“Assessing the performance of American and European Leveraged Exchange Traded Funds”

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ASSESSING THE PERFORMANCE OF AMERICAN AND EUROPEAN LEVERAGED EXCHANGE TRADED FUNDS

Abstract

Leveraged Exchange Traded Funds (ETFs) (LETFs) are a recent and highly successful financial innovation; yet, investors and several studies criticized them for not performing as advertised, especially in the long term. This paper discusses their unique characteristics and their path-dependent price dynamics, which may result in unexpected returns. Furthermore, the authors evaluate the performance of a large sample of European and American leveraged ETFs since each fund's inception and show that they perform as intended for daily holding periods. Leveraged ETFs are also successful in delivering the promised performance over holding periods of up to one week, their performance starts to deviate when the holding period increases to one month. Empirical evidence suggests that bear (short) ETFs deviate from their target return more quickly than their bull (long) counterparts as the holding period lengthens. A possible explanation for this is that transaction costs, which are related to daily rebalancing activity, are higher for bear funds. When comparing the daily performance of European vs American funds, the authors find them both to be equally efficient in replicating their benchmarks, although European leveraged ETFs are much smaller in their Assets Under Management (AUM) compared to US LETFs.

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INTRODUCTION

Leveraged ETFs use derivatives and debt to provide a steady multiple of the returns of their underlying indexes by maintaining a daily stable position of leverage and since their inception, LETFs have been drawing ever increasing considerable interest from investors and traders. Two types of leveraged ETFs exist: bull and bear. Most bull (or long) ETFs try to achieve a daily return of 2 or 3 times of the daily return of their benchmark, while bear (or short) ETFs try to achieve a return that is –1, –2 or –3 times of the daily benchmark return. In theory, a leveraged fund with n leverage ratio would have a daily return of $n\%$ if its underlying index return is 1%, although in real world, transaction costs and management fees might undermine this theoretical return. Leveraged ETFs can use various methods to maintain leverage to an index return such as borrowing, short selling, swaps, futures, options, and other techniques. In practice, leverage is usually obtained with the use of derivatives such as forward contracts and total return swaps. The counterparties to these contracts agree to deliver to the fund daily returns based on an agreed benchmark in exchange for fees and expenses (Charupat & Miu, 2010). In practice, swaps are vastly more used, as they are more flexible than futures because futures require standard amounts and expiration time (Rompotis, 2014). Also futures are more limited in terms of index representation, and the risk related to imperfect hedging is significantly higher than with total return swaps (Cheng & Madhavan, 2009).

Leveraged ETFs seek to provide constant leverage daily and follow a dynamic leverage trading strategy in order to obtain a constant leverage factor. For one day, a fund can obtain a return, which is 2 or 3 times higher that of the underlying index by using leverage to invest in enough stocks or other derivatives. But if the underlying index increases (decreases), the fund becomes under-leveraged (over-leveraged) and needs to rebalance to ensure every new investor gets the advertised leverage ratio. The same principle applies for short ETFs as well, and rebalancing is typically done once a day at the end of the trading day[1]. Unlike traditional ETFs, which are passively managed, leveraged ETFs require active management, which naturally leads to higher management fees[2]. An ETF with leverage n and Net Asset Value *NAV* would need an exposure of $n \cdot NAV$ in order to achieve its target return. If the index moves by r, then the fund's exposure would be equal to $\left(1+r\right)\cdot n\cdot NAV$ and the new *NAV* would be $\left(1+n\cdot r\right)\cdot NAV$, hence, the next day's needed exposure would be $n\cdot\left(1+n\cdot r\right)\cdot NAV$ meaning that the rebalancing amount needed for the next day would be:

$$Rebalancing\ amount\ needed = n\cdot\left(1+n\cdot r\right)\cdot NAV - \left(1+r\right)\cdot n\cdot NAV = r\cdot\left(n^2-n\right)\cdot NAV. \tag{1}$$

For $1x$ ETFs, $n^2-n=0$ meaning that they do not need daily rebalancing, but for leveraged ETFs, $n^2-n\neq 0$ and if $r\neq 0$ too, rebalancing must occur. For n = –1, –2, –3, +2, +3 $n^2-n>0$, which means that both bull and bear funds have positive rebalancing needs when the underlying index goes up and negative rebalancing needs when the underlying index goes down. Furthermore, as we show in Table 1, a $3x$ fund has three times the rebalancing needs of a $2x$ fund. A $–3x$ fund has six times the rebalancing needs of a $2x$ fund. Inevitably, the higher the leverage, the higher the rebalancing needs and, therefore, the fund's costs.

Table 1. ETF daily rebalancing needs

Leverage ratio	n^2-n	Daily rebalancing needs
1	0	0
2	2	$2r\cdot NAV$
3	6	$6r\cdot NAV$
–1	2	$2r\cdot NAV$
–2	6	$6r\cdot NAV$
–3	12	$12r\cdot NAV$

For holding periods longer than one day, leveraged ETFs' cumulative returns may, and probably will, be different than n times the underlying index's returns. When leveraged ETFs were introduced in the US market in 2006[3], they were largely misunderstood and misused in portfolios, resulting in unexpected returns and important losses. Their performance in the long term is not n times the performance of the underlying index, but may be considerably lower or even higher, relying on the behavior of the underlying index. This difference between the real return for the fund in the holding period and the naïve investors' expected return for the holding period is frequently referred to as tracking error[4]. Initially, this aspect of leveraged ETFs was not fully understood by many traders and institutions leading to lawsuits against leveraged ETF providers, accusing them of misleading the investors about the declared performance targets of their products (Tang & Xu, 2013).

1 Rebalancing also prevents the funds from going bankrupt. For example a 3x leveraged ETF would go bankrupt only if the benchmark index drops more than 33.33% in one day. Given that the largest drop in S&P 500 history was 20.47%, we can assume that funds replicating this index can be safe for the most part. Of course, ETF managers can hedge their funds in more volatile periods/indexes against this probability by purchasing put options.

2 Most bull and bear funds have management fees close to 1% per year or even higher. These costs can be increased/decreased depending on interest rates and derivative costs.

3 The first of the leveraged ETFs was introduced by ProFund Advisors LLC in the summer of 2006 in three leverage multiples, 2x, –1x, and –2x.

4 Although the term tracking error is usual in academic literature, we prefer the term tracking deviation, because this is not an error due to management or market inefficiencies, but rather the effect of daily compounding in the funds' returns.

The long-term performance of leveraged ETFs is actually path-dependent on its benchmark, meaning that regardless of the cumulative performance of an index, different paths would yield different returns for a leveraged fund. In Table 2, we examine three different 5-day paths for a hypothetical index resulting in the same cumulative performance and the theoretical return of a perfectly replicating daily rebalanced bull 3*x* fund. For simplicity, we assume no transaction costs and management fees in this example.

Table 2. Different index paths – different LETF returns

Day	Path A				Path B				Path C			
	Index	Daily index return	3x ETF price	Daily ETF return	Index	Daily index return	3x ETF price	Daily ETF return	Index	Daily index return	3x ETF price	Daily ETF return
0	100	–	100	–	100	–	100	–	100	–	100	–
1	101	0.01	103	0.03	102	0.02	106	0.06	95	–0.05	85	–0.15
2	102.01	0.01	106.09	0.03	104	0.0196	112.235	0.0588	105	0.1052	111.8421	0.3157
3	103.03	0.01	109.27	0.03	106	0.0192	118.710	0.0577	97	–0.0761	86.27819	–0.2285
4	104.06	0.01	112.55	0.03	106	0	118.710	0	112	0.1546	126.30416	0.4639
5	105.1	0.01	115.93	0.03	105.1	–0.0084	115.69	–0.0254	101	–0.0616	102.9638	–0.1847

In the first scenario (Path A), the daily return of an index is 1% for each day resulting in a 5.1% cumulative return for the index. A perfectly replicating 3*x* ETF would have a 3% daily return for each day and a cumulative return of 15.93%, which is more than 3 times the 5.1% cumulative return of the index. In this scenario, there is no volatility and a positive trend of the market exists. In this case, compounding helps investors gain 0.63% more than a naïve investor would expect. For the second scenario (Path B), our index has also a 5.1% cumulative return, but achieves it with a different, volatile path. Our perfectly replicating 3*x* bull ETF has a cumulative return of 15.69%, which is again more than 3 times the 5.1% cumulative return of the index, but less than 15.93% of the previous path indicating that volatility is starting to erode the leveraged fund's returns. Lastly, in the third scenario (Path C), we choose an extremely high volatility path that has again a 5.1% cumulative return for the index. The cumulative return of the ETF is only 2.96%, an unexpected result for a naïve investor that would gain 12.34% less than he expected. In fact, in this scenario, he would be better off if he had invested in a traditional 1*x* ETF. This observation, although peculiar for some investors, is just the effect of employing daily replication strategies from leveraged funds. As we see in extremely high volatile paths, leveraged ETFs tend to underperform greatly even in short periods of time; this phenomenon is described in academic literature as volatility decay (Avellaneda & Zhang, 2010; Cheng & Madhavan, 2009; Guo & Leung, 2014).

The effect of compounding can also work in favor of an investor as in scenario A, because a period of consecutive gains produces leveraged gains over and above existing leveraged gains, resulting in a cumulative return higher than expected (Ginley et al, 2015). The cumulative loss for leveraged ETFs is less than expected, because in every consecutive day, exposure is decreased. In our example, a daily loss of 1% would mean a cumulative 4.9% loss for the index after 5 trading days, but only a 14.1% loss for a 3*x* ETF contrary to a 14.7% loss that some investors might expect. On the one hand, if the index exhibits high volatility and insignificant price movements, the constant daily re-balancing will lead the value of the fund to decline. Consequently, leveraged ETFs are long momentum and short volatility. It is not a coincidence that leveraged funds received a lot of criticism in the highly volatile period following the 2008 financial crisis. In 2008 and early 2009, most leveraged ETFs, both bull and bear, underperformed their stated target. In short holding periods and low volatility markets, the leveraged ETFs have more probabilities to produce returns close to the stated multiple. On the other hand, the higher the absolute value of leverage or the holding period, the higher the probability that leveraged ETF's return will differ substantially from its stated target. It is even possible for a bull ETF to have negative cumulative returns even when its benchmark index has positive returns. In Table 2, the third scenario is an extreme example that is unlikely to occur in real markets, but is indicative of these funds' path depended returns.

In volatile periods, compounding is not the only problem. Rebalancing is costlier during the periods of high volatility. The underperformance in the first years since LETF introduction, and especially during the period 2008–2009, led to the publication of several papers and articles that warned investors that holding leveraged ETFs for long periods may result in exposing them to considerable risk, as the funds' returns will deviate from the desired multiple (Bansal & Marshall, 2015A). In a highly volatile environment, derivatives like futures and options may be better suited for investors opting for leveraged exposure over a longer time horizon.

In real world, ETFs face transaction costs, financing costs, management fees and bid/ask spreads, and may not be able to return exactly n times the return of the index in each and every trading day. The ability of a fund to track its benchmark on its target multiple also depends on its controllers' efficiency. Obviously, ETF managers cannot control the underlying index's return nor its volatility or interest rates, but the employment of skillful and experienced managers can benefit the fund's efficiency. Bansal and Marshall (2015B) argue that by employing sophisticated ways of achieving leverage, managers can minimize transaction costs, overhead costs, management fees, and produce income for the fund from securities lending.

For a two-day holding period, we can estimate the impact of compounding in a n-times leveraged fund. The cumulative return of the underlying index would be:

$$R_{index} = \left(1+r_1\right)\cdot\left(1+r_2\right)-1 = r_1 + r_2 + r_1\cdot r_2$$

and the cumulative return for a perfectly replicating leverage fund would be:

$$\begin{aligned}&\left(1+n\cdot r_1\right)\cdot\left(1+n\cdot r_2\right)-1 = 1+n\cdot r_1 + n\cdot r_2 + n^2\cdot r_1\cdot r_2 - 1 = \\ &= n\cdot r_1 + n\cdot r_2 + n^2\cdot r_1\cdot r_2 + n\cdot r_1\cdot r_2 - n\cdot r_1\cdot r_2 = \\ &= n\cdot\left(r_1+r_2+r_1\cdot r_2\right)+\left(n^2-n\right)\cdot r_1\cdot r_2 = n\cdot R_{imdex} + \left(n^2-n\right)\cdot r_1\cdot r_2.\end{aligned} \tag{2}$$

The difference between the real and the naïve expected ETF 2-day return is equal to $\left(n^2-n\right)\cdot r_1\cdot r_2$, which means that since $n^2-n>0$ for n = –1, –2, –3, +2, +3, the real return would be more than naïvely expected for 2 consecutive positive or 2 consecutive negative index returns (positive compounding effect) and less than naïvely expected for one positive and one negative index return (negative compounding effect). Using the values from Table 1, we note that the deviations due to compounding are $2\cdot r_1\cdot r_2$, $6\cdot r_1\cdot r_2$, $2\cdot r_1\cdot r_2$, $6\cdot r_1\cdot r_2$ and $12\cdot r_1\cdot r_2$ for $2x$, $3x$, $-1x$, $-2x$ and $-3x$ funds, respectively, meaning that the compounding effect, positive or negative, is higher for bear funds.

The advent of leveraged ETFs can be explained by many factors. Firstly, these funds allow small investors to perform hedge fund-like strategies without the need of expensive margin accounts or using derivatives, but with the ease of trading common stocks. In theory, a private investor can achieve ±2 and ±3 times the return of an index on his own by using derivatives, borrowing or short selling; yet, such transactions are, in practice, complicated and require knowledge, skill, time and expertise (Curcio et al., 2012). In spite of the high expense ratios that leveraged ETFs have compared to $1x$ funds, they are usually less expensive to use than other forms of margin. Short selling can cost 3% annually or more on the amount borrowed and the use of margin to buy stock can become similarly expensive and may even lead to margin calls if the position starts losing money. Also, the amount of money an individual may want to invest might not be enough for purchasing derivatives, whereas, with leveraged ETFs, one can achieve leverage with less than USD 100[5]. Traditional and leveraged ETFs don't charge early redemption fees, as most mutual funds do (Fevurly, 2013), and allow investors to hold their position for shorter time periods than regular mutual funds. Furthermore, the use of bear ETFs can help investors circumvent possible short-sale constraints.

5 Leveraged funds tend to split when their price goes significantly high and reverse split when their price goes too low, probably because not only they don't want the initial investment for an individual to be too high, but also would not want to trade in market prices of a penny stock.

But in spite of their innovative nature, they also proved highly controversial both for individual and institutional investors. There is a lot of speculation as to whether leveraged ETFs can intensify market moves and boost volatility because of their daily rebalancing. Especially, ±3*x* ETFs have even higher rebalancing needs and will, in theory, create excess demand or selling strain in the direction of the market, as leveraged ETFs buy high, and sell low. For example, a 2*x* fund will have to buy when the market moves up (or it will be underexposed and have a leverage of less than 2) and sell when the market moves down (or it will be overexposed and have a leverage of more than 2). Actually, the needed exposure adjustment is at all times in the similar direction as the underlying benchmark's movement both for long and short funds. The more volatile the underlying index is and the more Assets Under Management (AUM) the ETF has, the larger the rebalancing flows will be. Daily rebalancing in LETFs also creates transaction costs for the funds on a daily basis, while 1*x* ETFs only need to rebalance when the underlying index is rebalanced. Leveraged ETFs with monthly instead of daily rebalancing are available for investors since 2009. Although for short holding periods (≤ one month), these funds do provide their stated multiple[6], in the long run (holding period > six months), they can experie ence important beta decay (Trainor, 2010A). Tax efficiency of leveraged ETFs is lower than 1*x* ETFs, as most trades settle in cash and gains from derivatives are taxed at ordinary income tax rates and not lower capital gains tax rates (Little, 2010). Because leveraged funds have to rebalance at a specific time of the day and in a predictable direction, potential profit opportunities are created for predatory traders, which might lead to higher costs for leveraged ETF investors. Shum et al. (2015) find that potential predatory traders can profit on days of large market fluctuations by front-running the potential rebalancing trades.

Undoubtedly, the biggest concern for investors is that LETFs can deviate considerably from their advertised leverage ratio; LETFs have been criticized by the press as regularly underperforming their stated objectives leading to portfolio losses. More than one decade after their inception, these products are still not well understood by some investors, and, therefore, more research and disclosure are needed.

The goal of this paper is to discover whether LETFs do work as intended for daily holding periods and also whether they deliver their leverage for longer holding periods. This aspect is very crucial, as investors should know if and when to add LETFs in their portfolios and for how long they can keep them without experiencing significant risk. For this purpose, we use a large sample of American and European equity leveraged ETFs following broad indexes and study their performance. Another objective of this paper is to assess whether European LETFs, which haven't been much researched in academic literature, are as efficient as American LETFs. To our knowledge, this is the first study to compare European LETFs with their American counterparts.

1. LITERATURE REVIEW

In the past decade, many scholars have shown interest in the price dynamics of leveraged funds. Hill and Teller (2009) argue that bear –1*x* ETFs can provide the inverse correlation daily needed for hedging as long as they are well monitored and rebalanced. Furthermore, –2*x* ETFs can also be employed for hedging and require less up-front capital, although investors using them have to rebalance their portfolios more frequently thus experiencing greater transaction costs.

Tang et al. (2014) study the performance of international leveraged ETFs that trade in the American stock exchange and find that funds replicating indexes in countries without overlapping trading hours are greatly under exposed. Underexposure also exists for countries with overlapping trading hours, but is much smaller. Furthermore, they find funds replicating China, Japan, Brazil, Mexico, and Europe to be highly exposed to the U.S. market, with S&P 500 index having an impact on the daily returns of international leveraged ETFs; this impact being larger for countries without overlap-

6 Actually only the investors that buy and sell on the fund's reset day can be certain that they will get the stated exposure as any movement of the benchmark index after purchase will diverge the exposure levels for purchases made during the month. Investors that buy Monthly Leveraged Funds on trading days other than the reset day will have less (more) exposure for a bull (bear) fund if the index has moved up and more (less) exposure for a bull (bear) fund if the index has moved down.

ping trading hours than those with overlapping trading hours. They argue that this shows overreaction of international funds to US market sentiments, which seems to fade as the holding period increases. On the contrary, the return correlation among the funds and their underlying indexes tends to rise as the holding period increases, especially for countries with overlapping trading hours. Their results show that investors may not get the exposure in broad markets they seek from international leveraged ETFs and tend to be exposed to the US market, especially in the *short*-term *horizon*.

Guo and Leung (2014) examine commodity ETFs and leveraged ETFs and find that LETFs, which track an illiquid index, tend to have more tracking errors than those that track a liquid index and also the longer the LETF is held, the more probable the LETF is to underperform against the naïve expected multiple. They further conclude that most commodity funds charge considerably higher expense fees than in theory, compared to what is stated on the funds' prospectuses.

Lu, Wang, and Zhang (2012) analyze the path-dependence of US leveraged ETFs in their performance and conclude that they are unsuited for long-term investors that employ buy-and-hold strategies. On the other hand, for investors with a horizon of less than 1 month, they find that the funds' returns are close to the expected multiple.

Haga and Lindset (2012) study Norwegian $\pm 2x$ ETFs and discover that their daily returns are slightly underexposed than their theoretical values, because the funds have not taken sufficient market positions to achieve returns ±2 times the index. Their explanation is that transaction costs have caused the funds' managers to take lower positions than they should in order to perfectly acquire the stated leverage. Also they show that risk-free interest rates can influence the leveraged ETFs' returns, most notably in the long term.

Bansal and Marshall (2015B) investigate the performance of a $2x$ bull ETF with the S&P 500, its underlying index, over a three-year period, and by using non-overlapping monthly holding periods, find that its average monthly tracking deviation is positive and not negative. This means that in spite of the costs of active management, financing costs and volatility decay, management contributed to the fund's returns in this period[7].

Trainor (2010B) tests whether leveraged ETFs and their daily rebalancing needs can explain volatility and large price swings at the end of the trading day in the S&P 500 and finds no evidence suggesting that volatility is increased because of leveraged ETFs' daily rebalancing. In general, he argues that trading associated with leveraged ETFs does not seem to have any significant effect on the S&P 500.

On the other hand, Bai et al. (2014) examine the impact of leveraged funds on underlying real estate stocks and find that the daily rebalancing needs of the funds can move the price and increase volatility in small and not actively traded stocks. They also observe that the rebalancing needs of leveraged ETFs are predictable and can result in front running and predation by strategic traders that may enhance the impact of LETF rebalancing on the underlying index's stocks.

Hill and Foster (2009) believe that the target multiple of a leveraged fund can be obtained for longer holding periods with constantly rebalancing the ETF portfolio by monitoring the return of the tracking index versus the return of ETFs and implementing a trigger percentage of deviation. Although rebalancing has trading costs for investors, it is a highly effective instrument for approximating the daily leverage target over time.

Charupat and Miu (2010) study Canadian leveraged ETFs and find that they tend to trade at larger premiums or discounts than traditional $1x$ ETFs, probably because arbitrage on leveraged ETFs is more difficult, and thus price deviations need to be high enough to make arbitrage worthy. They also find that leveraged ETFs are mostly traded by short-term, retail traders with average holding periods of less than two weeks, much shorter than traditional $1x$ ETFs with the same benchmark. Furthermore, they suggest that leveraged ETFs are efficient in delivering their stated performance over holding periods of up to a week, but start to fade in longer holding periods.

7 The three-year period they used is from October 31, 2011 to October 31, 2014, a period the interest rates were very low. It is uncertain that in different periods management would be that efficient.

Tang and Xu (2013) characterize the return deviation of leveraged ETFs as a conundrum and attribute it to compounding effect, fund management tracking error, and market inefficiencies. They find that investors holding leveraged ETFs for long periods experience return deviations not only due to compounding effect, but also due to NAV deviations because of management's tracking error in achieving a fund's target return and market price deviations because of market frictions and inefficiencies.

Li and Zhao (2014) use event study analysis to investigate if leveraged funds' trading has implications on the trading activity and market quality of the underlying indexes' stocks and find that the trading volume of the stocks is positively correlated with the trading volume of leveraged ETFs, but their volatility is not affected by ETF trading.

Trainor and Carroll (2013) argue that in low volatility markets, volatility decay can be offset by momentum and show that when volatility levels are as low as in the 90's and mid 2000's, $2x$ and $-1x$ funds can be held for periods even beyond one year. Moreover, holding periods of up to 6 months can be justified for $3x$, $-2x$, and $-3x$ funds.

Holzhauer et al. (2013) study the effects of expected market volatility as measured by VIX index on the tracking error of leveraged funds and find that both expected market volatility and daily changes of expected market volatility have an important effect on the funds' tracking error. Also, they show that these effects increase with leverage and that they are more pronounced for bear ETFs compared to bull ETFs with similar leverage.

Lin (2016) tries to find if bear ETF trading can forecast negative underlying index returns, but concludes that the trading of inverse ETFs cannot predict potential future negative index returns. He argues that information provided from bear ETF trading about future index returns reflects lagging or less informed bearish market signal.

Leveraged ETF inception coincided with the global market crisis of the period 2007–2009, which led to large volatility decays for these funds and inevitably most studies found that the funds underperformed for holding periods larger than one month, warning investors not to buy and hold them. But Loviscek et al. (2014) dispute this notion. By using real return data of the Dow Jones Industrial Average (INDU) since 1896, they simulate the performance of hypothetical leveraged ETFs that rebalance daily, monthly, annually, and every five years and find that compounding does not negatively affect investor returns over the holding period of a year or longer. They also find that the average performance of the daily and monthly rebalanced funds is higher than that of the annually rebalanced and five-year rebalanced funds. Although the performance of the Dow Jones Industrial Average had a very important average upward trend[8] since its inception, they show us that buy and hold strategies with LETFs will not necessarily lead to losses and underperformance in comparison to the naïve expected return.

2. DATA, AIM AND THE METHODOLOGY

Academic literature of leveraged ETFs focuses mainly on the effect that these funds may have on market volatility and on their efficiency in replicating the stated multiples of their underlying indexes. We conduct this study under the perspective of the investor, and therefore, the main aim of this paper is to assess leveraged ETFs performance under different holding periods. Our goal is to provide investors with useful information regarding LETF performance since their inception, our sample consists of American and European LETFs following broad equity indexes.

Although the first ETF was introduced in 1993, the idea that investors could trade a whole stock basket with only one transaction is not that modern. US brokerage firms presented similar program trading facilities as early as the late 1970s, notably for the S&P 500 index (Deville, 2008). The first ETF to appear in the present form was SPDR S&P 500, which followed the S&P 500, it was an immediate success and became the largest ETF in the world. The first ETF's in Europe were introduced in 2000: the LDRs DJ STOXX 50 and the LDRs

8 An investment of USD 1 in the INDU in 1896 would have grown to USD 1,526 at the close of 2010. Should the same amount of money have been invested to a 3x bull fund, it would have grown to USD 18,619 (Loviscek et al., 2014).

DJ Euro STOXX 50 were listed on the Deutsche Boerse, developed by Merrill Lynch International (Hill et al., 2015). Since then, ETFs have grown into an important component of the investor's toolkit, with their market experiencing rapid growth. According to research company ETFGI, global ETFs' Assets Under Management rose from USD 580 billion in 2006 to USD 4,661 billion in 2017 and their number rose from 727 ETFs to 5,311 ETFs in the same period. In 2006, the US-listed ETFs were 350 with USD 416 billion AUM, these numbers increased in 2017 to 1,834 ETFs and USD 3,331 billion AUM. The European ETF market also proliferated in the same period with 276 products listed and AUM of USD 94 billion in 2006 and 1,610 products listed and AUM of USD 762 billion in 2017[9]. Both the number of ETFs and their Assets Under Management in US and European markets increased considerably in the examined time horizon, however, European ETFs represent only a small fraction of the global market. One explanation for this lag may be the later inception of European funds, which means less years of trading. Also, according to Thomadakis (2018), the reason could be the fact that European ETFs have multiple listings over many exchanges and low engagement of retail investors compared to the US market.

Leveraged ETFs are much more recent acquisitions to the ETF universe. They first appeared in 2006, when ProShares launched ETFs with a leverage of +2, –1, and –2 times the daily returns on 3 major indexes (S&P 500, Dow Jones Industrial Average and NASDAQ-100). In Europe, the first leveraged ETF was launched by Lyxor in 2006 (Lyxor DAILY LevDAX UCITS ETF). Leveraged ETFs are only a small fraction of the global ETF market. According to **ETFGI,** the Assets Under Management of LETFs in 2017 was USD 77.1 billion with 834 listings. 419 were bull funds, with assets of USD 43.6 billion and 415 were bear funds with USD 33.5 billion assets. Undoubtedly, United States is the largest market for leveraged ETFs, as, by the end of 2017, American LETFs had assets of USD 54.2 billion, invested in 273 products[10].

Tang and Xu (2013) have shown that the deviation of leveraged funds, positive or negative, due to compounding, can be approximated by the following formula:

$$r_{ETF} - n \cdot r_{index} = \frac{n^2 - n}{2} r_{index}^2 - \frac{\left(n^2 - n\right) \cdot T}{2} \sigma_{index}^2, \quad (3)$$

where r_{ETF} is the cumulative return for the leveraged fund for a holding period of T days and r_{index} is the cumulative return for its underlying index for the same period. Naïve investors would expect $r_{ETF} = r_{index}$, which is rarely true for $T > 1$. $r_{ETF} - n \cdot r_{index}$ can be positive, as in examples A and B in Table 2, meaning investors would have better returns than naïvely expected or negative, as in example C, meaning investors would have worse returns than naïvely expected. From this formula, we observe that $r_{ETF} > n \cdot r_{index}$ when $r_{index}^2 > T \cdot \sigma_{index}^2$ meaning that leveraged ETFs' returns are positively related to the squared cumulative return of the underlying index and negatively related to holding periods and index variance.

Obviously, investors not only care about the funds' expected returns, but also for their risk. *The volatility of leveraged ETFs is affected both by market movements and by the amount of target leverage. The higher (lower) the market volatility, the higher (lower) the leveraged fund's volatility and the higher (lower) the absolute value of its stated leverage, the higher (lower) the leveraged fund's volatility.* Volatility is usually measured by using the standard deviation of the returns of a security/index. The daily volatility of an index is

$$\sigma_{index} = \sqrt{\frac{1}{T} \sum_{i=1}^{T} \left(r_i - \bar{r}\right)^2} \quad \text{with} \quad \bar{r} = \frac{1}{T} \sum_{i=1}^{T} r_i.$$

A perfectly replicating n-times leveraged fund that tracks the same index would have a volatility of

$$\sigma_{ETF} = \sqrt{\frac{1}{T} \sum_{i=1}^{T} \left(n \cdot r_i - n \cdot \bar{r}\right)^2} = \sqrt{\frac{1}{T} \sum_{i=1}^{T} n^2 \left(r_i - \bar{r}\right)^2} = \quad (4)$$
$$= \sqrt{\frac{n^2}{T} \sum_{i=1}^{T} \left(r_i - \bar{r}\right)^2} = |n| \sigma_{index},$$

therefore, we expect ±1x, ±2x and ±3x ETFs to have the same, double and triple the underlying index volatility respectively.

9 Data were collected from the ETFGI website https://etfgi.com

10 Data were collected from the ETFGI website https://etfgi.com

Our sample consists of 8 families of ETFs, 4 in the US and 4 in Europe, a total of 46 funds. We use the complete ETF series for each index from –3*x* to +3*x* with the exception of FTSE100 and DAX, where only the –1*x* funds are missing. Daily NAV prices were obtained from each fund's website from their inception until April 28, 2017 and information about each fund from their brochures. The daily benchmark index prices were obtained from Yahoo Finance. In Table 3, we present descriptive statistics for all funds included in the study with their ticker symbol, stated leverage, Assets Under Management, yearly expense ratio, inception date, benchmark index, daily mean return and daily standard deviation. Along with leveraged funds, we include traditional 1*x* ETFs for the same underlying index.

The average yearly expense ratio for the examined 1*x* funds is 0.1868%, whereas the average yearly expense ratio for the examined leveraged funds is 0.78%. We could argue that the high expense ratios of the examined leveraged ETFs reflect their daily rebalancing needs. Moreover, 1*x* funds are vastly larger in size with an average amount of Assets Under

Table 3. ETF characteristics and descriptive statistics

Name	Ticker	Leverage	Assets under management	Expense ratio, %	Inception date	Underlying index	Mean return, %	Standard deviation, %
SPDR S&P 500	SPY	1	USD 237 billion	0.09	22/1/1993	S&P 500	0.0297	1.258
ProShares Ultra S&P 500	SSO	2	USD 1,883 million	0.89	19/6/2006	S&P 500	0.0647	2.5514
ProShares UltraPro S&P500	UPRO	3	USD 898 million	0.94	23/6/2009	S&P 500	0.1772	2.9111
ProShares Short S&P500	SH	–1	USD 1,993 million	0.89	19/6/2006	S&P 500	–0.043	1.2976
ProShares UltraShort S&P500	SDS	–2	USD 1,421 million	0.90	11/7/2006	S&P 500	–0.078	2.5638
ProShares UltraPro Short S&P500	SPXU	–3	USD 688 million	0.90	23/6/2009	S&P 500	–0.187	2.9124
SPDR Dow Jones Industrial Average ETF	DIA	1	USD 16.2 billion	0.17	14/1/1998	Dow Jones	0.0299	1.1306
ProShares Ultra Dow30	DDM	2	USD 328 million	0.95	19/6/2006	Dow Jones	0.0638	2.3503
ProShares UltraPro Dow30	UDOW	3	USD 214 million	0.95	9/2/2010	Dow Jones	0.154	2.6739
ProShares Short Dow30	DOG	–1	USD 263 million	0.95	19/6/2006	Dow Jones	–0.0429	1.1866
ProShares UltraShort Dow30	DXD	–2	USD 232 million	0.95	11/7/2006	Dow Jones	–0.0859	2.3798
ProShares UltraPro Short Dow30	SDOW	–3	USD 214 million	0.95	9/2/2010	Dow Jones	–0.1649	2.6727
PowerShares QQQ	QQQ	1	USD 49.7 billion	0.20	10/3/1999	NASDAQ-100	0.051	1.3547
ProShares Ultra QQQ	QLD	2	USD 1,135 million	0.95	19/6/2006	NASDAQ-100	0.1057	2.7345
ProShares UltraPro QQQ	TQQQ	3	USD 1,443 million	0.95	9/2/2010	NASDAQ-100	0.214	3.2103
ProShares Short QQQ	PSQ	–1	USD 267 million	0.95	19/6/2006	NASDAQ-100	–0.0607	1.3693%
ProShares UltraShort QQQ	QLD	–2	USD 288 million	0.95	11/7/2006	NASDAQ-100	–0.1222	2.7439
ProShares UltraPro Short QQQ	SQQQ	–3	USD 518 million	0.95	9/2/2010	NASDAQ-100	–0.224	3.2096
iShares Russell 2000 ETF	IWM	1	USD 40.5 billion	0.20	22/5/2000	Russell 2000	0.0381	1.6052
ProShares Ultra Russell2000	UWM	2	USD 153 million	0.95	23/1/2007	Russell 2000	0.075	3.2986
ProShares UltraPro Russell2000	URTY	3	USD 115 million	0.95	9/2/2010	Russell 2000	0.1798	3.9264
ProShares Short Russell2000	RWM	–1	USD 348 million	0.95	23/1/2007	Russell 2000	–0.0539	1.7215
ProShares UltraShort Russell2000	TWM	–2	USD 166 million	0.95	23/1/2007	Russell 2000	–0.0965	3.3340

Table 3 (cont.). ETF characteristics and descriptive statistics

Name	Ticker	Leverage	Assets under management	Expense ratio, %	Inception date	Underlying index	Mean return, %	Standard deviation, %
ProShares UltraPro Short Russell2000	SRTY	–3	USD 103 million	0.95	9/2/2010	Russell 2000	–0.1945	3.9265
iShares Core FTSE 100	ISF	1	GBP 4,744 million	0.07	27/4/2000	FTSE 100	0.0134	1.2501
ETFS FTSE 100® Leveraged (Daily 2x) GO UCITS ETF	LUK2	2	GBP 6.2 million	0.50	15/6/2009	FTSE 100	0.0792	2.0032
ETFS 3x Daily Long FTSE 100	UK3L	3	GBP 2.1 million	0.70	7/4/2014	FTSE 100	0.0794	2.8686
ETFS FTSE 100® Super Short Strategy (Daily 2x) GO UCITS ETF	SUK2	–2	GBP 27 million	0.60	15/6/2009	FTSE 100	–0.1018	2.0043
ETFS 3x Daily Short FTSE 100	UK3S	–3	GBP 13.6 million	0.70	7/4/2014	FTSE 100	–0.0914	2.8681
iShares Core DAX® UCITS ETF	DAXEX	1	EUR 8.175 million	0.16	27/12/2000	DAX	0.0327	1.4361
ETFS DAX® Daily 2x Long GO UCITS ETF	DEL2	2	EUR 41.8 million	0.40	22/6/2009	DAX	0.1026	2.5820
ETFS 3x Daily Long DAX	GY3L	3	EUR 17.8 million	0.70	14/4/2014	DAX	0.1288	3.799
ETFS DAX® Daily 2x Short GO UCITS ETF	DES2	–2	EUR 73.3 million	0.60	18/8/2009	DAX	–0.1248	2.5822
ETFS 3x Daily Short DAX	GY3S	–3	EUR 13.4 million	0.70	14/4/2014	DAX	–0.145	3.7989
Lyxor CAC 40 (DR) UCITS ETF	CAC	1	EUR 4,377 million	0.25	22/1/2001	CAC 40	0.0085	1.5185
Lyxor Daily Leverage CAC 40 UCITS ETF	LVC	2	EUR 186 million	0.40	23/5/2008	CAC 40	0.0423	3.0501
ETFS 3x Daily Long CAC 40	FR3L	3	EUR 0.9 million	0.70	27/5/2014	CAC 40	0.1032	3.7796
Lyxor Daily Short CAC 40 UCITS ETF	SHC	–1	EUR 42.7 million	0.40	13/6/2008	CAC 40	–0.0307	1.5476
Lyxor CAC 40 Daily Double Short UCITS ETF	BX4	–2	EUR 196 million	0.60	16/1/2007	CAC 40	–0.0456	2.9374
ETFS 3x Daily Short CAC 40	FR3S	–3	EUR 1.7 million	0.70	27/5/2014	CAC 40	–0.1283	3.7777
iShares FTSE MIB UCITS ETF EUR	IMIB	1	EUR 466 million	0.35	06/7/2007	FTSE MIB	–0.0124	1.7549
Lyxor FTSE MIB Daily Leveraged UCITS ETF	LEBMIB	2	EUR 240 million	0.60	11/2/2008	FTSE MIB	–0.01	3.5811
ETFS 3x Daily Long FTSE MIB	IT3L	3	EUR 19.9 million	0.70	27/5/2014	FTSE MIB	0.0407	4.9474
LYXOR UCITS ETF FTSE MIB DAILY SHORT	BERMIV	–1	EUR 53.4 million	0.60	11/2/2008	FTSE MIB	–0.0134	1.7419
Lyxor FTSE MIB Daily Double Short (XBear) UCITS ETF	XBRMIB	–2	EUR 168.6 million	0.60	11/2/2008	FTSE MIB	–0.0234	3.5341
ETFS 3x Daily Short FTSE MIB	IT3S	–3	EUR 13.9 million	0.70	27/5/2014	FTSE MIB	–0.078	4.9640

Notes: Assets Under Management volume is presented as of April 28, 2017. Mean return is the sample average of the simple daily returns from each LETF's inception to April 28, 2017 and in the case of 1x funds from January 1, 2006 to April 28, 2017, with the only exception of iShares FTSE MIB UCITS ETF EUR that started trading in July 6, 2007. Standard deviation is the sample standard deviation of the simple daily returns for each fund in the same time horizon.

Management[11] of USD 45,521 million compared to USD 365 million for leveraged funds[12]; leveraged ETFs are only a small fraction of the ETF industry. US funds are larger in size too, with an average amount of Assets Under Management of USD 14.854 million per fund compared to USD 979 million for European funds.

The measurement of the performance of passive investments can't be the same as in the case of active investments. It is unsuitable to use a performance measure based on absolute returns to assess the performance of leveraged ETFs. The objective of an ETF is to track the performance of a benchmark and not to outperform it and, therefore, popular performance measures, such as Sharpe Ratio and Information Ratio, might not be ideal for assessing passive investments in different benchmarks (Roncalli, 2014). The risk adjusted performance of ETFs with different benchmarks are not comparable to each other, as their risk and returns are heavily relied on the index they replicate. Ideally, the risk adjusted performance of an ETF would be exactly the same as its benchmark.

For our study, we regress the daily NAV returns of the leveraged ETFs since their inception on the benchmark index's returns and a constant intercept term to assess whether the leveraged ETFs perform as the management attempts to. If leveraged funds do replicate perfectly the target exposure, we expect them to have no abnormal return performance and their daily exposure to the benchmark index to be equal to their stated leverage $n \in (2, 3, -1, -2 \text{ or } -3)$. Hence, our null hypotheses would be $a = 0$ and $b = n$. For $1x$ funds, we use the same model and also expect to find $a = 0$ and $b = 1$. The funds' daily returns are estimated using changes in their NAVs, and not market prices so as to be certain that possible price inefficiencies due to premiums and discounts in the market prices impede our results. The management of the funds is responsible for achieving the daily target return for the fund, but has no control over potential market price inefficiencies. For investors purchasing these funds, premiums and discounts tend to appear, but usually average deviations are small, as they tend to offset one another (Charupat & Miu, 2010).

One constraint of our study is the large difference between the size of the examined funds. As shown in Table 3, the Assets Under Management of LETFs vary from USD 1 million to USD 1.8 billion and for $1x$ funds from USD 0.5 billion to USD 237 billion. Also the inception dates of the funds are not the same, as $\pm 3x$ funds are more recent additions.

3. EMPIRICAL ANALYSIS

The analysis presented in this section attempts to assess empirically the return performance[13] of US and European leveraged ETFs.

The time horizon of this study starts from each fund's inception date, as shown in Table 3, to April 28, 2017. In the case of $1x$ funds, the time horizon of the study starts on January 1, 2006 until April 28, 2017 with the only exception of iShares FTSE MIB UCITS ETF EUR that started trading on July 6, 2007. Most leverage Funds started trading from the period 2006–2010, providing us with 7-11 years of daily prices, a sample large enough to evaluate their performance. Generally speaking, higher $|n|$ times funds are more recent additions to the market. ETFS $3x$ Daily Long FTSE 100, ETFS $3x$ Daily Short FTSE 100, ETFS $3x$ Daily Long DAX, ETFS $3x$ Daily Short DAX, ETFS $3x$ Daily Long CAC 40, ETFS $3x$ Daily Short CAC 40, ETFS $3x$ Daily Long FTSE MIB and ETFS $3x$ Daily Short FTSE MIB started trading in 2014 so only 3 years of data are available for these funds. To assess the performance of the examined funds, we regress the daily NAV returns of the leveraged ETFs since their inception on the benchmark index's returns and a constant intercept term. We also regress non overlapping 5-day (weekly) and 21-day (monthly) NAV returns of leveraged ETFs on the 5-day and 21-day index returns to assess how leveraged ETFs perform if held more than one day. The use of non-overlapping time periods is to avoid dependence among returns. We do not use 6-month and yearly holding periods as leveraged ETFs are traded mainly by short-term traders with an average holding period of under 15 days (Charupat & Miu, 2010). The results for each fund are presented in Table 4.

11 As of April 28, 2017.

12 To convert AUM prices for European funds in USD, we used the currency exchange rates as of April 28, 2017.

13 We define performance as the ability of each fund to achieve its target return.

Table 4. Regression analysis from ETF inception to April 28, 2017 during different holding periods[1]

Name	Target leverage	1 day holding period			1 week holding period			1 month holding period		
		α	β	R^2, %	α	β	R^2, %	α	β	R^2, %
SPDR S&P 500	1	–0.00000013	0.996720***	99.7166	0.000000797	0.994687***	99.6461	–0.00000282	0.996243***	99.6280
ProShares Ultra S&P 500	2	0.0000167	1.999826***	99.7746	–0.0000847	2.001186***	99.5676	–0.001085*	2.028422***	99.3482
ProShares UltraPro S&P500	3	0.000162***	3.001446***	99.9648	0.000836***	2.994882***	99.8289	0.001232*	3.056619***	99.6427
ProShares Short S&P500	–1	–0.000113**	–0.995465***	95.5744	–0.000782***	–0.974545***	93.4942	–0.004516***	–0.917204***	89.0497
ProShares Ultra Short S&P500	–2	–0.000170***	–1.995884***	98.7698	–0.001491***	–1.954217***	96.9638	–0.010090***	–1.761719***	92.2069
ProShares UltraPro Short S&P500	–3	–0.000256***	–3.002483***	99.9483	–0.001225***	–3.016763***	99.3749	–0.010741***	–2.828944***	98.5582
SPDR Dow Jones Industrial Average ETF	1	0.000000135	0.997237***	99.7854	0.00000188	0.994264***	99.8071	0.0000052	0.997854***	99.9406
ProShares Ultra Dow30	2	0.0000252	1.998914***	99.4209	0.0000925	1.982665***	99.1658	–0.000164	1.982512***	98.7586
ProShares UltraPro Dow30	3	0.000207***	2.997523***	99.9258	0.000998***	2.978591***	99.7864	0.004287***	2.953244***	99.5254
ProShares Short Dow30	–1	–0.000125***	–0.994391***	96.5238	–0.000652***	–1.010870***	95.7579	–0.003901***	–0.959541***	92.9278
ProShares UltraShort Dow30	–2	–0.000259***	–1.989840***	96.3711	–0.001371***	–2.039140***	94.8713	–0.009893***	–1.823361***	89.7318
ProShares UltraPro Short Dow30	–3	–0.000317***	–2.996215***	99.9278	–0.001582***	–3.047756***	99.2303	–0.007328***	–3.019539***	98.8214
PowerShares QQQ	1	0.0000121	0.969751***	94.0127	0.0000125	0.997291***	99.9330	0.0000638	0.998978***	99.9283
ProShares Ultra QQQ	2	0.0000661**	1.995953***	99.6774	–0.000455***	1.993997***	99.4959	–0.001514*	1.979051***	99.3441
ProShares UltraPro QQQ	3	0.000058***	2.998077***	99.9765	0.000171	3.014599***	99.8304	0.000127	3.068113***	99.5706
ProShares Short QQQ	–1	0.0000466**	–0.997283***	99.2388	–0.000354**	–1.002388***	98.7358	–0.001663**	–0.992000***	98.2542
ProShares UltraShort QQQ	–2	0.0000845	–1.995590***	99.0007	–0.000829**	–1.998843***	97.9623	–0.004597***	–1.936799***	97.0103
ProShares Ultra Pro Short QQQ	–3	–0.000157***	–2.997223***	99.9606	–0.001109***	–2.954167***	99.4022	–0.007419***	–2.790694***	98.5886
iShares Russell 2000 ETF	1	0.000000534	0.998995***	99.9022	0.00000199	0.999443***	99.9132	0.0000341	0.991313***	99.9114
ProShares Ultra Russell2000	2	0.000030***	1.998466***	99.9784	0.00000716	1.999249***	99.7953	–0.000673	1.949288***	99.5569
ProShares UltraPro Russell2000	3	0.000129***	2.996161***	99.9807	0.000773***	2.976622***	99.7086	0.000251	3.021252***	99.5390
ProShares Short Russell2000	–1	–0.000182*	–0.993494***	90.7086	–0,001070**	–0.988415***	88.6087	–0.004471**	–1.094075***	90.5980
ProShares UltraShort Russell2000	–2	–0.000247*	–1.993950***	97.4216	–0,001686**	–1.991124***	95.2270	–0.009111***	–2.087013***	95.7012
ProShares UltraPro Short Russell2000	–3	–0.000277***	–2.996252***	99.9783	–0.001089**	–3.040892***	98.6699	–0.013377***	–2.801614***	98.0848
iShares Core FTSE 100	1	0.00000299	0.992895***	98.4178	0.0000169	1.001575***	98.9096	0.0000835	1.013943***	99.2450
ETFS FTSE 100® Leveraged (Daily 2x) GO UCITS ETF	2	0.000163***	1.971526***	98.1480	0.000796***	1.993893***	99.7868	0.002572***	2.003319***	99.5304
ETFS 3x Daily Long FTSE 100	3	0.000327***	2.994991***	99.7282	0.001710***	2.979707***	99.6502	0.003728**	2.971940***	98.9062
ETFS FTSE 100® Super Short Strategy (Daily 2x) GO UCITS ETF	–2	–0.000388***	–1.971958***	98.0842	–0.00184***	–2.011177***	99.4218	–0.010780***	–1.881186***	98.6680

Note: * Statistically significant at the 10% level, ** statistically significant at the 5% level, *** statistically significant at the 1% level.

1 In the case of 1x funds, the time horizon of the study is from January 1, 2006 to April 28, 2017, with the only exception of iShares FTSE MIB UCITS ETF EUR that started trading in July 6, 2007.

Table 4 (cont.). Regression analysis from ETF inception to April 28, 2017 during different holding periods

Name	Target leverage	1 day holding period			1 week holding period			1 month holding period		
		α	β	R^2, %	α	β	R^2, %	α	β	R^2, %
iShares Core DAX® UCITS ETF	1	–0.000033***	0.999679***	99.8698	–0.00016***	0.998705***	99.8732	–0.000703***	0.997908***	99.8658
ETFS DAX® Daily 2x Long GO UCITS ETF	2	–0.000109*	1.989286***	99.0372	–0.00059***	1.997198***	99.8324	–0.002565***	1.994841***	99.7648
ETFS 3x Daily Long DAX	3	–0.000077***	2.999798***	99.9998	–0.000601**	3.009869***	99.8633	–0.001321	3.114484***	99.4947
ETFS DAX® Daily 2x Short GO UCITS ETF	–2	–0.000113**	–1.989331***	99.0249	–0.000593**	–2.008987***	99.2126	–0.002792	–1.989758***	97.7741
ETFS 3x Daily Short DAX	–3	–0.000084***	–2.999763***	99.9997	–0.000934*	–2.970872***	99.4375	–0.004097	–2.728063***	98.1783
Lyxor CAC 40 (DR) UCITS ETF	1	0.00000406	0.996452***	97.9983	0.0000219	0.990818***	97.4328	–0.0000745	0.994994***	96.3428
Lyxor Daily Leverage CAC 40 UCITS ETF	2	0.000133**	1.972642***	99.3144	0.000500*	1.966540***	98.9661	0.001373	1.974424***	97.9981
ETFS 3x Daily Long CAC 40	3	0.000187**	3.004246***	99.7184	0.000897*	3.039151***	99.5067	0.000845	3.032620***	99.3037
Lyxor Daily Short CAC 40 UCITS ETF	–1	–0.000144***	–1.002123***	99.8179	–0.00090***	–1.003196***	992981	–0.004979***	–0.972445***	98.2937
Lyxor CAC 40 Daily Double Short UCITS ETF	–2	–0.000279***	–1.939426***	99.4862	–0.00194***	–1.960613***	98.7801	–0.011146***	–1.868335***	97.1135
ETFS 3x Daily Short CAC 40	–3	–0.000438***	–3.001939***	99.6643	–0.00225***	–2.960511***	99.1332	–0.016325***	–2.794755***	97.1995
iShares FTSE MIB UCITS ETF EUR	1	0.00000532	0.978366***	97.1134	0.0000469	0.991978***	98.1554	0.000323	1.008003***	98.6495
Lyxor FTSE MIB Daily Leveraged UCITS ETF	2	0.000000010	1.983643***	98.7778	–0.000121	1.974842***	98.5682	–0.001212	1.984363***	98.4638
ETFS 3x Daily Long FTSE MIB	3	0.000152*	2.994987***	99.7547	–0.000437	3.029877***	99.2990	0.004612	3.085932***	98.9971
LYXOR UCITS ETF FTSE MIB DAILY SHORT	–1	–0.000187***	–0.964339***	98.7387	–0.00108***	–0.986115***	98.5599	–0.005319***	–0.954309***	98.2078
Lyxor FTSE MIB Daily Double Short (XBear) UCITS ETF	–2	–0.000334***	–1.961488***	99.1689	–0.00210***	–2.034410***	98.2642	–0.011704***	–1.882275***	97.1687
ETFS 3x Daily Short FTSE MIB	–3	–0.000525***	–3.001968***	99.5462	–0.00508***	–2.934897***	97.4894	–0.011889	–2.704546***	94.9138

The beta coefficients for all 46 funds are statistically significant at the 1% level and the R^2 values are all greater than 85%, indicating a strong linear fit. Most intercepts are statistically significant and negative, which can be explained by the management fees and expenses leveraged ETFs have. Yet, this is not the case for all funds, as some intercepts of bull funds are positive and statistically significant. Bansal and Marshall (2015) have also found favorable to the investors tracking deviations when examining the monthly performance of SSO (+2). Intercepts for bear funds are always negative and increase as the holding period increases. Their value can be even lower than –1% for monthly holding periods suggesting that investors who want to hold bear funds for such holding periods need to take notice of them. That seems not to be the case for bull funds though. Although, in theory, bull and bear ETFs have similar yearly expense ratios, bear funds seem to underperform. A possible explanation might be the higher daily rebalancing needs that bear funds have as shown from equation (2) that would inevitably lead to higher transaction costs involved in delivering the advertised returns.

The betas for almost all the funds, both leveraged and non-leveraged, are close to their stated target for daily holding periods meaning that the management of the funds succeeds in performing as stated. Most funds are also performing very well for the weekly holding period, which means investors can safely invest for such a period without important return deviations. Beta deviations start to occur for the monthly holding period, as compounding effect becomes important. Lu et al. (2012) also found that for periods of less than a month, investor can safely expect LETF's promised returns of the underlying benchmark, but as the holding period gets longer, investors need to be cautious about the long term-returns. Again, it is the bear funds that tend to underperform more from their stated leverage than their bull counterparts with the worst deviation for ETFS 3*x* Daily Short FTSE MIB fund with a beta of –2.7 instead of –3. This finding is consistent with Shum and Kang (2013) who showed that bear ETFs deviate from their target return more quickly than their bull counterparts, as the holding period lengthens, and Charupat and Miu (2010) who found that for any holding period, the returns of bear funds deviate more from the promised ratio than the returns of bull funds. We could argue that the bear funds' negative return deviations are similar to the cost of security-borrowing that short-sellers experience.

To evaluate separately US and European ETF performance, we calculated the average alpha and beta coefficients for same-leveraged US and European Funds for the 3 holding periods examined. The results are presented in Table 5.

The average alpha and beta coefficients for same-leveraged US and European funds do not differ importantly for any of the 3 holding periods. European funds seem to be as effective in replicating their benchmarks as their American counterparts, although, they are on average 15 times smaller in their Assets Under Management. The truth is that the path dependency of the leveraged funds undermines the reliability of comparing weekly and monthly holding periods between US and European ETFs, as volatility and momentum of the different benchmarks can erode or proliferate their returns. Yet, daily returns are not affected by them and are a far better indication when comparing the effectiveness of leveraged ETFs across different benchmarks, as daily return deviations are entirely due to non-compounding effects. Although, in theory, one might expect US leveraged funds (and especially those tracking S&P 500) to have better performance in terms of efficiently replicating *n*-times their benchmark index, because their underlying assets are very liquid and a plethora of index products, which can be used for index replication exist and are densely traded, in practice, European funds seem to be equally efficient in replicating their benchmarks on a daily basis too.

Table 5. US vs EU funds' average regression coefficients during different holding periods

Name	1 day holding period			1 week holding period			1 month holding period		
	$\overline{\alpha}$	$\overline{\beta}$	$\overline{R}^2$, %	$\overline{\alpha}$	$\overline{\beta}$	$\overline{R}^2$, %	$\overline{\alpha}$	$\overline{\beta}$	$\overline{R}^2$, %
US 1x Funds	0	0.99067575	98.35422	0	0.99642125	99.82485	0	0.996097	99.85207
European 1x Funds	0.000007502	0.991848	98.28237	–0.000034525	0.995769	98.59277	–0.00017575	1.003712	98.47935
US 2x Funds	0.000024025	1.99828975	99.71282	–0.00011196	1.9942742	99.50615	–0.0008590	1.98481825	99.25195
European 2x Funds	0.0000468	1.9792743	98.81935	0.0001765	1.98311825	99.28837	0.00000175	1.98923675	98.93927
US 3x Funds	0.000139	2.99830175	99.96195	0.00061133	2.9911735	99.78857	0.00137975	3.024807	99.56942
European 3x Funds	0.00014725	2.9985055	99.80027	0.0005015	3.014651	99.5798	0.0009320	3.051244	99.17542
US –1x Funds	–0.00009335	–0.99515825	95.51140	–0.0007145	–0.9940545	94.14915	–0.00363775	–0.9907050	92.70742
European –1x Funds	–0.000170	–0.983231	99.2783	–0.00099	–0.9946555	98.9290	–0.005149	–0.963377	98.25075
US –2x Funds	–0.0001690	–1.993816	97.89080	–0.0013442	–1.9958310	96.25610	–0.00842275	–1.90222300	93.66255
European –2x Funds	–0.0002785	–1.96555075	98.94105	–0.00161825	–2.00379675	98.91967	–0.0084075	–1.9053885	97.68107
US –3x Funds	–0.00025175	–2.99804325	99.95375	–0.00125125	–3.0148945	99.16932	–0.00971625	–2.86019775	98.51325
European –3x Funds	–0.0003735	–2.99948875	99.73270	–0.0025685	–2.9836382	98.82385	–0.0080615	–2.7838287	97.16627

CONCLUSION

ETFs are one of the most successful innovations of the past two decades in financial markets globally. Their introduction was not controversial until the introduction of leveraged ETFs in 2006; unlike traditional ETFs, LETFs have leverage embedded as part of their design and are preferably used by short-term traders. The leveraged ETF market is continuously growing in size since its inception one decade ago and, therefore, it is important for both investors and regulators to understand and evaluate the potential risks involved with trading these funds. Although the introduction of LETFs provides investors all around the world with a new instrument to leverage their exposure to indexes, commodities and specific market segments, the sources and dynamics of the possible return deviations of these funds need to be recognized and taken seriously into account when investing.

Leveraged ETFs are required to maintain a constant leverage ratio which creates what is known as a constant leverage trap – they require daily rebalancing in order to meet the daily exposure needed. These funds are designed to provide a positive or negative multiple of an index on a daily basis and not for greater periods of time, where they will probably exhibit deviations. Their returns are path-dependent by the benchmark index during the investor's holding period. We use a five-day example to demonstrate the relation between a *+3x* leveraged ETF and its benchmark. An index with high momentum and low return volatility would intensify the holding period performance of LETFs, on the other hand, a low momentum market with high return volatility would have a negative effect on LETFs' performance. In a high volatility environment, investors seeking leveraged exposure over long time periods may be better off using derivatives such as futures and options. Generally speaking, buy and hold investors should prefer LETFs following less volatile indexes.

In this paper, we have focused on the performance of European and American equity leveraged funds under the perspective of the potential investor. From an investor's point of view, the actual daily beta should be exactly equal to the stated target multiple promised by the fund sponsor. To conduct the analysis, we study 8 families of leveraged funds following broad equity indexes, 4 in US and 4 in Europe. Firstly, we examine how much actual exposure these funds have on a daily basis with respect to their benchmark index and test if the beta coefficients deviate from the advertised leveraged exposure, if the intercept is statistically and economically different from zero and if variations in the underlying index explain a significant part of the variations in the returns of the leveraged ETFs, as shown by a high adjusted R^2. The results of our regression analyses suggest that the examined leveraged ETFs are successful in delivering their promised performance on a daily basis. Furthermore, when expanding holding periods to one week and one month[14], we find that they are also successful in delivering the promised performance over holding periods of up to one week; their performance starts to deviate when the holding period is one month. These findings are consistent with Lu et al. (2012), Charupat and Miu (2010) who found that LETFs can provide the stated leverage for holding periods of up to one week. We have also found empirical evidence that bear ETFs deviate from their target return much more quickly than bull funds as the holding period lengthens. A possible explanation is that transaction costs related to daily re-balancing activity are higher for bear funds, as shown in Table 1. These findings are similar with Shum and Kang (2013) and Charupat and Miu (2010) who have also shown that the performance of bear ETFs starts to fade more than the performance of bull ETFs, when the holding period increases.

When comparing average alpha and beta coefficients for US vs European LETFs, we found no significant differences for any of the 3 holding periods meaning that both US and European funds seem to be equally effective in replicating their benchmarks' leveraged returns in spite of the fact that the European funds examined are on average 15 times smaller in their Assets Under Management compared to their US counterparts. To our knowledge, this is the first study to compare the tracking efficiency of US vs

14 We use non-overlapping holding periods due to potential bias created by overlapping samples.

European LETFs. It has to be noted though that LETFs considered in this study follow broad indexes with very high liquidity and established derivative markets, therefore, it is easier for the funds' management to successfully follow these indexes and replicate their leveraged daily returns efficiently. Should less broad indexes be examined, it is possible that LETFs following them may not be able to successfully replicate their leveraged returns even on a short-term basis.

REFERENCES

1. Avellaneda, M., & Zhang, S. (2010). Path-dependence of leveraged ETF returns. *SIAM Journal of Financial Mathematics, 1,* 586-603. https://doi.org/10.1137/090760805
2. Bai, Q., Bond, S. A., & Hatch, B. (2014). The Impact of Leveraged and Inverse ETFs on the Underlying Stock Returns. *Real Estate Economics, 43,* 37-66. https://doi.org/10.1111/1540-6229.12061
3. Bansal, V., & Marshall, J. (2015). A Tracking Error Approach to Leveraged ETFs: Are They Really That Bad? *Global Finance Journal, 26,* 47-63. https://doi.org/10.1016/j.gfj.2015.01.004
4. Bansal, V., & Marshall, J. (2015). Tracking error decomposition and return attribution for leveraged exchange traded funds. *Global Finance Journal, 28,* 84-94. https://doi.org/10.1016/j.gfj.2015.11.006
5. Charupat, N., & Miu, P. (2010). The pricing and performance of leveraged exchanged-traded funds. *Journal of Banking and Finance, 35,* 966-977. https://doi.org/10.1016/j.jbankfin.2010.09.012
6. Cheng, M., & Madhavan, A. (2009). The Dynamics of Leveraged and Inverse Exchange-Traded Funds. *Journal of Investment Management, 7,* 43-62. Retrieved from https://papers.ssrn.com/sol3/papers.cfm?abstract_id=1539120
7. Curcio, R., Anderson, R., Guirguis, H., & Boney, V. (2012). Have leveraged and traditional ETFs impacted the volatility of real estate stock prices? *Applied Financial Economics, 22,* 709-722. https://doi.org/10.1080/09603107.2011.624080
8. Deville, L. (2008). Exchange Traded Funds: History, Trading and Research. In C. Zopounidis, M. Doumpos, P. Pardalos (Eds.), *Handbook of Financial Engineering* (pp. 1-37). Springer. Retrieved from https://halshs.archives-ouvertes.fr/halshs-00162223/document
9. Fevurly, K. (2013). The Handbook of Professionally Managed Assets: A Definitive Guide to Profiting from Pooled Investments. *Apress.* Retrieved from https://www.apress.com/br/book/9781430260196
10. Ginley, M., Scott, D. W., & Ensor, K. E. (2015). Simulation of Leveraged ETF Volatility Using Nonparametric Density Estimation. *Journal of Mathematical Finance, 5,* 457-479. http://dx.doi.org/10.4236/jmf.2015.55039
11. Guo, K., & Leung, T. (2014). Understanding the Tracking Errors of Commodity Leveraged ETFs. *Energy and Environmental Finance, 74,* 39-63. http://dx.doi.org/10.2139/ssrn.2389411
12. Haga, R., & Lindset, S. (2012). Understanding bull and bear ETFs. *The European Journal of Finance, 18,* 149-165. https://doi.org/10.1080/1351847X.2011.574980
13. Hill, J., & Foster, G. (2009). Understanding Returns of Leveraged and Inverse Funds. *Journal of Indices, 12,* 40-58. Retrieved from http://m.vixek.com/Understanding%20Returns%20Of%20Leveraged%20And%20Inverse%20Funds%20-%20JOI%20Articles.pdf
14. Hill, J., & Teller, S. (2009). Rebalancing Leveraged and Inverse Funds. Eighth Annual Guide to Exchange Traded Funds & Indexing Innovations. *Institutional Investor Journals, Institutional Investors Journals Investment Guides,* 67-76. Retrieved from http://ieor.columbia.edu/files/seasieor/industrial-engineering-operations-research/pdf-files/Rebalancing_Leveraged_and_Inverse_Funds_White_Paper_Nov_2009.pdf
15. Hill, J., Nadig, D., Hougan, M., & Fuhr, D. (2015). A Comprehensive Guide to Exchange-Traded Funds (ETFs). *CFA Institute Research Foundation.* Retrieved from https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2616223
16. Holzhauer, H., Lu, X., McLeod, E., & Mehran, J. (2013). Bad News Bears: Effects of Expected Market Volatility on Daily Tracking Error of Leveraged Bull and Bear ETFs. *Managerial Finance, 39,* 1169-1187. https://doi.org/10.1108/MF-09-2012-0203
17. Li, M., & Zhao, X. (2014). Impact of Leveraged ETF Trading on the Market Quality of Component Stocks. *North American Journal of Economics and Finance, 28,* 90-108. https://doi.org/10.1016/j.najef.2014.02.001
18. Lin, J. (2016). Does the inverse exchange-traded fund trading convey a bearish signal to the market? *Investment Management and Financial Innovations, 13*(2), 279-284. http://dx.doi.org/10.21511/imfi.13(2-2).2016.02
19. Little, P. (2010). Inverse and Leveraged ETFs: Not Your Father's ETF. *The Journal of Index Investing, 1,* 83-90. https://doi.org/10.3905/jii.2010.1.1.083
20. Loviscek, A., Tang, H., & Xu, X. (2014). Do Leveraged Exchange-Traded Products Deliver Their Stated Multiples? *Journal of Banking & Finance, 43,* 29-47. https://doi.org/10.2469/dig.v44.n6.13

21. Lu, L., Wang, J., & Zhang, G. (2012). Long Term Performance of Leveraged ETFs. *Financial Services Review, 21,* 63-80. http://dx.doi.org/10.2139/ssrn.1344133

22. Rompotis, G. (2014). On leveraged and inverse leveraged exchange traded funds. *Aestimatio, the IEB international journal of finance, 9,* 150-181. Retrieved from https://www.ieb.es/ww2017/wp-content/uploads/2015/02/n9/1.pdf

23. Roncalli, T. (2014). *Improving the efficiency of the European ETF market: Implications for regulators, providers, exchanges and investors.* Working Group on Risk, ESSEC Business School, February 5, 2014 (Paris). Retrieved from http://www.thierry-roncalli.com/download/improving-etf-efficiency.pdf

24. Shum, P., & Kang, J. (2013). Leveraged and inverse ETF performance during the financial crisis. *Managerial Finance, 39,* 476-508. https://doi.org/10.1108/03074351311313825

25. Shum, P., Hejazi, W., Haryanto, E., & Rodier, A. (2015). Intraday Share Price Volatility and Leveraged ETF Rebalancing. *Review of Finance, 20,* 2379-2409. https://doi.org/10.1093/rof/rfv061

26. Tang, H., & Xu, X. (2013). Solving the Return Deviation Conundrum of Leveraged Exchange-Traded Funds. *Journal of Financial and Quantitative Analysis, 48,* 309-342. https://doi.org/10.1017/S0022109012000622

27. Tang, H., Xu, X., & Yang, Z. (2014). Can international LETFs deliver their promised exposure to foreign markets? *Journal of International Financial Markets, Institutions & Money, 31,* 30-74. https://doi.org/10.1016/j.intfin.2014.03.003

28. Thomadakis, A. (2018). *The European ETF Market: What can be done better? ECMI Commentary, 53.* Retrieved from http://aei.pitt.edu/93708/1/AT_EuropeanETFMarket_0.pdf

29. Trainor, W. (2010). Do Leveraged ETFs Increase Volatility? *Technology and Investment, 1,* 215-220. https://doi.org/10.4236/ti.2010.13026

30. Trainor, W. (2010). Monthly vs Daily Leveraged Funds. *Journal of Finance and Accountancy, 6,* 1-14. Retrieved from http://www.aabri.com/manuscripts/10676.pdf

31. Trainor, W., & Carroll, M. (2013). Forecasting Holding Periods for Leveraged ETFs Using Decay Thresholds: Theory and Applications. *Journal of Financial Studies & Research,* 1-13. https://doi.org/10.5171/2013.715425