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Performance of ProShares Triple-Leveraged Equity ETFs

Ramesh Adhikari[1*], Humnath Panta[1] & M. Kabir Hussan[2]
[1]*School of Business, Humboldt State University, USA.*
[2]*Department of Economics and Finance, University of New Orleans, USA.*

Abstract: Research Question: How well do triple leveraged exchange-traded funds (ETFs) issued by ProShares perform and track their underlying indices? **Motivation:** Prior research on the relative performance and tracking ability of leveraged and inverse ETFs (LETFs) is not conclusive. We re-examine and extend the findings of prior research (Charupat and Miu, 2011; Loviscek *et al.*, 2014). We have a unique set of LETFs, more recent and historical price data over a longer sample period, and a unifying methodological framework. Our findings help many investors understand the implications of including LETFs in their portfolios for up to six months. **Idea:** We examine how well LETFs achieve their objectives using mean deviations and tracking errors of cumulative and holding period returns over various non-overlapping holding periods. Our holding period ranges from one day to six months. We also study how much LETFs deviate from their benchmark indices during high volatile markets. **Data:** We use daily prices of LETFs and values of their underlying indices from the inception date of each LETF to May 29, 2020. We have data for 2,749 trading days. We retrieve all data from Money.net. **Method/Tools:** We use three sets of statistical tools to examine the return deviations. They include univariate tests, pooled regression-based alphas, betas, and tracking errors and bootstrapping. **Findings:** Although tracking errors increase with the number of holding periods, LETFs do well up to six months, and the magnitude of deviations are different for bull and bear ETFs. But, LETFs fail to deliver promised returns during high volatile markets. Our findings complement some prior research and contrast with others and bring some new insights on the performance of LETFs. **Contributions:** We provide new evidence that LETFs provide premiums or discounts beyond one month up to six months, but they fail to track their indices during high volatile markets.

Keywords: ETFs, LETFs, leveraged, inverse, performance, tracking error.
JEL classification: G10, G11, G14

1. Introduction

The leveraged and inverse exchange-traded funds (LETFs) were introduced in the United States in 2006. They differ from the traditional exchange-traded funds (ETFs) because they attempt to provide investors a multiple of the daily return of an underlying index. Typically, the majority of LETFs seeks to match the performance of -1×, ±2×, and ±3× the daily return of their benchmark indices. To achieve the stated results, LETFs use complex financial

* Corresponding author: Ramesh Adhikari. Tel.: 707-8265805. Email: ramesh.adhikari@humboldt.edu

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products such as futures, swaps, and other derivatives. Since the introduction of LETFs in the US market in 2006, LETFs on major equity indices and funds have become increasingly popular for several reasons. First, they allow investors to increase their market exposure without a margin account, and any expertise in leveraging or derivative securities (Shum and Kang, 2013). Second, they serve as an alternative for short-selling when underlying assets are restricted for short-selling, complicated, and expensive to borrow. Finally, they permit investors to execute hedge fund-like strategies with the liquidity and convenience of an ETF (Tang and Xu, 2013).

Because of the popularity of LETFs, the number of LETFs are rapidly increasing in the markets. According to ETFdb.com, there were only eight LETFs in 2006. However, the number of LETFs has risen to 200 in 2020. These LETFs aim to provide multiple of -3 × to +4× to their benchmark indices and cover a wide range of markets such as a bond, currency, commodity, equity, multi-assets, real estate and volatility markets with $44.16 billion assets under management (AUM) as of May 29, 2020. As of May 29, 2020, there are 149 equity LETFs with $36.89 billion in total AUM, 74 double LETFs with $11.45 billion AUM, and 70 triple LETFs with $25.41 billion AUM globally[1].

Although LETFs have been tremendously popular financial products, there are concerns that LETFs may not provide the stated returns. There are still many investors who do not know how well LETFs achieve their target returns when they are held for more than a one-day holding period. Statements written in the prospectus by the LETFs issuers make these products even more complex to understand. For example, in a recent article written by staff at Direxion[2], one of the pioneers of LETFs issuers, also suggests seeking some advice from an investment professional before making an investment in their leveraged ETFs. Similarly, the following excerpt from ProShares' fact sheet also warns investors about returns deviations if LETFs are held for more than a day:

"Due to the compounding of daily returns, holding periods of greater than one day can result in returns that are significantly different than the target return and ProShares' returns over periods other than one day will likely differ in amount and possibly direction from the target return for the same period. These effects may be more pronounced in funds with larger or inverse multiples and in funds with volatile benchmarks. Investors should monitor their holdings as frequently as daily."[3]

Prior empirical studies also cast doubt on the promised returns of LETFs. For instance, using the actual historical data of LETFs from 2006 to 2008, Lu *et al.* (2012) document that the inverse double leveraged exchange-traded fund fails to provide twice the performance of the benchmark index if the holding period is more than one quarter. Similarly, Hill and Foster (2009) examine the history of the SPX, an ETF that tracks S&P 500 Index, and find that the compounding effect is neutral to LETF returns. These concerns have led lawsuits from investors and warning from federal regulators such as the Financial Regulatory Industry Authority (FINRA) and the Securities and Exchange Commission (SEC) to leveraged ETF issuers (SEC, 2009)[4]. The popularity of LETFs has also drawn the attention of academics and researchers. However, the research on LETFs is in its preliminary stage (Charupat and Miu, 2013). The prior studies on LETFs focus on pricing and the performance (Charupat and Miu, 2011), methods to measure the performance (Charupat and Miu, 2014), return and multiple deviations (Loviscek *et al.*, 2014; Tang and Xu, 2013), path dependence (Avellaneda and

[1] See Etfdb (2020) for details. We calculate the AUM using data from Etfdb.com.
[2] Direxion (2020) See Understanding Leveraged Exchange-Traded Funds available at https://www.direxion.com/education/understanding-leveraged-exchange-traded-funds
[3] See ProShares (2020) for details.
[4] See the warnings from the SEC on leveraged ETFs for details https://www.sec.gov/investor/pubs/leveragedetfs-alert.htm.

Zhang, 2010) and tracking error decomposition and return attribution (Bansal and Marshall, 2015).

Several recent studies on LETFs motivate us to investigate the performance of LETFs further. For instance, Rompotis (2012), using 28 leveraged and 40 inverse ProShares funds tracking both domestic and international equity markets, sectors, and commodities, concludes that the funds under consideration meet their target leveraged returns on a daily basis using net asset value, but the results are weak using closing prices. However, Charupat and Miu (2011) find that the tracking errors are small for holding periods up to a week but becomes increasingly more significant for longer horizons. Loviscek *et al*. (2014), using simulated Dow Jones Industrial Average, find that LETFs target returns over various holding periods perform mainly in line with and no worse than their naïve expected returns. Similarly, Bansal and Marshall (2015) argue that LETFs are suitable for long-term investors despite their more substantial tracking errors.

It is not conducive to draw a conclusion about the performance of LETF based on the concerns and prior research findings, mainly for four reasons. First, the warnings from the regulatory agencies are based on a short sample. Second, the financial crisis was a unique event, and the generalizations from an exclusive event could be misleading. Third, most prior studies either use a simulated sample or use a limited sample period. Fourth, most previous research use only compounding returns on their analysis rather than stated return based on a daily basis, as indicated by the issuers. Finally, a comprehensive framework and appropriate sample period to determine the performance of a broad-based LETFs with different holding period frequencies over various holding periods are yet to be provided.

Complementing and building on the prior research, we construct a comprehensive framework to examine the performance of LETFs using both compounding and holding period returns for various non-overlapping investment periods. Specifically, we evaluate the performance of both bull and bear ETFs relative to their benchmark indices for different holding periods using a more extended sample period (inception date of respective LETF to May 29, 2020). We examine ten triple leveraged ETFs issued by ProShares, one of the largest providers of LETFs. In specific, we consider the performance of LETFs for different time horizons (namely daily, two days, three days, four days, one week, two weeks, three weeks, one month, two months, three months, and six months) using cumulative and holding period returns over non-overlapping time intervals.

Our findings can be summarized in five main points. First, both bull and bear ETFs provide returns more than the returns implied by the index for most of the time horizons considered. Bear ETFs deviate more from its underlying benchmark indices than their counter bull ETFs. Our findings are consistent with many prior studies (see. Charupat and Miu 2011; Shum and Kang, 2013; Lu *et al.*, 2012; Jiang and Peterburgsky, 2017; Zhang, 2018; Tsalikis and Papadopoulos, 2018) but also show that LETFs deliver stated multiple up to six months. Since we use non-overlapping time interval and regression analysis, we cannot test whether LETFs are suitable for buy-and-hold investors over six months.

Second, averages and standard deviations of the differences between the returns of LETFs and three times the index returns get more extensive as the number of holding period increases, which is consistent with many prior studies (Charupat and Miu, 2011; Shum and Kang, 2013; Tang and Xu, 2013). Third, during high volatile markets, the average deviations between the returns of LETFs and three times the index are much larger than average differences during the whole period. Fourth, the discrepancy between the bear ETFs and underlying index return is much larger than the disparity between the bull ETFs and underlying index returns during the high market volatility periods if the holding period is more than one day. Finally, when the market rises or declines steadily, LETFs amplify the returns of an underlying index by a higher multiple.

We also document that the discrepancy between the bear and underlying index returns is much more significant than the disparity between the bull ETFs and underlying index returns during high market volatility periods, particularly during the COVID-19 crisis. Our findings indicate that LETFs, no matter what direction, will destroy investors' wealth over time if they hold for a more extended period if the market is highly volatile.

Although our results support the view that LETFs are good for investing up to six months despite their large tracing errors, our findings do not imply that LETFs are good for long-term investors because of their nature of construction. They should be interpreted in a historical perspective, not as the future returns. For example, a 5% decrease (increase) after a 5% increase (decrease) on $100 is different. Therefore, during the volatile markets, LEFTs can lose a significant value even if the market is not moving to either direction. For example, if the value of the market index is 100 and it changes by 5 points each day (one day up and the next day down) for the next 20 days, the overall value of the market index will still be 100. However, the value of LEFTs would change significantly. That is, if we assume that the starting values of both bull and bear ETFs are 100, the value of the bull ETF would be approximately 86.66, and the value of bear ETF would be approximately 74.80 at the end of the 20-day cycle. Therefore, one must be very careful while investing in these LETFs.

Our research makes a significant contribution in many ways. First, prior research on LETSs either simulate data (e.g., Jiang and Peterburgsky, 2017) or use minimal study period (e.g., Charupat and Miu, 2011; Tang and Xu, 2013), and their findings are not conclusive. As the triple LETFs are new products, there is a need for more comprehensive research to understand their characteristics and underlying risk for investing. Notably, we explicitly focus on the most liquid ProShares triple LETFs and use approximately eleven years of data. To our knowledge, none of the prior studies exclusively study these products and use the most recent and longer time horizon sample. Second, we follow a unique approach in the sense that we look at not only compounding returns (focus of most prior studies) but also consider other types of returns such as the same-day returns, overnight returns and holding period returns, and use a panel data framework to examine performance and the tracking error of LETFs, unlike using individual LETF in the prior research. Third, we evaluate the performance of LETFs for different non-overlapping time horizons. No prior studies examine the broad set of time horizons and use both cumulative and holding period return on their analysis. Finally, we also perform bootstrapping technique to examine the unique behaviour of LETFs during high volatile markets as well as steadily rising or declining markets. Thus, our research fills the void on the research on LETFs by documenting the performance of LETFs relative to their benchmark indices using more comprehensive framework, methodologies, and data.

The remainder of the paper is organized as follows. Section 2 provides a brief synopsis of existing literature. Section 3 describes the data and methodological approach. Section 4 describes our results. Finally, section 5 concludes the paper.

2. Literature

Although LETFs were introduced in financial markets a decade ago, the research in this area is still in its preliminary stage. The existing literature on LETFs provides mixed and contradictory empirical evidence on whether they are suitable products for a short and long-term investor. In this section, we provide a brief review of the existing literature on LETFs.

Avellaneda and Zhang (2010) model the relationship between LETFs returns and the returns of the underlying indices and make a case that LETFs are unsuitable for buy-and-hold investors, which is also consistent with the finding of Cheng and Madhavan (2009). However, Charupat and Miu (2011) and Shum and Kang (2013) find that LETFs deliver stated multiple up to one week, but the tracking error starts to get more substantial and statistically significant for a holding period greater than one week. They also show that bear EFTs return deviations

are different from bull ETFs. Lu *et al.* (2012) examine the path dependence of US LETFs in their performance. The authors find that returns on the funds are close to the expected multiples for investors with less than the one-month horizon but unsuitable for long-term investors who employ buy and hold strategies. Tang and Xu (2013) find that return deviations increase with the size of holding periods; as the holding period increases, so does the compounding deviation.

Paudel *et al.* (2020) examine the downside risk associated with three different demographic subgroups: gender, income levels, and the education levels based on their consumer sentiment index (CSI) from the passive investment in the exchange-traded funds' (ETFs). Their results show that the risk associated with investor sentiment is short-lived (up to 18 months) depending upon the investors' demographic characteristics. They find that individual female investors are more risk-averse and have longer-lasting CSI influence in comparison to the individual male investors. The findings also show that the more educated the investors are, the stronger the impact of negative sentiment on the downside risk premium for ETF returns. However, the investors of medium-income levels have a higher and statistically significant CSI impact.

Jiang and Peterburgsky (2017) analyse investment strategies using LETFs by simulating daily returns over 48 years and document that LETFs investment strategies significantly outperform the S&P 500 on a risk-adjusted basis. Zhang (2018) examines whether LETFs products have historically behaved the way they intended by design using five years' daily returns of the top 10 largest LETFs. The author finds that the levered products appear to deliver magnified gains and losses as intended over the entire sample period. Ivanov and Lenkey (2018) evaluate whether LETFs amplify late-day return and volatility. Using a sample of US equity-based LETFs from 2006 to 2014, the authors find no impact of LETFs holding period on late-day returns volatility when accounting for capital flows and standard risk factors. Tsalikis and Papadopoulos (2018) assess the performance of American and European leveraged ETFs since each fund's inception date to April 28, 2017. The authors show that LETFs perform as indented for daily holding periods. They also find that LETFs perform as intended for the holding period up to a week, but the performance starts deviating when the holding period increases to one month. They find that the bear ETFs deviation from their target returns more quickly than their bull counterparts as the holding period lengthens.

Overall, most prior studies use a very short study period and find mixed and contradictory results. Based on the previous research findings, it is difficult to draw a conclusion regarding both the short and long-term performance of LETFs. Therefore, it is crucial to develop a comprehensive framework and use long-term data to evaluate the performance and tracking error of the leveraged ETFs. In this paper, we attempt to fill the void in LETFs literature.

3. Data and Methodology

3.1 Data and Variables Constructions

In this paper, we examine ten different triple leveraged ETFs issued by ProShares. These leveraged ETFs seek to provide three times the returns of the benchmark index on a daily basis (measured from one NAV calculation to the next) before fees and expenses. The bull leveraged ETFs include SRTY, UPRO, UMDD, TQQQ, and UDOW. They track Russell 2000, S&P 500, S&P MidCap 400, Nasdaq-100, and Dow Jones Industrial Average respectively and seek to provide three times the returns of the benchmark index on a daily basis before fees and expenses. Similarly, the bear leveraged ETFs include SRTY, SPXU, SMDD, SQQQ, and SDOW. They are designed to follow Russell 2000, S&P 500, S&P MidCap 400, Nasdaq-100, and Dow Jones Industrial Average respectively and seek to provide negative three times returns of these indices on a daily basis. The sample period ranges from the inception of each LETFs to May 29, 2020. We retrieve the daily prices of LETFs and

indices from Money.Net. Our final sample includes daily prices of LETFs and values of their underlying indices for 2,749 trading days consisting of 13,108 observations.

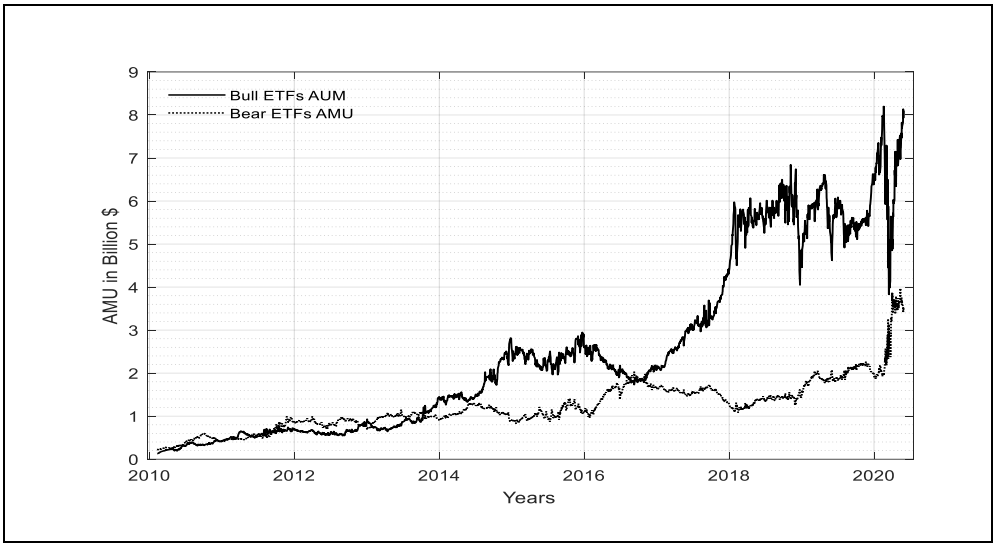

Figure 1: Assets under management

We present the asset under management for all ten LETFs that are included in this study. As shown in Figure 1, the asset under management, particularly for bull LETF in our sample, has been increasing rapidly since 2010, and the growth for bull ETFs has been growing at a higher rate than bear ETFs.

We compute returns as the same-day returns, overnight returns, night plus day returns, cumulative returns (CR), and holding period returns (HPR). The same day returns are computed as the percentage change in the prices from open to close on the same day. The overnight daily returns are calculated using open prices on date t and close prices on date t-1 day. Night plus day daily returns are computed by adding overnight returns and same-day returns. Similarly, continuous daily returns are calculated as a percentage change in the closing prices and holding period returns are calculated as a percentage change in the prices from beginning to end period of any time interval considered. The n-day cumulative return on any security S, is calculated as $\sum_{t=1}^{n} r_d$, where r_t is the percentage change in prices on time *t* from *t-1*. The n-day holding period return on the security S, is calculated as $S_t/S_{t-n} - 1$. The value at risk (VaR) is computed as 5% quintile of the empirical return distribution and conditional value at risk (CVaR) is computed as averages of all returns less than VaR.

To examine how closely LETFs track the benchmark indices, following prior research (Charupat and Miu, 2011; Loviscek *et al.*, 2014), we define return deviation (RD) between the index and associated LETFs as $Returns\ on\ LETF - l \times 3 \times Index\ returns$, where $l = 1$ for bull ETFs and $l = -1$ for inverse ETFs.

3.2 Methodology

We use three different tools to examine the tracking ability of LETFs. The first set of tools includes univariate tests. We compute RD variables for different types of returns (same day returns, overnight returns, night plus day returns, cumulative returns, and holding period returns) and test whether their averages for different investment periods are different from zero. We consider eleven investment horizons: daily, two days, three days, four days, one week, two weeks, three weeks, one month, two months, three months, and six months. The

choices of these time horizons are based on the assumption that LETFs are designed for short-term investment. All these time intervals are considered on non-overlapping time intervals.

Second, we estimate alphas, betas, and tracking errors using pooled regressions. Since our goal is to examine LETFs together rather than analyzing them individually, we use pooled regressions. We carry out this analysis in three steps for bull ETFs and bear ETFs separately. First, we compute non-overlapping cumulative returns and holding period returns for each LETF and each index for different time horizons. Second, we estimate the following regression model for each time horizon considered:

$$LETFR_{it} = \alpha + \beta\, INDR_{it} + \varepsilon_{it} \quad (1)$$

where $LETFR_{it}$ is either cumulative returns or holding period returns on LETFs, $INDR_{it}$ is cumulative returns or holding period returns on benchmark indices, ε_{it} is the error term, α is an unobservable effect, and β is an unknown parameter. We analyse the values of α and β to analyse whether LETFs are successful in keeping their promises. The value of α is expected to be zero for both bull and bear ETFs and β is 3 for bull ETFs and -3 for bear ETFs.

Third, we compute pool regression-based tracking errors and confidence intervals. Tracking errors are computed as the standard deviation of the error terms from each regression, and 95 percent confidence intervals are computed using Chi-square (χ^2) distribution or normal distribution as we have a large number of observations.

Finally, we use bootstrapping to examine the performance of LETFs during high volatile markets. We drop index returns with an absolute value of less than 2 percent on a daily basis. This cut-off value is based on a 90% confidence interval of a normal distribution, which yields 983 observations. Using bootstrapping technique, we resample observations 10,000 times with replacement and compute mean deviations of a single day to multiple days cumulative returns. Then we compute the mean, the standard deviations, and their 95 percent confidence intervals. We are also interested in LETFs performance in steadily rising and falling markets[5]. Therefore, we further divide high volatile market returns into two sub-samples, one with all negative returns and the other with all positive returns. Using these two sub-samples, we examine how LETFs track their indices during steadily rising markets (all positive returns) and steadily falling markets (all negative returns). Again, we resample daily returns 10,000 times with replacement and compute averages and tracking errors of the return deviations for six different time horizons, one day, two days, three days, four days, one week and two weeks.

4. Results

We present the main results of our analysis in the following two sub-sections. Section 4.1 presents descriptive statistics of the indices and LETFs and results from return performance and tracking error analysis using data from the entire sample. Section 4.2 provides results from the analysis of LETFs during high volatile markets.

4.1 Performance and Tracking Error of LETFs

Figure 2 depicts the average cumulative returns of LETFs and the market indices over different holding periods. Cumulative returns of inverse ETFs are multiplied by -1 to adjust for the scale. We observe that the average cumulative returns of both bear and bull ETFs are higher than the three times the index returns. LETFs amplify the returns of the underlying indices. The discrepancy between the cumulative returns of LETFs and their indices increases as the number of holding periods increases, and the divergence of average cumulative return

[5] For details on steadily rising and falling markets see Direxion (2020) Understanding Leveraged Exchange-Traded Funds available at https://www.direxion.com/education/understanding-leveraged-exchange-traded-funds

of the bear ETFs from the index's average cumulative returns is higher than that of the bull ETFs.

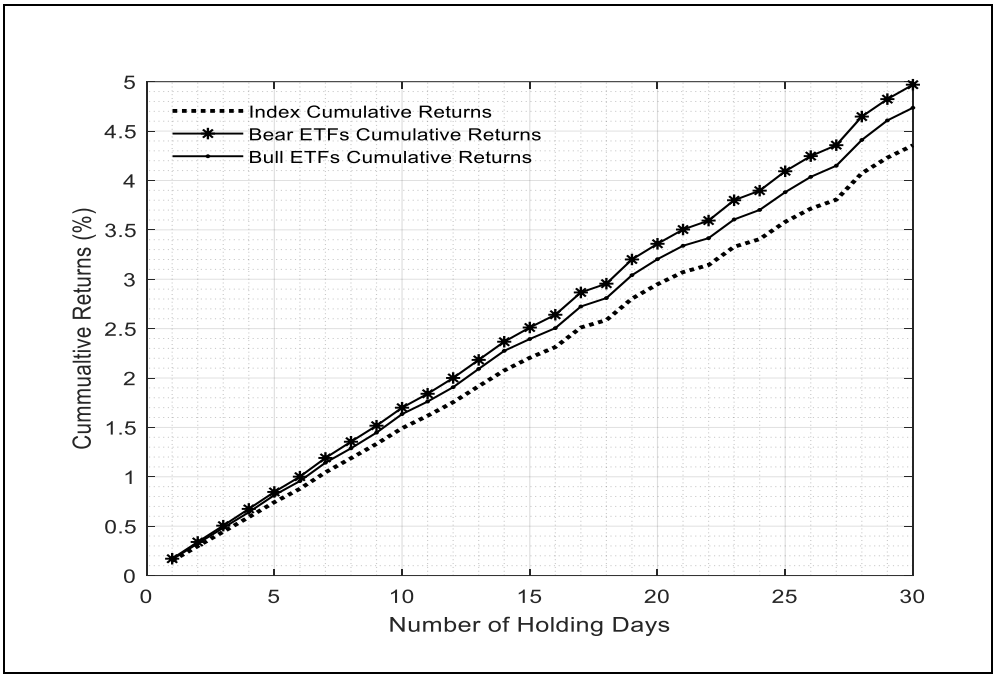

Figure 2: Average cumulative returns of LETFs and indices over different holding periods

Table 1 presents different characteristics and descriptive statistics of LETFs and their respective benchmark indices included in our sample. Panel A presents statistics associated with Russell 2000, S&P 500, and S&P Mid-cap 400 indices and associated LETFs, whereas Panel B presents summary statistics for NASDAQ and Dow Jones indices and the associated LETFs. The table shows that average daily returns and average returns on various holding periods for LETFs are not precisely three times the returns on the underlying indices. LETFs associated with NASDAQ 100 and S&P 500 have higher assets under management. For example, as of May 2020, TQQQ has $ 5.9 billion, SQQQ has $ 1.1 billion, UPRO has $1.4 billion, and SPXU has $1.2 billion assets under management. All average returns and standard deviations are reported in percentages. Russell 2000 has the highest daily standard deviation (1.42) followed by S&P Mid-Cap 400 (1.27). NASDAQ 100 has the highest daily average returns (0.07%), the highest average daily return to standard deviation ratio (0.06%), and the highest holding period returns (430%). The table also reports value at risk (VaR) and conditional value at risk (CVaR). Based on these measures, Russell 2000 is the riskiest index, and Dow 30 is the least risky index.

Table 1: LETFs characteristics and descriptive statistics

Description	Russell 2000	URTY	SRTY	S&P 500	UPRO	SPXU	S&P Mid-Cap 400	UMDD	SMDD
Panel A: Russell and S&P Indices and LETFs									
Inception date		2/9/2010	2/9/2010		6/23/2009	6/23/2009		2/9/2010	2/9/2010
# of holdings		1,960	1,956		505	505		400	399
AUM as of May 2020 (million)		$174.23	$181.88		$1,373.48	$1,328.34		$20.95	$14.69
Expense ratio		0.95%	0.95%		0.92%	0.91%		0.95%	0.95%
Avg. daily trading volume (million)		4.39	1.85		17.17	38.67		0.03	0.10
Avg. daily returns	0.04	0.17	-0.15	0.05	0.16	-0.17	0.04	0.13	-0.14
Avg. one week returns	0.19	0.78	-0.74	0.24	0.76	-0.86	0.20	0.62	-0.71
Avg. two weeks returns	0.38	1.53	-1.46	0.48	1.57	-1.70	0.39	1.16	-1.37
Avg. three weeks returns	0.48	1.99	-2.06	0.67	2.08	-2.57	0.51	1.50	-1.98
Avg. one month returns	0.80	3.20	-3.67	1.00	3.03	-3.98	0.83	2.43	-3.51
Avg. two months returns	1.10	4.81	-6.07	1.75	5.19	-7.25	1.22	3.67	-5.91
Avg. three months returns	1.91	7.97	-10.09	2.37	7.75	-9.55	2.06	6.01	-9.89
Avg. six months returns	6.30	25.32	-20.10	5.68	17.85	-20.57	6.26	20.09	-19.48
Avg. one year returns	9.63	44.85	-32.59	12.18	39.85	-38.86	9.84	30.83	-31.90
Daily standard deviation	1.42	4.61	4.07	1.10	3.26	3.24	1.27	3.74	3.82
Daily returns to std. dev. ratio	0.03	0.04	-0.04	0.04	0.05	-0.05	0.03	0.03	-0.04
Holding period returns	124.54	444.43	-99.77	228.32	1642.00	-99.77	142.41	342.59	-99.62
Cumulative returns	107.04	430.61	-392.89	135.47	434.62	-463.97	109.40	335.70	-369.81
Minimum returns	-14.27	-43.31	-26.91	-11.98	-34.95	-27.79	-13.75	-39.17	-32.12
Maximum returns	9.39	104.57	34.66	9.38	27.97	32.66	10.71	32.08	46.95
Daily value at risk (VaR)	-2.06	-6.00	-5.90	-1.65	-4.93	-4.50	-1.79	-5.47	-5.02
Daily conditional VaR (CVaR)	-3.38	-9.88	-9.17	-2.69	-8.02	-7.28	-3.08	-9.15	-8.44

Notes: This table presents descriptive statistics and different characteristics of the benchmark indices, and their LETFs used in this study. Panel A presents statistics for Russell 2000 and S&P 500, S&P Mid-Cap 400indices, and the associated triple LETFs, and Panel B presents statistics for Nasdaq 100 and Dow Jones indices and the associated triple LETFs.

Table 1 *(continued)*

Description	NASDAQ-100	TQQQ	SQQQ	Dow 30	UDOW	SDOW
Panel B: NASDAQ 100 and Dow Jones Indices and LETFs						
Inception date		2/9/2010	2/9/2010		2/9/2010	2/9/2010
# of holdings		104	103		31	30
AUM as of May 2020 (million)		$5,915.15	$1,115.97		$717.49	$816.02
Expense ratio		0.95%	0.95%		0.95%	0.95%
Avg. daily trading volume (million)		57.40	76.90		7.29	13.79
Avg. daily returns	0.07	0.21	-0.23	0.04	0.14	-0.15
Avg. one week returns	0.34	0.99	-1.14	0.19	0.64	-0.73
Avg. two weeks returns	0.67	1.99	-2.22	0.38	1.25	-1.46
Avg. three weeks returns	0.97	2.79	-3.27	0.52	1.68	-2.14
Avg. one month returns	1.46	4.17	-5.20	0.81	2.57	-3.55
Avg. two months returns	2.60	7.33	-9.51	1.35	4.24	-6.72
Avg. three months returns	4.21	11.65	-15.16	2.20	6.94	-10.46
Avg. six months returns	9.68	30.48	-27.75	5.94	19.68	-20.60
Avg. one year returns	17.74	58.34	-45.39	10.81	38.02	-34.68
Daily standard deviation	1.23	3.60	3.60	1.09	3.18	3.20
Daily returns to std. dev. ratio	0.06	0.06	-0.06	0.04	0.04	-0.05
Holding period returns	430.26	4486.61	-99.95	147.19	777.97	-99.44
Cumulative returns	186.47	552.90	-590.69	105.85	351.47	-385.11
Minimum returns	-12.19	-34.47	-28.35	-12.93	-35.43	-31.64
Maximum returns	10.07	26.99	32.74	11.37	32.67	36.08
Daily value at risk (VaR)	-1.89	-5.61	-5.32	-1.56	-4.62	-4.35
Daily conditional VaR (CVaR)	-2.98	-8.78	-8.24	-2.63	-7.80	-7.10

Notes: This table presents descriptive statistics and different characteristics of the benchmark indices, and their LETFs used in this study. Panel A presents statistics for Russell 2000 and S&P 500, S&P Mid-Cap 400indices, and the associated triple LETFs, and Panel B presents statistics for Nasdaq 100 and Dow Jones indices and the associated triple LETFs.

Table 2: Average differences between index return and LETFs returns

Duration	Same Day	Overnight	Night+Day	CAR	HPR
Panel A: Bear ETFs					
Daily	0.0059	-0.0337[a]	-0.0280	-0.0213[a]	-0.0213[a]
	(0.46)	(-2.73)	(-1.51)	(-5.88)	(-5.88)
Two days	0.0233	-0.0502[a]	0.0069	-0.0426[a]	-0.0236[a]
	(1.42)	(-3.09)	(0.27)	(-8.33)	(-4.48)
Three days	0.0103	-0.0397[c]	-0.0333	-0.0617[a]	-0.0374[a]
	(0.48)	(-1.95)	(-1.07)	(-10.09)	(-4.1)
Four days	0.0093	-0.0367	-0.0047	-0.0839[a]	-0.0792[a]
	(0.4)	(-1.63)	(-0.13)	(-10.14)	(-4.96)
One week	0.0223	-0.0451	-0.0158	-0.1044[a]	-0.1489[a]
	(0.78)	(-1.62)	(-0.42)	(-11.41)	(-6.71)
Two weeks	0.0994[a]	-0.1137[a]	0.107[c]	-0.2082[a]	-0.3133[a]
	(2.53)	(-2.91)	(1.89)	(-12.24)	(-6.01)
Three weeks	0.0673	-0.0762	-0.0297	-0.3051[a]	-0.6597[a]
	(1.39)	(-1.58)	(-0.47)	(-14.86)	(-6.68)
One month	0.0314	-0.0685	0.1587[b]	-0.4502[a]	-1.0428[a]
	(0.59)	(-1.41)	(2.07)	(-15.7)	(-6.15)
Two months	-0.0237	0.0287	0.0640	-0.863[a]	-2.1841[a]
	(-0.3)	(0.37)	(0.52)	(-15.88)	(-6.6)
Three months	0.0468	-0.1033	0.1762	-1.2345[a]	-2.5958[a]
	(0.64)	(-1.46)	(1.51)	(-16.24)	(-7.82)
Six months	-0.0460	0.0019	-0.0118	-2.4789[a]	-4.9441[a]
	(-0.39)	(0.01)	(-0.07)	(-12.34)	(-5.03)
Panel B: Bull ETFs					
Daily	-0.0641[a]	0.0755[a]	0.0114	0.0134	0.0134
	(-5.37)	(5.38)	(0.60)	(1.61)	(1.61)
Two days	-0.0731[a]	0.094[a]	-0.0176	0.0269[c]	0.0051
	(-4.43)	(4.22)	(-0.72)	(1.66)	(1.31)
Three days	-0.0627[a]	0.0608[a]	0.0413	0.0389	0.044*
	(-2.97)	(2.98)	(1.08)	(1.62)	(1.83)
Four days	-0.0585[a]	0.0646[a]	-0.0139	0.0513	0.0483
	(-2.46)	(2.82)	(-0.39)	(1.61)	(1.56)
One week	-0.0958[a]	0.0908[a]	-0.0229	0.0675[c]	0.0471
	(-3.44)	(3.3)	(-0.65)	(1.69)	(1.23)
Two weeks	-0.1693[a]	0.1696[a]	-0.1442[a]	0.1343[c]	0.1089
	(-4.01)	(4.2)	(-2.68)	(1.68)	(1.3)
Three weeks	-0.1222[a]	0.1227[a]	-0.0273	0.1915	0.1313
	(-2.35)	(2.42)	(-0.45)	(1.6)	(1.08)
One month	-0.1356[a]	0.1571[a]	-0.2895[a]	0.2843	0.1149
	(-2.8)	(3.39)	(-3.76)	(1.6)	(0.66)
Two months	-0.0952	0.1114	-0.2047	0.5669	0.3456
	(-1.25)	(1.53)	(-1.62)	(1.58)	(1.04)
Three months	-0.1252[b]	0.1373[b]	-0.2325[a]	0.9726[c]	0.3458
	(-2.12)	(2.3)	(-2.44)	(1.81)	(0.58)
Six months	-0.0973	0.1278	-0.1272	2.0136[c]	0.4402
	(-1.05)	(1.34)	(-0.79)	(1.78)	(0.28)

Notes: This table presents averages of differences between the returns on LETFs and their benchmark indices for various holding periods. The same-day return is calculated as the price change during a single day. Overnight return is computed as a percent change in prices from closing to opening. Night + Day return is the sum of the same day and overnight returns. CAR refers to cumulative average returns. HPR refers to holding period returns. Panel A presents the results for bear ETFs, and Panel B shows results for bull ETFs. The associated t-statistics are reported in the brackets. a, b, and c denote statistical significance at 1%, 5%, and 10% significance level, respectively.

Table 2 presents the averages of differences between LETFs and three times the index returns over different holding periods. We calculate returns of LETFs for the same day, overnight, previous night plus a day, cumulative returns, and holding period returns, as discussed in the methodology section. If LETFs provide returns, as promised by the issuers on a daily basis, then the average difference between the index return and LETFs should be zero.

In Panel A, we present univariate test results for bear ETFs. The test results indicate that the bear ETFs track the benchmark indices very closely during the day and previous night plus day but yield higher returns if we calculate return as overnight, cumulative, and holding period. We are particularly interested in cumulative returns since most prior research uses cumulative returns on their analysis. The results show that the bear ETFs provide higher return compared to the benchmark index even on a daily basis. The difference between the benchmark indices and bear ETFs increases as we increase the number of holding periods. These results suggest that bear ETFs decline more than three times the index returns, and the gap increases as the number of holding periods increases. For instance, the average difference between index return and bear ETFs for a six-month holding period is -2.4789% (t-stat>1.96). Most of the existing literature (see. Charupat and Miu, 2011; Shum and Kang, 2013; Lu *et al.*, 2012; Jiang and Peterburgsky, 2017; Zhang, 2018; Tsalikis and Papadopoulos, 2018) show that LETFs perform better than their benchmark returns up to a week. However, we find that the bear ETFs underperform the benchmark index even up to six-month holding periods.

In Panel B, we present averages of the differences between the index return and bull ETFs return over various holding periods using the same-day returns, overnight returns, cumulative returns, and holding period returns. The statistically significant average differences between returns on indices and returns on LETFs indicate that average returns of bull ETFs are different from three times the returns on the index. Similar to the findings of the existing studies which show that LETFs perform as intended for a holding period up to a week (Loviscek *et al.*, 2014; Tsalikis and Papadopoulos, 2018) or a month (Bansal and Marshall, 2015; Charupat and Miu, 2011; Lu *et al.*, 2012), we find that the bull ETFs perform in-line with or better relative to their benchmark indices up to six-month investment horizons.

In Table 3, we present estimation results from the pooled regressions, equation (1). We report values of the constant terms (alphas) and the slope coefficients (betas) of different regressions for both bear and bull ETFs. The dependent variable is the cumulative or holding period returns of LETFs, and the independent variable is cumulative or holding period returns of the benchmark indices. The values of alphas show the performance of LETFs relative to the benchmark index. Therefore, the values of alphas are expected to be zero if LETFs track the benchmark index closely or significantly different from zero if LETFs fail to follow their benchmark indices.

Columns (1) and (3) in Table 3 present the estimates of alphas for bear ETFs for different investment horizons. For both measures of returns, the values of alphas are negative and statistically significant at 1% level. The discrepancy between the index and bear ETFs amplifies as we increase the number of holding periods. In columns (5) and (7), we present estimates of alphas for bull ETFs. The positive and statistically significant alphas indicate that the bull ETFs outperform the benchmark index. Overall, the pool regression results support our main findings in Table 2 that both bear and bull ETFs perform better than the benchmark indices on both short and long-term, and the average difference widens as the holding period increases. Contrary to concerns of the SEC and FINRA, these results indicate that LETFs perform better than the benchmark indices even up to six-month investment horizons. The findings also suggest that the average return differences of LETFs compared to the benchmark indices are more for bear ETFs than that of bull ETFs.

Table 3: Pool regression results

	Bear ETFs				Bull ETFs			
	CAR		HPR		CAR		HPR	
Duration	Alpha (1)	Beta (2)	Alpha (3)	Beta (4)	Alpha (5)	Beta (6)	Alpha (7)	Beta (8)
Daily	-0.0251 [a]	-2.9234 [a]	-0.0251 [a]	-2.9234 [a]	0.0168 [b]	2.9310 [a]	0.0168 [b]	2.9310 [a]
	(-7.12)	(-1016.79)	(-7.12)	(-1016.00)	(2.03)	(431.57)	(2.03)	(431.57)
Two days	-0.0455 [a]	-2.9716 [a]	-0.0277 [a]	-2.9140 [a]	0.0297 [c]	2.9720 [a]	0.0085 [b]	2.9300 [a]
	(-8.92)	(-953.28)	(-5.43)	(-734.65)	(1.83)	(299.87)	(2.27)	(1004.20)
Three days	-0.0650 [a]	-2.9778 [a]	-0.0373 [a]	-3.0020 [a]	0.0420 [c]	2.9800 [a]	0.0460 [c]	2.9671 [a]
	(-10.66)	(-986.99)	(-4.09)	(-574.11)	(1.74)	(250.27)	(1.92)	(216.24)
Four days	-0.0891 [a]	-2.9732 [a]	-0.1032 [a]	-2.8516 [a]	0.0549 [c]	2.9820 [a]	0.0491	2.9946 [a]
	(-10.82)	(-847.39)	(-6.87)	(-400.90)	(1.72)	(220.05)	(1.58)	(205.00)
One week	-0.1107 [a]	-2.9738 [a]	-0.1608 [a]	-2.9342 [a]	0.0742 [c]	2.9724 [a]	0.0500	2.9830 [a]
	(-12.16)	(-826.64)	(-7.28)	(-295.2)	(1.85)	(183.76)	(1.30)	(172.51)
Two weeks	-0.2245 [a]	-2.9650 [a]	-0.3044 [a]	-3.0263 [a]	0.1382 [c]	2.9916 [a]	0.1487 [c]	2.8751 [a]
	(-13.40)	(-662.75)	(-5.82)	(-196.47)	(1.71)	(136.05)	(1.78)	(114.91)
Three weeks	-0.3240 [a]	-2.9730 [a]	-0.8332 [a]	-2.7054 [a]	0.1736	3.0255 [a]	0.1373	2.9893 [a]
	(-15.82)	(-606.28)	(-9.08)	(-116.61)	(1.43)	(103.52)	(1.12)	(95.82)
One month	-0.4653 [a]	-2.9848 [a]	-1.4837 [a]	-2.5311 [a]	0.2535	3.0312 [a]	0.0585	3.0600 [a]
	(-15.91)	(-470.58)	(-10.08)	(-81.00)	(1.39)	(73.58)	(0.33)	(79.83)
Two months	-0.9058 [a]	-2.9760 [a]	-3.1398 [a]	-2.4205 [a]	0.5441	3.0128 [a]	0.3246	3.0129 [a]
	(-16.22)	(-345.96)	(-12.07)	(-60.69)	(1.46)	(52.33)	(0.94)	(57.40)
Three months	-1.2358 [a]	-2.9996 [a]	-4.3195 [a]	-2.4154 [a]	0.8937	3.0249 [a]	-0.1192	3.1579 [a]
	(-14.21)	(-227.69)	(-18.70)	(-71.06)	(1.46)	(32.47)	(-0.19)	(32.98)
Six months	-2.4728 [a]	-3.0010 [a]	-11.8600 [a]	-1.8768 [a]	1.1347	3.1315 [a]	-3.1858	3.5929 [a]
	(-8.11)	(-87.52)	(-13.48)	(-18.91)	(0.66)	(16.44)	(-1.53)	(15.20)

Notes: This table presents the results from the pooled regressions. The dependent variable is the returns on LETFs, and the independent variable is the returns on the benchmark indices. The associated t-statistics are reported in the brackets. a, b, and c denote statistical significance at 1%, 5% and 10% significance level, respectively.

Similarly, if LETFs track their indices and provide stated multiple, then values of the beta have to be no different from -3 for bear ETFs and from 3 for bull ETFs. The larger deviations of beta coefficients from ±3 imply that LETFs fail to track the index and give promised returns. The test results in columns (2) and (4) in Table 4, show that betas for bear ETFs are predominantly downward bias. The columns (6) and (8) present betas for bull ETFs. The test results indicate that the bull ETFs also fail to yield 3x returns for the short-term holding period. However, the results suggest that the betas for bull ETFs are upward bias if the holding period is over two weeks. Overall, again the results indicate that the discrepancies between average returns of the index and LETFs are larger for holding period returns compared to compounding returns for both bear and bull ETFs.

Table 4 presents pooled regression-based tracking errors using cumulative and holding period returns for both bear and bull ETFs. The tracking errors are calculated as the standard deviation of residual from the panel regression. The 95 % confidence intervals are computed using the Chi-square distribution and reported in the brackets.

Columns (1) and (2) show that tracking error for bear ETFs and columns (3) and (4) present the tracking error for bull ETFs. The test results indicate that the tracking errors for bear ETFs are larger than that of bull ETFs, and the tracking error gets larger as we increase the number of holding periods irrespective of the type of LETFs. These results hold for both cumulative and holding period returns. These results again support our findings in Table 2 and 3 that the return difference of bear ETFs get larger than that of bull ETFs as the number of holding periods increases.

4.2 Performance of LETFs During Volatile Markets

We are also interested in the performance of bear and bull ETFs during high market volatility periods, particularly during COVID-19 generated market volatility. Therefore, we analyze the

Table 4: Pooled regression-based tracking errors

	Bear ETFs		Bull ETFs	
	CAR	HPR	CAR	HPR
Duration	Tracking Error	Tracking Error	Tracking Error	Tracking Error
Daily	0.4024	0.4024	0.9507	0.9507
	(0.3976, 0.4074)	(0.3976, 0.4074)	(0.9394, 0.9624)	(0.9394, 0.9624)
Two days	0.4111	0.4113	1.3076	0.3026
	(0.4043, 0.4184)	(0.4045, 0.4186)	(1.2860, 1.3310)	(0.2976, 0.3080)
Three days	0.4010	0.6028	1.5821	1.5815
	(0.3929, 0.4098)	(0.5905, 0.6159)	(1.5500, 1.6160)	(1.5490, 1.6160)
Four days	0.4689	0.8569	1.8176	1.7689
	(0.4580, 0.4807)	(0.8368, 0.8784)	(1.7750, 1.8630)	(1.7280, 1.8130)
One week	0.4632	1.1253	2.0387	1.9547
	(0.4511, 0.4763)	(1.0960, 1.1570)	(1.9850, 2.0960)	(1.9040, 2.0100)
Two weeks	0.6003	1.8811	2.8812	2.9956
	(0.5785, 0.6247)	(1.8130, 1.9570)	(2.7760, 2.9980)	(2.8870, 3.1170)
Three weeks	0.5942	2.6708	3.5131	3.5553
	(0.5680, 0.6242)	(2.5530, 2.8050)	(3.3580, 3.6900)	(3.3980, 3.7350)
One month	0.6920	3.4951	4.2816	4.1886
	(0.6554, 0.7350)	(3.3100, 3.7120)	(4.0550, 4.5480)	(3.9670, 4.4490)
Two months	0.9132	4.2817	6.0944	5.6429
	(0.8465, 0.9972)	(3.9690, 4.6750)	(5.6490, 6.6540)	(5.2300, 6.1610)
Three months	1.0561	2.8843	7.4291	8.1762
	(0.9635, 1.1790)	(2.6310, 3.2190)	(6.7780, 8.2910)	(7.4590, 9.1250)
Six months	1.9280	6.0424	10.8031	14.3335
	(1.6960, 2.2780)	(5.3140, 7.1390)	(9.5010, 12.7600)	(12.6100, 16.9300)

Notes: This table reports the tracking errors computed from the error terms of the pooled regressions using returns of the different holding periods for the bull and bear ETFs. The dependent variable is the return on LETFs, and the independent variable is the return on the benchmark index. The 95 percent confidence intervals are reported in the brackets. The CAR refers to cumulative average returns, and HPR means holding period returns.

performance of our sample LETFs during the most-recent COVID-19 generated bear and bull markets. Based on market volatility define February 19, 2020 to March 23, 2020 as bear market period and March 24, 2020 to May 29, 2020 as the bull market period.

Table 5 shows the performance of all individual indices and LETFs during the recent market movements due to COVID-19 crises and global economic responses to minimize the economic impact of the COVID-19 crisis. We divide the period from February 19, 2020 to May 29, 2020 into the bear market period (from February 19, 2020 to March 23, 2020) and the bull market period (from March 24, 2020 to May 29, 2020) and compute different measures for each index, and LETFs included in our sample. Panel A and B show the results for bear and bull markets, respectively. There are a few observations worth noting.

As shown in the table, in most cases, the returns on LETFs fail to yield the stated multiples of the respective benchmark indices during both the bear and bull markets. For instance, cumulative return for Russell 2000 (S&P 500) is -47.53% (-37.78%) in Panel A. If LETFs perform as intended, then the returns for their respective LETFs should yield at least three times of the index returns. However, both SRTY and URTY fail to track the return of the index. SRTY return was 131.87%, which is less than the index return (-47.53*3), and URTY's return was 146.7%, which is more than the index return (-47.53*3). Similar scenarios exist for other LETFs as well. In Panel B, we present results for the bull market period. The results show that SRTY declines more (110.46%>107.37%) than the index return and URTY fails to provide three times the index return (105%<107.3%). We also observe that bear ETFs have higher tracking errors, computed as the standard deviation of the differences between the LETF returns and three times the index returns, than bull ETFs.

Table 5: Performance of LETFs during high volatility markets

Description	Russell 2000	URTY	SRTY	S&P 500	UPRO	SPXU	S&P MID CAP 400	UMDD	SMDD	NASDAQ 100	TQQQ	SQQQ	DOW 30	UDOW	SDOW
Panel A: Bear Market Period (2/19/2020 to 3/23/2020)															
Minimum daily return	-14.27	-43.31	-21.59	-11.98	-34.95	-27.25	-13.75	-39.17	-24.55	-12.19	-34.47	-28.35	-12.93	-35.43	-27.11
Maximum daily return	7.77	22.68	34.66	9.29	27.76	32.66	8.41	17.33	46.95	10.07	26.99	32.74	9.36	26.25	36.08
Cumulative return	-47.53	-146.70	131.87	-37.78	-113.84	111.68	-49.85	-153.48	152.00	-28.61	-89.49	82.74	-41.71	-128.51	123.34
Holding period return	-40.46	-84.54	195.53	-33.61	-76.49	137.99	-41.67	-85.18	225.86	-27.24	-68.96	79.21	-36.40	-79.71	160.30
Minimum deviation		-11.96	-11.94		-2.05	-4.10		-7.90	-3.88		-3.23	-4.58		-5.34	-2.70
Maximum deviation		7.47	9.15		1.80	2.61		2.14	5.71		2.74	3.48		3.35	1.07
Tracking error		3.10	4.68		0.79	1.32		1.82	1.82		1.32	1.60		1.49	0.74
Value of $10k	5922	1523	29971	6608	2318	24159	5807	1459	33007	7210	3017	18437	6335	2004	26331
Panel B: Bull Market Period (3/24/2020 to 5/29/2020)															
Minimum daily return	-7.03	-20.32	-26.91	-4.41	-13.36	-27.79	-5.69	-17.29	-32.12	-4.19	-12.41	-22.52	-4.44	-13.57	-31.64
Maximum daily return	9.39	26.73	20.09	9.38	27.97	13.23	10.71	32.08	17.54	7.81	22.29	12.80	11.37	32.67	12.98
Cumulative return	35.79	105.84	-110.46	32.44	97.07	-99.93	39.63	118.72	-121.32	32.56	96.54	-99.99	33.10	98.50	-102.52
Holding period return	39.07	128.21	-74.48	36.06	130.65	-68.58	44.76	162.27	-77.28	36.37	132.37	-68.01	36.53	128.56	-70.39
Minimum deviation		-1.96	-2.06		-1.28	-1.97		-1.02	-1.00		-1.38	-2.07		-1.43	-2.96
Maximum deviation		1.76	1.96		1.08	1.10		1.05	0.80		1.34	1.24		0.96	2.46
Tracking error		0.62	0.68		0.32	0.46		0.54	0.42		0.49	0.61		0.34	0.66
Value of $10k	12713	18008	3491	12439	18024	4351	13076	19858	3347	12650	19001	4129	12259	17228	4332

Notes: This table presents the performance of LETFs, and their associated indices during the recent bear and bull market resulted from the COVID-19 crisis and global economic response to combat the negative impact of the COVID-19.

To investigate the performance of LETFs during high volatile markets, we use the bootstrapping technique. In our bootstrap analysis, we create three sub-samples of data to represent three hypothetical market conditions. The first sample consists of daily returns of the indices and LETFs from those days when the market moves more than two percent to represent volatile markets. The second sample is the sub-sample of the first sample consist of only the positive index returns, which we define as aggressive bull markets. Similarly, the third sample is also the sub-sample of the first sample with only negative index returns representing aggressive bear markets. From each sample, we resample 10,000 observations with replacement and compute means and tracking errors of the deviation of the returns for different investing periods.

Table 6: Performance of LETFs – bootstrapping results

Duration	Bear ETFs		Bull ETFs	
	Mean	Tracking Error	Mean	Tracking Error
Panel A: High volatile market				
One day	-0.0248	0.9855	-0.0250	0.7170
	(-0.0437, -0.0054)	(0.9084, 1.0741)	(-0.0398, -0.0118)	(0.6556, 0.7937)
Two days	-0.0747	1.3054	-0.0532	1.0591
	(-0.1004, -0.0494)	(1.2274, 1.3905)	(-0.0744, -0.0331)	(0.9894, 1.1382)
Three days	-0.1243	1.5691	-0.0584	1.2497
	(-0.1553, -0.0938)	(1.4926, 1.6597)	(-0.0841, -0.0351)	(1.1830, 1.3263)
Four days	-0.1131	1.7864	-0.0946	1.482
	(-0.1488, -0.0788)	(1.7091, 1.8705)	(-0.1245, -0.0655)	(1.4123, 1.5595)
One week	-0.1447	2.1047	-0.0976	1.6171
	(-0.1855, -0.1043)	(2.0196, 2.2043)	(-0.1303, -0.0660)	(1.5534, 1.6900)
Two weeks	-0.3065	3.0693	-0.2079	2.3063
	(-0.3680, -0.2474)	(2.9798, 3.1639)	(-0.2534, -0.1635)	(2.2312, 2.3857)
Panel B: Steadily rising market				
One day	0.1884	0.7706	-0.2576	0.8202
	(0.1741, 0.2043)	(0.7083, 0.8450)	(-0.2741, -0.2428)	(0.7492, 0.9058)
Two days	0.3885	1.0702	-0.5001	1.1172
	(0.3681, 0.4100)	(1.0057, 1.1406)	(-0.5230, -0.4791)	(1.0396, 1.2072)
Three days	0.5834	1.4103	-0.7627	1.4056
	(0.5552, 0.6107)	(1.3428, 1.4848)	(-0.7918, -0.7362)	(1.3309, 1.4965)
Four days	0.7735	1.5580	-1.0281	1.6989
	(0.7433, 0.8048)	(1.4920, 1.6342)	(-1.0620, -0.9963)	(1.6174, 1.7904)
One week	0.9643	1.7377	-1.2986	1.8804
	(0.9301, 0.9980)	(1.6717, 1.8098)	(-1.3366, -1.2629)	(1.8015, 1.9649)
Two weeks	1.8817	2.4474	-2.5893	2.6699
	(1.8343, 1.9318)	(2.3769, 2.5245)	(-2.6423, -2.5373)	(2.5864, 2.7634)
Panel C: steadily falling market				
One day	-0.2123	1.0278	0.1625	0.5441
	(-0.2329, -0.1933)	(0.9450, 1.1160)	(0.1525, 0.1734)	(0.5093, 0.5872)
Two days	-0.4204	1.4959	0.3574	0.8366
	(-0.4505, -0.3918)	(1.4104, 1.5860)	(0.3419, 0.3746)	(0.7974, 0.8822)
Three days	-0.6466	1.7763	0.5229	1.0348
	(-0.6812, -0.6121)	(1.6878, 1.8680)	(0.5024, 0.5433)	(0.9926, 1.0856)
Four days	-0.8197	1.9726	0.6948	1.1835
	(-0.8581, -0.7818)	(1.8905, 2.0599)	(0.6723, 0.7183)	(1.1368, 1.2390)
One week	-1.0404	2.1800	0.8498	1.2893
	(-1.0854, -0.9998)	(2.0923, 2.2716)	(0.8252, 0.8759)	(1.2480, 1.3336)
Two weeks	-2.1004	3.2444	1.7159	1.8447
	(-2.1669, -2.0384)	(3.1504, 3.3569)	(1.6809, 1.7535)	(1.7970, 1.8995)

Notes: This table presents averages of the return deviations and tracking errors of LETFs for different investment horizon computed from bootstrapping. The 95 percent confidence intervals are reported in the brackets. Panel A, B, and C report averages return deviations and tracking error for both bear and bull ETFs for high volatile markets, high volatile bull markets, and high volatile bear markets, respectively.

Table 6 reports the results from our bootstraps. The averages and standard deviations of the return differences between LETFs returns and index returns, and their 95 percent confidence intervals are reported in Table 6. Panel A presents the results for the full sample. When we compare the results of Panel A with Table 2, we observe that the average deviation of the returns of LETFs is higher than three times the return of the index during volatile markets. In Panel B and C, we present results for volatile bull and bear markets, respectively. The results indicate the average returns of both bear and bull ETFs are less than three times returns of the underlying indices. These results suggest that both bear and bull ETFs underperform the benchmark indices during the aggressive markets. Overall, the bootstrapping results support our main findings in Table 5 that LETFs fail to track the benchmark indices even on a daily basis, and the error widens as we increase the number of holding periods when the market is more volatile.

5. Concluding Remarks

Leveraged and inverse ETFs have become popular financial products among investors since their inception in 2006. These LETFs allow investors to amplify directional bets on the underlying index. Our test results indicate that LETFs usually produce returns in line with or higher as the issuers seek to provide relative to the benchmark indices. However, we find that the average differences and tracking error increases as we increase the holding periods.

We also analyse the performance and tracking error of both bear and bull ETFs during the high market volatility period. Particularly, we examine the performance of LETFs during high market volatility. We find that bear ETFs do not provide three times the multiple of the index returns during the bear market but decline more than three times the multiple of the index return during the bull market period. Similarly, bull ETFs decline more than three times the multiple of the index return during the bear markets and provide less than three times the multiple of the index returns during the bull markets. We also find that the tracking errors of bear ETFs are much larger than bull ETFs during COVID-19 generated bear and bull markets.

Our research contributes to research on LETFs by documenting the performance and tracking errors for both bear and bull ETFs during high market volatility periods. Contrary to existing literature, we find that LETFs provide returns in line with or better than the implied benchmark returns up to six months holding periods.

We examine triple leveraged equity ETFs issued by ProShares for consistency purposes, but there are other triple and double leveraged ETFs worth exploring. Other resampling or simulation techniques may be more appropriate to examine the performance of LETFs for more than six-month holding periods using non-overlapping cumulative or holding period returns. Our sample period coincides with the expansionary economic cycle. Therefore, we are not sure whether these results would hold during a prolonged contractionary economic cycle. We do not address the impact of compounding vs. non-compounding on cumulative returns for more than one day holding period. Therefore, our results should not be interpreted as proof of future returns.

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