their NAVs. Table 1 shows that although the average premium is within one basis point, there is significant variation overtime. We sort ETF pairs by their last month average premium. Panel A also shows that the long-long strategy loss is higher for the group with higher past month premium. Finally, the table also provides some evidence that the long-long strategy loss increases with market cap and the last month turnover of the ETF pairs. We don't find evidence that the long-long return changes with institutional ownership.

We also run a Fama-MacBeth regression of long-long returns on these characteristics. As shown in column 1 of Panel B, the strong predictors are index volatility and average premium in the prior month, as well as the embedded leverage. They subsume the predictive power of market cap and turnover.

3.5 Arbitrage

There is a well-established arbitrage mechanism in the ETF market. Through share creation and redemption, arbitrageurs can profit from deviations of ETF prices from NAVs. Moreover, both prices and NAVs of most ETFs can be accurately measured at daily frequency. This offers a rich set of data to empirically examine the deviations of prices from fundamental values in a dynamic setup.

We have noted earlier in Table 1 that the average premium in our sample is less than one basis point, suggesting that arbitrage forces are effective in bringing ETF prices towards their NAVs and that there is no mispricing on average. As a starting point, we examine the long-long strategy returns in a hypothetical world in which arbitrage forces completely peg ETF prices to NAVs. That is, we treat NAVs as if they were ETF prices when calculating the long-long portfolio returns. For convenience, we refer to this hypothetical portfolio return as "NAV return". If ETF prices closely track their NAVs, the NAV return should be similar to the long-long portfolio return that we obtained earlier. Surprisingly, however, although the average premium in our sample is less than one basis point, the difference between the NAV return and the long-long portfolio return is substantial. As shown in Panel A of Table 4, for example, in contrast to the -20.9 basis points return from the long-long strategy, the NAV return is 1.4 basis points per month. The difference between the two returns, which we refer to as "GAP", is highly significant, with a t-statistics of 2.6. What causes GAP?

GAP arises due to the combination of two factors. The first one is that ETF returns appear to "under-react to NAV returns." Specifically, we run panel regressions of daily ETF returns on contemporaneous NAV-based return, and the results are reported in Panel A of Table 6.[4] Column 1 is for levered long ETFs only. The coefficient estimate for NAV return is 0.944, which is significantly different from 1 (t = 10.3). Moreover, the coefficient for the premium on the prior day, $Premium_{t-1}$, is –0.988, which is is indistinguishable from −1. Note that if the discrepancy between price and NAV completely disappears after one day, this coefficient should be −1. So, our evidence suggests that the discrepancy between price and NAV almost completely disappears after one day. The second column reports the results on levered short ETFs. The coefficient estimate for NAV return is 0.951, which is significantly different from 1 (t = 9.50). Interestingly, the coefficient for $Premium_{t-1}$ is –0.923 (t = 1.86), suggesting that the discrepancy between price and NAV does not completely disappear after one day. Perhaps arbitrage forces are less efficient in driving prices to NAVs for levered short ETFs. Columns 3 and 4 replace $Premium_{t-1}$ by lagged NAV returns. The coefficient is highly significant for the prior day NAV return, but becomes insignificant for the NAV returns for early days.

The second factor is that the daily rebalance in the long-long strategy is contrarian in nature: It moves investment out of the winner of the ETF pair, and into the loser of the pair. It is the combination of under-reaction and contrarian trading that leads to the under-performance of the long-long strategy relative to NAV returns: Suppose, for instance, an index increases by 1% today, the 2-time long ETF on this index tends to increase by around 190 basis points (0.944×200), rather than 200 basis points that it is designed to deliver. Similarly the 2-time short ETF on this index tends to decrease by only 190 basis points, rather than 200 basis points. As a result, the levered long ETF becomes underpriced and the levered short ETF becomes overpriced relative to their NAVs. Note that the daily rebalance means moving investment from the under-priced long ETF to the over-priced short ETF. As shown in Panel A of Table 6, these price discrepancies tend to disappear the next day. This implies that the long-long strategy returns tend to lower than the NAV returns, leading to the GAP.

[4]ETF returns are calculated based on prices recorded at 4pm. However, NAVs are recorded at different time. This dissynchronization creates problems for our inferences. Hence, we restrict our sample to ETFs based on US equities in these regressions, where bother prices and NAVs are recorded at the same time.

The above evidence suggests that arbitrage forces cannot perfectly peg the price of an ETF to its NAV. Rather, NAV is the "moving target", to which arbitrage forces *partially* push the ETF price. This is a sensible strategy when arbitrageurs face costs when setting up their trades, similar to the intuition in the literature of optimal portfolio choice with transaction costs. For example, Garleanu and Pedersen (2012) find that in an environment with predictable return and transaction costs, the optimal strategy is to "trade partially towards the current aim". The above interpretation implies that GAP returns should be higher when NAVs are more volatile, and so can only be tracked less closely by ETF prices. Consistent with this implication, Panel A of Table 5 shows that the GAP return is -28.5 basis points per month for 3-time ETFs, and is -12.1 for 2-time ETFs. Moreover, if we sort ETFs based on their underlying indices' past month volatility, the GAP return for the top half ETFs is -29.8 basis points per month, but is only -6.8 basis points per month for the bottom half. Panel B runs a Fama-MacBeth regression of GAP on leverage and index volatility etc. It also shows that GAP increases in index volatility, average premium in the prior month, and leverage, although the coefficient for leverage becomes insignificant.

To further examine this interpretation, we construct the underreaction measure as follows. For each levered ETF, we use a 3-month rolling window of daily data to estimate the following regression.

$$Return_t = \alpha_t + \beta_t NAVReturn_t + \gamma_t Premium_{t-1}. \tag{1}$$

Then, for each ETF, we obtain an under-reaction measure UDR_t as the following

$$UDR_t = -(1 - \beta_t)\gamma_t. \tag{2}$$

Finally, we obtain the under-reaction measure for each ETF pair as the average of the two UDR_t estimates for the two ETFs. The distribution of the underreaction measure estimates are reported in Panel B of Table 6. For levered long ETFs, the mean and standard deviation of β_t estimates are 0.955 and 0.046; the mean and standard deviation of γ_t estimates is –0.971 and

0.139. The estimates for levered short ETFs are similar and are reported in the rows 3 and 4. The distribution of the estimates of UDR_t is reported in the last row. The mean and standard deviation of our estimates are 0.041 and 0.040. We will now explore the variations in UDR_t to test our hypothesis that GAP is caused by underreation.

Due to the estimation errors in UDR_t, we create a dummy variable, which is 1 if the estimate of the ETF pair's UDR_t is higher than the median across all pairs in that month, and 0 otherwise. We run a panel regression of GAP on index volatility and underreation. The results are reported in Table 7. Our hypothesis implies that GAP should increase (i.e., becomes more negative) with index volatility and this underreation dummy. Column 1 is consistent with this prediction: the coefficients for both index volatility and the undereaction dummy are significantly negative. Column 2 includes the interaction term of index volatility and the underreaction dummy. The coefficient of this interaction term is –0.349 ($t = 4.9$), suggesting that for the ETF pairs with stronger underreaction, index volatility has a stronger impact on GAP. Similarly results are obtained in the last column which includes other controls such as the pair's average premium in the prior month and leverage.

4 Conclusion

We have documented that controlling for the underlying index, the turnover in the levered ETF market is several times higher than that in the regular ETF market. However, we also find that levered ETFs have significantly higher bid-ask spreads and lower liquidity ratios. Our interpretation is that levered ETFs appeal certain type of investors who are interested in short-term levered speculation or hedging. In aggregate, the overall cost levered ETF investors incur is around 5% of the market capitalization, or around $1 billion, each year. Moreover, in aggregate, levered ETF investors appear to be contrarain: monthly fund flows are strongly negatively correlated with both their contemporaneous and past month returns. In contrast, for regular ETFs, monthly fund flows are strongly positively correlated with both their contemporaneous and past month returns. Finally, we find that the average premium in our sample is less than one basis point, suggesting that arbitrage forces are effective in bringing ETF prices towards their NAVs and that there is no mispricing on average. However, our evidence shows that arbitrage forces cannot perfectly peg the price of an ETF to its NAV. Rather, NAV is the "moving target", to which arbitrage forces push the ETF price. Due to limits of arbitrage, ETF prices only gradually converge to their fundamental values.

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Table 1 Summary Statistics

This table reports summary statistics of the main variables in our analysis. Panel A reports the number of levered ETFs and total market capitalization (in billion $) by leverage ratios at the end of each year from 2006 to 2011. Panel B reports the time-series averages of monthly cross-sectional statistics of each variable. *Return* is the monthly return of levered ETFs compounded from daily returns. *NAV Return* is the monthly return that is compounded from hypothetical daily returns computed based on daily NAVs. *Spread* is the closing bid-ask spread, ask price minus bid price divided by the average of bid and ask prices, at the end of the month. *Turnover* is the sum of daily share turnover rate within each month. *Flow* is the monthly capital flow rate. *Cap* is the market capitalization at the end of the month, denoted in $ billion. *LnCap* is the natural log of market capitalization in dollars. *IO* is the most recent report of institutional ownership from 13F filings. *Premium* is the month-end price to NAV ratio minus one. *Index Return* is the monthly return of ETF's benchmark index. *Index Vol* is standard deviation of daily returns of ETF's benchmark index. *Turnover*, *Spread*, *Flow* and *Premium* are winsorized within all ETF sample at both 1% and 99% level at each cross-section. The sample period spans from 2006/07 to 2012/02.

Panel A: # of levered ETFs and total market size at the end of each year

Year	**# of ETFs**				**Total**	**Sum of Market Capitalization ($B)**				**Total**
	2x long	**2x short**	**3x long**	**3x short**		**2x long**	**2x short**	**3x long**	**3x short**	
2006	4	4	0	0	8	0.53	1.25	0.00	0.00	1.78
2007	26	30	0	0	56	2.24	6.15	0.00	0.00	8.39
2008	37	43	7	7	94	8.48	8.49	0.63	0.29	17.89
2009	42	48	14	14	118	6.75	12.20	2.85	2.37	24.17
2010	44	43	24	24	135	7.68	11.60	4.53	2.88	26.69
2011	52	47	28	28	155	6.47	9.96	4.95	3.26	24.64

Panel B: time-series averages of cross-sectional statistics

	Mean	**St Dev**	**1%**	**25%**	**Median**	**75%**	**99%**	**# of ETFs**
Return	-0.88%	11.96%	-25.08%	-10.19%	-1.32%	8.53%	25.25%	89.6
NAV Return	-0.78%	12.11%	-25.27%	-10.29%	-1.22%	8.73%	26.66%	87.0
Spread	0.41%	0.54%	-0.02%	0.13%	0.29%	0.49%	3.06%	89.6
Turnover	4.74	5.53	0.26	1.00	2.14	6.34	18.63	89.6
Flow	15.62%	32.88%	-32.42%	0.26%	7.61%	25.50%	118.09%	87.3
Cap ($B)	0.19	0.46	0.01	0.01	0.03	0.13	2.46	87.3
LnCap	17.47	1.66	14.71	16.19	17.14	18.56	21.41	87.3
IO	27.40%	21.77%	1.57%	11.09%	20.62%	39.08%	84.98%	80.0
Premium	0.01%	0.59%	-1.60%	-0.24%	0.00%	0.25%	1.95%	86.2
Index Return	0.00%	12.25%	-26.43%	-9.40%	0.19%	9.48%	26.41%	89.6
Index Vol	1.57%	0.48%	0.67%	1.28%	1.49%	1.77%	3.07%	84.9
# of dates	68							

Table 2 Liquidity of ETFs by Leverage Ratios

This table compares three liquidity measures of ETFs across leverage ratios. *Turnover* is defined in Table 1. *Spread* is the closing bid-ask spread and is obtained daily. *Liquidity Ratio* is the monthly trading volume (in billion $) divided by the sum of absolute value of daily returns. This measure is also winsorized within all ETF sample at both 1% and 99% level at each cross-section. Panel A is for the subsample where all the underlying indices have both 1x and 2x ETFs. If multiple ETFs on an index have the same leverage ratio (e.g., both a 1-time ETF and a –1-time ETF have a leverage ratio of 1), we aggregate the liquidity measures of these ETFs by their value-weighted averages, weighted by the market capitalization of these ETFs on the prior data. Then, for each leverage ratio, we obtain a time series of the three liquidity measures by taking an equal-weighted average across all indices. Panel A reports the time series mean and standard deviation of the three liquidity measures for 1x and 2x ETFs. *Diff: 2x – 1x* is the difference between the means of the liquidity measures of 2x and 1x ETFs. *T* -statistics are reported in parenthesis. Panel B is for the subsample where all the underlying indices have 1x, 2x and 3x ETFs. All definitions are analogous to those for Panel A. Panel C compares the liquidity measures of 1x ETFs across two subsamples. In the first subsample, "w/o 2x ETFs", the underlying indices don't have 2x ETFs. In the second subsample, "w/ 2x ETFs", the underlying indices also have 2x ETFs. *"Diff: w2x – wo2x"* is the difference between the means of the liquidity measures across these two subsamples. *T* -statistics are reported in parenthesis. Panel D compares the liquidity measures of 2x ETFs across two subsamples. In the first subsample, "w/o 3x ETFs", the underlying indices don't have 3x ETFs. In the second subsample, "w/ 3x ETFs", the underlying indices also have 3x ETFs. *"Diff: w3x – wo3x"* is the difference between the means of the liquidity measures across these two subsamples. *T* -statistics are reported in parenthesis. All t-stats are Newey-West adjusted with 3 lags (for *Turnover* and *Liquidity Ratio*) or 20 lags (for *Spread*). The sample period for Panels A and C is from 2006/07 to 2012/02, and the sample period for Panel B and D is from 2009/01 to 2012/02.

Panel A: 1x and 2x ETFs					
		Turnover	**Spread**	**Liquidity Ratio**	# of Indices
1x ETFs	Mean	2.37	0.13%	54.24	15.1
	St. Dev.	*1.00*	*0.19%*	*58.78*	
2x ETFs	Mean	5.70	0.30%	9.07	15.1
	St. Dev.	*3.65*	*0.42%*	*4.76*	
Diff: 2x - 1x		3.332	0.17%	-45.2	
		(5.25)	(5.69)	(-3.38)	
# of dates		68	1447	68	

Panel B: 1x, 2x and 3x ETFs					
		Turnover	**Spread**	**Liquidity Ratio**	# of Indices
1x ETFs	Mean	2.69	0.07%	31.62	5.7
	St. Dev.	1.96	0.09%	17.21	
2x ETFs	Mean	7.73	0.12%	12.13	5.7
	St. Dev.	*4.90*	*0.10%*	*6.35*	
3x ETFs	Mean	10.07	0.34%	4.01	5.7
	St. Dev.	*6.17*	*0.52%*	*1.42*	
Diff: 2x - 1x		5.040	0.05%	-19.480	
		(4.79)	(9.21)	(-4.51)	
Diff: 3x - 2x		2.335	0.22%	-8.128	
		(3.61)	(3.71)	(-5.18)	
# of dates		40	856	40	

Panel C: 1x ETFs					
		Turnover	**Spread**	**Liquidity Ratio**	# of Indices
w/o 2x ETFs	Mean	0.61	0.43%	3.31	585.5
	St. Dev.	*0.19*	*0.44%*	*0.91*	
w/ 2x ETFs	Mean	2.32	0.13%	53.00	15.1
	St. Dev.	*0.96*	*0.19%*	*59.69*	
Diff: w2x – wo2x		1.704	-0.31%	49.7	
		(10.51)	(-7.90)	(3.80)	
# of dates		68	1447	68	

Panel D: 2x ETFs					
		Turnover	**Spread**	**Liquidity Ratio**	# of Indices
w/o 3x ETFs	Mean	2.70	0.34%	2.42	38.3
	St. Dev.	*2.02*	*0.36%*	*1.73*	
w/ 3x ETFs	Mean	7.84	0.12%	12.22	5.7
	St. Dev.	*4.92*	*0.10%*	*6.41*	
Diff: w3x – wo3x		5.143	-0.22%	9.803	
		(6.27)	(-5.12)	(5.04)	
# of dates		40	856	40	

Table 3 Levered ETF Investor Behavior

This table reports coefficients of pooled regressions. In Panel A, we regress *Flow* at month *t* on benchmark *Index Return* at month *t*, at month *t-1* (or *t-1* to *t-3*, *t-1* to *t-12*), *Index Vol* at month *t-1* and *Premium* at month *t-1*. In Panel B, we regress *Index Return* at month *t* is regressing on *Flow* at month *t-1*, *Index Return* at month *t-1* and *Index Vol* at month *t-1*. Panel C regresses Turnover at month *t* on benchmark *Index Return* at month *t and t-1*, *Index Vol* at month *t-1* and ETF *Premium* at month *t-1*. All variables are defined as in Table 1. If an index has both 2-time and 3-time (or, –2-time and –3 time) levered ETFs, we aggregate the measures by taking a value weighted average of the measures across the two ETFs, weighted by the market capitalization of the two ETFs on the prior data. We run the regressions separately for levered long and levered short ETFs. Panel D repeat the regressions in Panels A-C on the 1-time long ETF sample. Standard errors are double clustered within each benchmark index and date times asset type, and *t*-statistics are reported in parenthesis. The sample period spans from 2006/07 to 2012/02 for levered ETF sample, and 1993/02 to 2012/02 for 1x long ETF sample.

Panel A: Regress Flow on past Index Return, Volatility and ETF Premium

	Flow$_t$					
	Long	Long	Long	Short	Short	Short
Index Return$_t$	-1.077	-1.069	-1.147	0.925	0.925	0.943
	(-3.73)	(-3.45)	(-3.42)	(2.86)	(2.74)	(2.80)
Index Return$_{t-1}$	-0.304			0.824		
	(-1.70)			(2.02)		
Index Return$_{t-1, t-3}$		-0.179			0.200	
		(-1.95)			(1.26)	
Index Return$_{t-1, t-12}$			-0.046			0.063
			(-0.75)			(1.06)
Index Vol $_{t-1}$	3.528	1.820	2.123	4.349	2.619	0.898
	(3.08)	(1.45)	(1.73)	(1.67)	(1.42)	(0.53)
Premium$_{t-1}$	2.654	1.781	1.952	0.503	2.626	4.500
	(1.33)	(1.90)	(1.82)	(0.16)	(0.89)	(1.27)
R2	0.07	0.06	0.06	0.02	0.02	0.02
# of obs.	2344	2222	1690	2344	2222	1690

Panel B: Regress Index Return on past Flow

	Index Return$_t$	
	Long	Short
Flow$_{t-1}$	-0.019	0.005
	(-2.44)	(0.89)
Index Return$_{t-1}$	0.049	0.060
	(0.44)	(0.54)
Index Return$_{t-1, t-12}$	-0.041	-0.042
	(-1.33)	(-1.35)
Index Vol $_{t-1}$	-1.292	-1.441
	(-1.66)	(-1.86)
R2	0.06	0.05
# of obs.	1690	1690

Panel C: Regress Turnover on past Index Return, Volatility and ETF Premium		
	$Turnover_t$	
	Long	Short
$Index Return_t$	-6.046	-10.446
	(-1.22)	(-1.10)
$Index Return_{t-1}$	4.508	-5.904
	(0.99)	(-0.58)
$Index Vol_{t-1}$	250.302	551.016
	(2.36)	(3.91)
$Premium_{t-1}$	-26.798	-79.393
	(-0.92)	(-1.41)
R2	0.06	0.16
# of obs.	2345	2345

Panel D: 1x long ETFs sample					
	$Flow_t$	**$Flow_t$**	**$Flow_t$**	**$Index Return_t$**	**$Turnover_t$**
$Index Return_t$	0.138	0.148	0.213		-0.334
	(2.16)	(2.15)	(5.34)		(-1.05)
$Index Return_{t-1}$	0.239			0.120	0.676
	(4.30)			(1.17)	(1.53)
$Index Return_{t-1,t-3}$		0.155			
		(2.92)			
$Index Return_{t-1,t-12}$			0.003	-0.023	
			(0.24)	(-1.04)	
$Index Vol_{t-1}$	0.067	0.619	-0.103	-0.586	25.364
	(0.20)	(1.97)	(-0.44)	(-0.95)	(5.50)
$Premium_t$	1.757	1.507	1.501		-0.716
	(5.06)	(4.58)	(4.67)		(-0.41)
$Flow_{t-1}$				-0.001	
				(-2.22)	
R2	0.00	0.00	0.01	0.02	0.03
# of obs.	42865	41228	34390	36385	42870

Table 4 Long-Long Portfolio Returns

This table reports monthly return of long-long portfolios, based on *Price Return* and *NAV Return*. *GAP* equals to *Price Return* minus *NAV Return*. We report time-series average of cross-section mean returns, both equal weighted and value weighed (by the sum of market capitalization of each pair at the beginning of each month). Panel A uses the full sample from 2006/07 to 2012/02, and Panel B reports the results by sub-samples. Panel C reports the results by different asset categories. Panel D value weights return performance within each pair by each side's last month capitalization. Newey-West *t*-statistics with lag of 3-month are reported in parenthesis.

Panel A: full sample

	Value-Weighted			Equal-Weighted			# of pairs
	Price Return	**NAV Return**	**GAP**	**Price Return**	**NAV Return**	**GAP**	
Long Long	-0.209%	0.014%	-0.224%	-0.165%	0.008%	-0.173%	42.38
	(-2.00)	(0.29)	(-2.60)	(-2.10)	(0.15)	(-2.88)	
# of Dates	68	68	68	68	68	68	

Panel B: by sub-samples

07/2006 to 04/2009	Value-Weighted			Equal-Weighted			# of pairs
	Price Return	**NAV Return**	**GAP**	**Price Return**	**NAV Return**	**GAP**	
Long Long	-0.143%	0.185%	-0.328%	-0.089%	0.184%	-0.273%	23.08
	(-0.71)	(3.34)	(-2.05)	(-0.60)	(3.18)	(-2.48)	
# of Dates	34	34	34	34	34	34	
05/2009 to 02/2012				Equal-Weighted			# of pairs
	Price Return	**NAV Return**	**GAP**	**Price Return**	**NAV Return**	**GAP**	
Long Long	-0.274%	-0.156%	-0.118%	-0.240%	-0.168%	-0.072%	61.67
	(-7.84)	(-33.99)	(-3.66)	(-9.16)	(-30.21)	(-3.29)	
# of Dates	34	34	34	34	34	34	

Panel C: by asset categories

	Value-Weighted			Equal-Weighted			# of pairs
Long Long	**Price Return**	**NAV Return**	**GAP**	**Price Return**	**NAV Return**	**GAP**	
Stock	-0.192%	0.017%	-0.209%	-0.147%	0.018%	-0.166%	30.73
	(-1.84)	(0.34)	(-2.39)	(-1.90)	(0.36)	(-2.69)	
Bond	-0.181%	-0.169%	-0.012%	-0.207%	-0.181%	-0.026%	3.63
	(-5.37)	(-8.45)	(-0.57)	(-8.59)	(-13.33)	(-1.73)	
Commodity	-0.693%	-0.230%	-0.462%	-0.448%	-0.250%	-0.198%	5.53
	(-3.78)	(-23.04)	(-2.57)	(-6.21)	(-10.99)	(-2.85)	
International	-0.421%	-0.229%	-0.193%	-0.338%	-0.195%	-0.144%	9.41
	(-7.03)	(-6.61)	(-3.14)	(-7.03)	(-7.03)	(-2.52)	
Currency	-0.081%	-0.089%	0.008%	-0.080%	-0.087%	0.007%	1.93
	(-3.13)	(-34.61)	(0.30)	(-3.18)	(-42.05)	(0.30)	

Panel D: value-weighted within each pair

	Value-Weighted			Equal-Weighted			# of pairs
	Price Return	**NAV Return**	**GAP**	**Price Return**	**NAV Return**	**GAP**	
Long Long	-0.197%	-0.003%	-0.194%	-0.156%	-0.066%	-0.090%	42.38
	(-1.66)	(-0.03)	(-3.08)	(-1.85)	(-0.91)	(-2.82)	
# of Dates	68	68	68	68	68	68	

Table 5 Cross-Section of Long-Long Portfolio Returns

This table reports cross sectional variations of long-long portfolio return performance on each pair's last month *Turnover*, *Cap*, *Index Vol*, *Leverage*, *Premium*, and *IO*. All variables are defined as in Table 1. Panel A reports results of portfolio sorts. Each month all pairs of levered ETFs are sorted into two halves (High and Low) based on each variable, then implement daily rebalanced long-long strategy within each group. Panel B reports coefficient estimation of Fama-Macbeth regression. Newey-West *t*-statistics with lag of 3-month are reported in parethesis. The sample period spans from 2006/07 to 2012/02.

Panel A: portfolio sorts

Sort on last month Index Vol	**Price Return**	**NAV Return**	**GAP**	*Sort on Leverage*	**Price Return**	**NAV Return**	**GAP**
High	-0.344%	-0.046%	-0.298%	**High**	-0.491%	-0.206%	-0.285%
	(-2.54)	(-0.86)	(-2.30)		(-3.75)	(-22.02)	(-2.15)
Low	-0.089%	-0.021%	-0.068%	**Low**	-0.276%	-0.155%	-0.121%
	(-1.46)	(-0.44)	(-2.15)		(-5.54)	(-26.61)	(-2.61)
Hi - Lo	-0.255%	-0.025%	-0.230%	**Hi - Lo**	-0.215%	-0.051%	-0.164%
	(-2.78)	(-1.75)	(-2.26)		(-2.55)	(-5.29)	(-1.86)
# of Dates	61	61	61	# of Dates	40	40	40

Sort on last month average Premium of the pair	**Price Return**	**NAV Return**	**GAP**	*Sort on last month average Cap of the Pair*	**Price Return**	**NAV Return**	**GAP**
High	-0.401%	0.018%	-0.419%	**High**	-0.215%	0.005%	-0.219%
	(-3.99)	(0.33)	(-4.35)		(-2.09)	(0.09)	(-2.66)
Low	0.093%	-0.002%	0.095%	**Low**	-0.103%	0.006%	-0.109%
	(1.25)	(-0.04)	(2.09)		(-1.25)	(0.12)	(-1.74)
Hi - Lo	-0.494%	0.020%	-0.513%	**Hi - Lo**	-0.112%	-0.001%	-0.110%
	(-7.06)	(1.20)	(-6.34)		(-2.60)	(-0.20)	(-2.44)
# of Dates	67	67	67	# of Dates	67	67	67

Sort on last month average Turnover of the pair	**Price Return**	**NAV Return**	**GAP**	*Sort on last month average IO of the pair*	**Price Return**	**NAV Return**	**GAP**
High	-0.247%	-0.006%	-0.242%	**High**	-0.202%	-0.025%	-0.177%
	(-2.22)	(-0.11)	(-2.69)		(-2.01)	(-0.47)	(-1.78)
Low	-0.090%	0.016%	-0.106%	**Low**	-0.237%	-0.043%	-0.194%
	(-1.30)	(0.31)	(-1.80)		(-2.82)	(-0.81)	(-3.08)
Hi - Lo	-0.157%	-0.022%	-0.135%	**Hi - Lo**	0.035%	0.018%	0.017%
	(-2.46)	(-3.80)	(-2.11)		(0.58)	(1.28)	(0.25)
# of Dates	67	67	67	# of Dates	57	57	57

Panel B: Fama-Macbeth Regression

	Price Return$_t$	**NAV Return$_t$**	**GAP$_t$**
Average CAP$_{t-1}$	0.000	0.000	0.000
	(0.45)	(0.96)	(0.14)
Average Turnover$_{t-1}$	0.000	0.000	0.000
	(0.27)	(0.98)	(0.14)
Index Vol$_{t-1}$	-0.207	-0.022	-0.185
	(-3.72)	(-0.82)	(-2.68)
Average Premium$_{t-1}$	-0.870	-0.002	-0.869
	(-9.30)	(-0.13)	(-9.48)
Leverage$_{t-1}$	-0.001	0.000	-0.001
	(-2.35)	(-3.25)	(-1.44)
Average IO$_{t-1}$	-0.001	0.000	-0.001
	(-1.23)	(-0.71)	(-1.08)
R2	0.51	0.25	0.53
# of Dates	61	61	61

Table 6 Under-reaction Estimation

Panel A reports results of pooled regressions. The independent variable is daily ETF price *Return* on day *t*. The dependent variables are *NAV Return* at day *t*, and *Premium* at day *t-1* or 5 lags of daily *NAV Return*. Regressions are run separately on levered long ETF and levered short sample. Standard errors are double clustered within each benchmark index and date, and *t*-statistics are reported in parenthesis (null hypothesis as indicated). Panel B reports distribution of the estimates of the coefficients in equations (1) and (2). This sample only includes US equity levered ETFs from 2006/07 to 2012/02.

Panel A: pooled regression

		$Return_t$			
		Long	Short	Long	Short
$NAV\ Return_t$		0.944	0.951	0.940	0.948
	H0:=1	(10.03)	(9.50)	(9.36)	(9.71)
$Premium_{t-1}$		-0.988	-0.923		
	H0:=1	(-0.55)	(-1.86)		
$NAV\ Return_{t-1}$				0.054	0.046
	H0:=0			(8.39)	(8.30)
$NAV\ Return_{t-2}$				0.003	0.002
	H0:=0			(1.02)	(0.69)
$NAV\ Return_{t-3}$				-0.001	-0.002
	H0:=0			(-0.42)	(-0.72)
$NAV\ Return_{t-4}$				0.003	0.002
	H0:=0			(1.03)	(0.58)
$NAV\ Return_{t-5}$				-0.001	0.000
	H0:=0			(-0.44)	(-0.09)
p-value of F-test				*0.466*	*0.295*
H0: Sum of coefficients of 5 NAV return lags = 1					
R2		0.98	0.98	0.95	0.96
# of observations		43738	43590	43738	43590

Panel B: Distribution of individual ETF's under-reaction coefficient

	Mean	**St Dev**	**25%**	**Median**	**75%**	**# of pairs**
Levered Long ETF						
β : Coefficient of $NAV\ Return_t$	0.955	0.046	0.940	0.967	0.984	
γ : Coefficient of $Premium_{t-1}$	-0.971	0.139	-1.066	-0.971	-0.876	
Levered Short ETF						
β : Coefficient of $NAV\ Return_t$	0.960	0.042	0.945	0.971	0.985	
γ : Coefficient of $Premium_{t-1}$	-0.960	0.121	-1.046	-0.961	-0.879	
Pair Average						
$(1-\beta)*\gamma$: Under-reaction Coefficient	0.041	0.040	0.016	0.030	0.057	29.1

Table 7 GAP, Under-reaction and Index Volatility

This table shows estimation of pooled regressions. *High Under-reaction* is a dummy variable which equals to one if the pair's average $\mathbf{UDR_t}$ is higher than sample median in that month, otherwise zero. *Index Vol$_t$*High Under-reaction* is the interaction term of *Index Vol* and *High Under-reaction*. Standard errors are double clustered within each benchmark index and date, and *t*-statistics are reported in parenthesis. This sample only includes US equity levered ETFs from 2006/07 to 2012/02.

		GAP_t	
Index Vol$_t$	-0.346	-0.152	-0.164
	(-5.66)	(-4.71)	(-5.93)
High Under-reaction$_t$	-0.002	0.004	0.003
	(-3.38)	(3.93)	(3.56)
Index Vol$_t$*High Under-reaction$_t$		-0.349	-0.297
		(-4.90)	(-4.82)
Average Premiun$_{t-1}$			-1.071
			(-12.54)
Leverage$_t$			-0.001
			(-1.80)
R2	0.27	0.33	0.56
# of obs	1917	1917	1917