5-2010

Investigating Efficiencies of Long and Inverse ETF Pairs

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The School of Business

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Fall 2009

Table of Contents

Introduction

Exchange-traded funds (EFTs) are amongst the most popular investment securities. The common question now is whether the average investor is getting what s/he paid for. How well do ETFs track their respective benchmarks? On a short-term daily return basis, do leveraged and inverse leveraged ETF paired returns net out at zero? What is the effect of market volatility as represented by the VIX on expected versus actual ETF return deviations?

Over the past year, ETFs have come under fire from the investment community as being poor long term investments due to the volatility error of the levered products versus the unlevered. This is caused by cumulative returns of investment affecting a base investment differently through leverage. This paper examines pairs of leveraged and inverse leveraged ETFs ability to track their benchmark index given ETF pairs that are from the same provider, extend the same leverage factor, and track the same index.

Literature Review

What are ETFs?

ETFs are investment vehicles that combine the pricing features of a stock with the net asset valuation features of a mutual fund. Each ETF represents a basket of securities, either stocks, bonds, or derivatives, that may be traded throughout the day on the open market at a continuous price level based on the net asset value of the underlying securities (Chen, 2009). A single share represents a claim on a trust that holds the pool of assets. Share prices may diverge from the underlying asset base; however, such divergence is limited through the constant creation and redemption of ETF shares. When ETF share prices rise too far above the pool's net asset value, more of the underlying securities will be purchased in order to create a new ETF share. Likewise, redemptions will be made when the ETF share prices fall too far below net asset value (Poterba and Shoven, 2002).

Rise in Popularity

After being introduced into the market in 1993, ETFs have become popular investment securities. By July 2009, ETFs accounted for nearly 10% of all long-term mutual and exchange traded fund assets versus less than 6% at the end of 2006 (Laise, 2009). According to a survey of 840 investment professionals sponsored by State Street Corporation and Wharton, 67% identified exchange traded funds as the most innovative investment vehicle of the last two decades and 60% reported that ETFs have fundamentally changed the way they construct investment portfolios. Additionally, the same financial advisors ranked low cost, liquidity, intraday trading, tax efficiency, and investment style purity as the most attractive characteristics of ETFs (Mayclim and McGehee, 2008).

Types of ETFs

Plain vanilla ETFs seek to mirror the daily returns of their respective benchmark index. These benchmarks include broad indices such as the S&P 500, but also individual market sectors and sometimes are even differentiated by growth/value investment orientations. Over the past few years, more exotic types of ETFs have emerged: the leveraged, inverse, and leveraged inverse ETFs. Leveraged ETFs seek to deliver double or triple the daily return of their index, inverse ETFs aim for the opposite of their benchmark index's daily returns, while inverse leveraged ETFs purportedly will return a magnified, reversed benchmark return (Choi and Elston, 2009). One of the major benefits of the inverse exchange traded fund is that they allow one to bet against the market without going short. When the wide-sweeping ban on short selling financial stocks occurred in the United States, many traders flocked to inverse exchange traded funds as a method to get around the regulation (Gaffen, 2008).

Creating Leverage and Going Short without Shorting

For plain vanilla ETFs, the trust typically will buy shares of equity. Leveraged and inverse products replace equity shares with futures and swaps in order to guarantee the appropriate multiples of return advertised by these products. Futures give the benefit of having a clearing corporation stated as the counterparty, a great credit risk advantage versus large banks that clear swaps. Futures also require standard amounts and times to expiration and also mark-to-market accounting; swaps do not, instead favoring more flexibility and in principle much more widespread use. For example, the ProShares Short S&P 500 ETF held weightings of 91% in swaps and 9% in futures (Choi and Elston, 2009).

Criticism

Recently, exchange traded funds have been the highlight of debate within the investment community, notably because of the leveraged and inverse leveraged products. The fact that volatility drastically alters return paths is not widely understood by the everyday investor. Leveraged ETFs seek to deliver a multiple of a daily index return. In a longer holding period; however, volatility may cause the levered product to return much more or less than the vanilla ETF due to cumulative compounding effects. Since ETFs attempt to return the daily benchmark index return, leverage returns produce vastly different return paths in the long-run (Sullivan, 2009).

Additionally, through the reliance on total return swaps leveraged, inverse, and leveraged inverse ETFs are required to be rebalanced at the end of each trading day to make sure that the correct magnitude of return is generated the next day. Rebalancing expenses are quite high. This rebalancing activity creates volatility in the market since the rebalancing is always in the same direction as the daily returns. Daily return streams from paired leveraged and inverse leveraged ETFs do not net out on a daily basis (Cheng and Madhavan, 2009).

Conclusions

ETFs are clearly at the cutting-edge of financial innovation. They give traders valuable flexibility in isolating specific types of daily returns; however, they also present several issues for the uninformed investor. At the end of the day, the one question remains on ETFs: do you get what you pay for? Alternatively, is the everyday investor correct in assuming s/he will receive the levered or inverse levered return on an index in high volatility?

Data Source

This study incorporates data sourced from the Center for Research in Security Prices (CRSP) and accessed via the Wharton Research Data Services (WRDS) platform. On WRDS, daily stock information requests also yield information on ETFs. A base list of all ETFs and their tickers from MasterData.com is used and includes 776 ETFs. The list was last updated on September 19, 2009.

The base list of funds is trimmed by 148 bond ETFs, isolating a total of 628 ETFs that attempt to track some form of equity benchmark index. These 628 ETFs were further limited to only those leveraged and inverse leveraged ETF pairs that meet the following criteria: provided by the same family of funds, have the same leverage factor, and attempt to track the same index.

Eighty-eight exchanged-traded funds fit the criteria, creating a total of forty-four pairs. PERMNOs were identified for each ETF using WRDS. Seven pairs of ETFs were unavailable in the CRSP database and were subsequently eliminated. Matching pairs of daily returns is important; each daily return for one leveraged ETF should have an inverse leveraged pair return. The data is trimmed accordingly. Data Figure I contains a list of all seventy-four ETFs or thirty-seven exchange traded fund pairs used. There are currently 12,907 paired daily price observations.

Daily benchmark index returns were extracted from a Bloomberg Terminal query and include thirty-four different equity benchmarks. Similarly, historical daily VIX levels were taken from Yahoo Finance and imported into Excel. Each daily ETF return pair was matched with the daily VIX level of the same date.

Data Figure I: Paired Sets of ETFs

Long Fund Name:	Ticker Symbol:	Short Fund Name:	Ticker Symbol:	Leverage:
Direxion Developed Markets Bull 3x Shares	DZK	Direxion Developed Markets Bear 3x Shares	DPK	3
Direxion Emerging Markets Bull 3x Shares	EDC	Direxion Emerging Markets Bear 3x Shares	EDZ	3
Direxion Energy Bull 3x Shares	ERX	Direxion Energy Bear 3x Shares	ERY	3
Direxion Financial Bull 3x Shares	FAS	Direxion Financial Bear 3x Shares	FAZ	3
Direxion Large Cap Bull 3x Shares	BGU	Direxion Large Cap Bear 3x Shares	BGZ	3
Direxion Small Cap Bull 3x Shares	TNA	Direxion Small Cap Bear 3x Shares	TZA	3
Direxion Technology Bull 3x Shares	TYH	Direxion Technology Bear 3x Shares	TYP	3
ProShares Ultra Basic Materials	UYM	ProShares UltraShort Basic Materials	SMN	2
ProShares Ultra Consumer Goods	UGE	ProShares UltraShort Consumer Goods	SZK	2
ProShares Ultra Consumer Services	UCC	ProShares UltraShort Consumer Services	SCC	2
ProShares Ultra Dow30	DDM	ProShares UltraShort Dow30	DXD	2
ProShares Ultra Financials	UYG	ProShares UltraShort Financials	SKF	2
ProShares Ultra Health Care	RXL	ProShares UltraShort Health Care	RXD	2
ProShares Ultra Industrials	UXI	ProShares UltraShort Industrials	SIJ	2
ProShares Ultra MidCap400	MVV	ProShares UltraShort MidCap400	MZZ	2
ProShares Ultra Oil & Gas	DIG	ProShares UltraShort Oil & Gas	DUG	2
ProShares Ultra QQQ	QLD	ProShares UltraShort QQQ	QID	2
ProShares Ultra Real Estate	URE	ProShares UltraShort Real Estate	SRS	2
ProShares Ultra Russell MidCap Growth	UKW	ProShares UltraShort Russell MidCap Growth	SDK	2
ProShares Ultra Russell MidCap Value	UVU	ProShares UltraShort Russell MidCap Value	SJL	2
ProShares Ultra Russell1000 Growth	UKF	ProShares UltraShort Russell1000 Growth	SFK	2
ProShares Ultra Russell1000 Value	UVG	ProShares UltraShort Russell1000 Value	SJF	2
ProShares Ultra Russell2000	UWM	ProShares UltraShort Russell2000	TWM	2
ProShares Ultra Russell2000 Growth	UKK	ProShares UltraShort Russell2000 Growth	SKK	2
ProShares Ultra Russell2000 Value	UVT	ProShares UltraShort Russell2000 Value	SJH	2
ProShares Ultra S&P500	SSO	ProShares UltraShort S&P500	SDS	2
ProShares Ultra Semiconductors	USD	ProShares UltraShort Semiconductors	SSG	2
ProShares Ultra SmallCap600	SAA	ProShares UltraShort SmallCap600	SDD	2
ProShares Ultra Technology	ROM	ProShares UltraShort Technology	REW	2
ProShares Ultra Telecommunications ProShares	LTL	ProShares UltraShort Telecommunications	TLL	2
ProShares Ultra Utilities	UPW	ProShares UltraShort Utilities	SDP	2
Rydex 2x Russell 2000® ETF	RRY	Rydex Inverse 2x Russell 2000® ETF	RRZ	2
Rydex 2x S&P 500 ETF	RSU	Rydex Inverse 2x S&P 500 ETF	RSW	2
Rydex 2x S&P MidCap 400 ETF	RMM	Rydex Inverse 2x S&P MidCap 400 ETF	RMS	2
Rydex 2x S&P Select Sector Energy ETF	REA	Rydex Inverse 2x S&P Select Sector Energy ETF	REC	2
Rydex 2x S&P Select Sector Financial ETF	RFL	Rydex Inverse 2x S&P Select Sector Financial ETF	RFN	2
Rydex 2x S&P Select Sector Health Care ETF	RHM	Rydex Inverse 2x S&P Select Sector Health Care ETF	RHO	2
Rydex 2x S&P Select Sector Technology ETF	RTG	Rydex Inverse 2x S&P Select Sector Technology ETF	RTW	2

Process Description

The first half of the analysis process is structured to identify the ability of leveraged and inverse leveraged ETFs to track their respective benchmark index. Using daily benchmark returns magnified by the same ETF leverage factor, expected versus actual ETF performance may be identified. Differences between expected and actual returns for leveraged and inverse leveraged ETFs will be tested separately.

H_0: Expected Leveraged ETF Returns – Actual Leveraged ETF Returns = 0

H_1: Expected Leveraged ETF Returns – Actual Leveraged ETF Returns ≠ 0

H_0: Expected Inverse Leveraged ETF Returns – Actual Inverse Leveraged ETF Returns = 0

H_1: Expected Inverse Leveraged ETF Returns – Actual Inverse Leveraged ETF Returns ≠ 0

Additionally, a statistical test on the sum of leveraged and inverse leveraged ETF paired returns theoretically should net out at zero since both should have the same magnitude, only a directional difference.

H_0: Actual Leveraged ETF Returns + Actual Inverse Leveraged ETF Returns = 0

H_1: Actual Leveraged ETF Returns + Actual Inverse Leveraged ETF Returns ≠ 0

The second portion of the analysis examines variance using an average absolute deviation metric for differences in expected and actual leveraged and inverse leveraged ETFs in addition to differences in actual leveraged and actual inverse leveraged return sums. A correlation test against the VIX index is then used to evaluate the relationship between volatility and absolute average deviation in ETFs.

Analysis

t-Test for the Difference between Two Means

Analysis Figure I depicts the results of the first difference t-test between expected and actual leveraged ETF returns. Over 12,906 observations, the mean difference in returns calculated is 0.010, with numbers reflecting returns in percentage notation. The t-statistic of -0.158 fails to cross the critical t-value of 1.960, failing to reject the null hypothesis that expected leveraged ETF returns minus actual leveraged ETF returns equal zero.

Results for inverse leveraged ETFs fall in line with the leveraged only test. Depicted in Analysis Figure II, the mean difference in expected and actual returns is 0.001, slightly lower than with the leveraged only ETFs. The t-statistic of -0.011 likewise fails to cross the threshold t-value of 1.960, failing to reject the null hypothesis that expected inverse leveraged ETF returns minus actual inverse leveraged ETF returns equal zero.

The third t-test in Analysis Figure III tests the relationship between actual return streams between pairs of leveraged and inverse leveraged ETFs. 0.010 is the mean of leveraged returns and negative inverse leverage returns. The t-statistic is also very small at -0.175, not statistically significant at the critical t-value of 1.960, failing to reject the null hypothesis that actual leveraged ETF returns plus actual inverse leveraged ETF returns equal zero.

All three tests are proven to not be statistically significant; however, standard deviation metrics for differences between actual and expected leveraged ETFs, actual and expected inverse leveraged ETFs, and actual leveraged and inverse leveraged sums are notably high at 2.175, 2.060, and 1.534 respectively.

Heteroskedasticity

There is a notable amount of heteroskedasticity when the return differences are graphed over a scatter plot. In Analysis Figures IV-VI, differences between returns are shown to straddle the x-axis with a largely increasing level of variability from July 14, 2006 to the last relative day observation on December 31, 2008. This suggests that although the difference t-tests are statistically insignificant, there might be value investigating volatility in return differences specifically toward the tail-end of 2008.

To account for the large level of heteroskedasticity, an average absolute deviation calculation provides more color on overall variability. The average absolute deviations are 1.027, 0.942, and 0.807 for differences between expected and actual leveraged ETF returns, expected and actual inverse leveraged ETF returns, and the sum of paired leveraged and inverse leveraged ETF returns respectively. This means that leveraged and inverse leveraged ETFs vary away from their daily benchmark index returns on an average close to 100BPS, which is extremely concerning given the nature of ETFs.

Figures VII-IX represent graphs for absolute daily differences between expected and actual leveraged ETF returns, expected and actual inverse leveraged ETF returns, and the sum of paired leveraged and inverse leveraged ETF returns. While most points on all three graphs generally fall below the 10.00 hash mark, daily return differences after the 550^{th} day observation exhibit extreme highs reaching in excess of 40.00 for differences between expected and actual returns of both leveraged and inverse leveraged ETFs.

Correlation to VIX

On the surface, it appears that differences between expected and actual ETF returns are governed by overall market volatility, given the extreme difference highs seen in the end of 2008. That tumultuous period was fueled by the subprime mortgage crisis and the ultimate bankruptcy of Lehman Brothers. This is supported by Analysis Figure X, which graphs the VIX price level over the same daily return observation periods as the return difference data.

Correlations between the VIX index and the three difference return data streams proved to all be both positive and statistically significant. VIX correlation coefficients were 0.050, 0.047, and 0.033 while t-statistics were all high at 49.673, 48.936, and 47.367 respectively for average absolute deviation on daily differences between expected and actual leveraged ETF returns, expected and actual inverse leveraged ETF returns, and the sum of paired leveraged and inverse leveraged ETF returns. This shows that there is a very strong relationship between absolute ETF versus benchmark volatility and the VIX index.

VIX Percentile Ranking

The table in Analysis Figure XIV ranks average absolute deviation by VIX percentile for leveraged, inverse leveraged and paired return differences, with lower VIX levels represented by the lower percentiles. The relationship between average absolute deviation and VIX percentile is clearly monotonic. The higher the VIX goes, the higher the average absolute deviation. Increases in average absolute deviation between percentile buckets average to roughly 10-20BPS from the first to fourth percentile. The movement from the fourth to fifth percentile are much larger at 150BPS for leveraged and inverse leveraged return differences and 95BPS for paired return differences.

Conclusions

Actual daily returns for leveraged and inverse leveraged ETF products do not deviate from expected returns in a statistically significant way over the long-run, nor do summed leveraged and inverse leveraged paired returns deviate from zero. While this may seem comforting to ETF investors, it should be noted that ETFs are meant to produce daily returns. On a daily basis, an individual fund may be reasonably expected to deviate from benchmark returns by roughly 100BPS on an absolute basis, or 50BPS in either direction.

While there are several clearly defined studies regarding the compounding effect and tracking error between leveraged ETFs and unlevered benchmarks, this study shows that leveraged and inverse leveraged ETF products will suffer from compounding and tracking-error compared to levered benchmark returns due to the high level of variability in actual daily returns versus the expected levered benchmark return. These differences do net out at zero in the long run across all leveraged and inverse leveraged products, but the daily variability is enough to create significant return path disruption over longer holding periods.

Additionally, the differences in expected and actual returns are highly correlated with the overall VIX level. The higher the VIX, the greater daily return deviation will be. Common advice on leveraged and inverse leveraged ETFs is to limit holding periods to very short term plays. Any increase in the VIX should further lower holding periods of ETFs. Notably VIX levels in the fifith percentile, or a VIX roughly above 30, should key investors in to avoid leveraged and inverse leveraged products as average absolute deviation increases over 150BPS for daily returns from the fourth percentile.

Analysis Figure I: Expected - Actual Leveraged ETF Returns Test

t-Test: Two-Sample Assuming Unequal Variances

	LONG_RET	*EXP_LONG*
Mean	-0.167937208	-0.158273989
Variance	22.37438153	25.61615344
Observations	12906	12906
Hypothesized Mean Difference	0	
df	25693	
t Stat	-0.158467367	
P(T<=t) one-tail	0.437044889	
t Critical one-tail	1.644912936	
P(T<=t) two-tail	0.874089779	
t Critical two-tail	1.960056264	

Analysis Figure II: Expected - Actual Inverse Leveraged ETF Returns Test

t-Test: Two-Sample Assuming Unequal Variances

	INV_RET	*EXP_INV*
Mean	0.157601991	0.158273989
Variance	22.77831223	25.61615344
Observations	12906	12906
Hypothesized Mean Difference	0	
df	25722	
t Stat	-0.010974018	
P(T<=t) one-tail	0.495622131	
t Critical one-tail	1.64491287	
P(T<=t) two-tail	0.991244262	
t Critical two-tail	1.96005616	

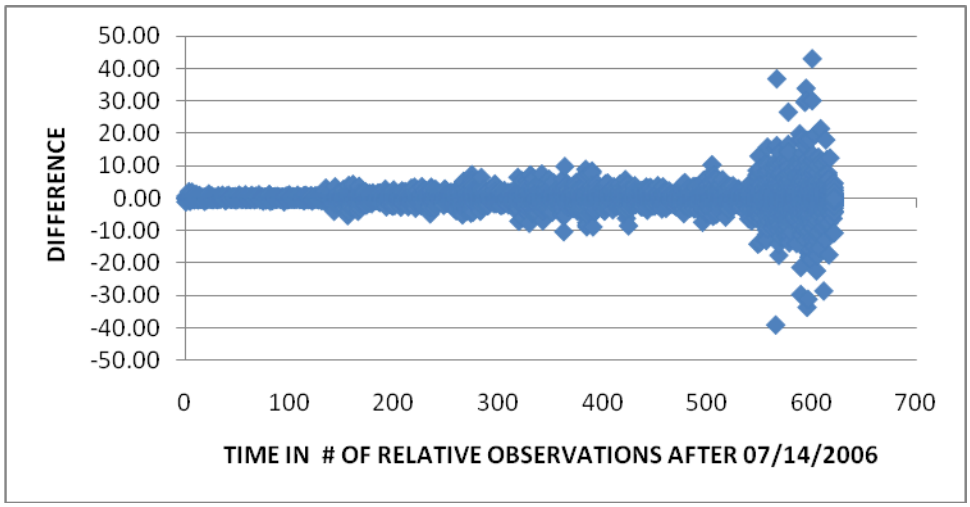
Analysis Figure III: Actual Paired Difference ETF Returns Test

t-Test: Two-Sample Assuming Unequal Variances

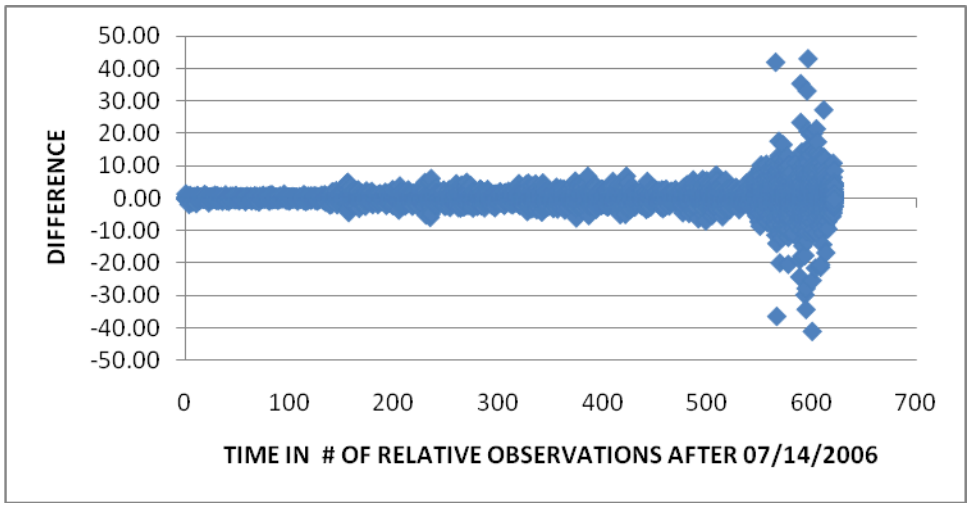
	LONG_RET	*NEG_INV_RET*
Mean	-0.167937208	-0.157601991
Variance	22.37438153	22.77831223
Observations	12906	12906
Hypothesized Mean Difference	0	
df	25808	
t Stat	-0.174732449	
P(T<=t) one-tail	0.43064562	
t Critical one-tail	1.644912672	
P(T<=t) two-tail	0.86129124	

t Critical two-tail	1.960055853

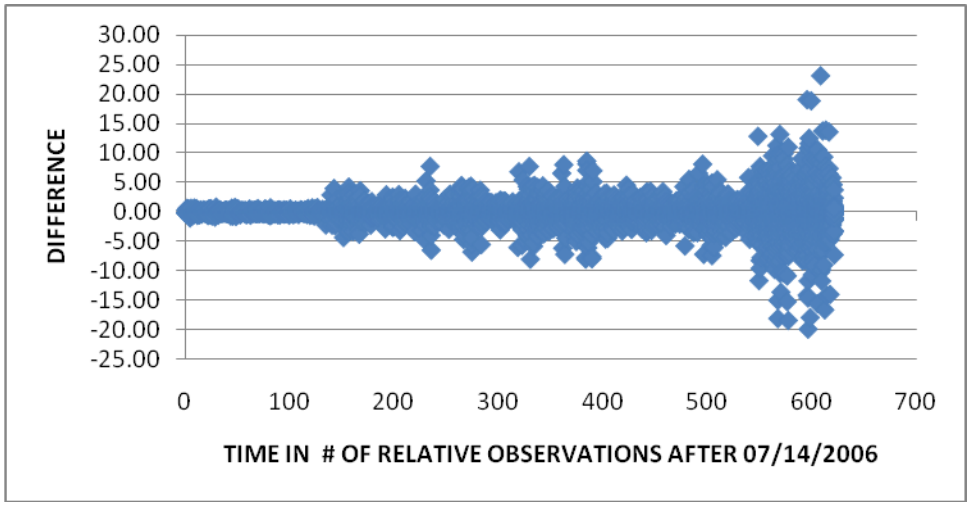
Analysis Figure IV: Expected - Actual Leveraged ETF Returns Plot



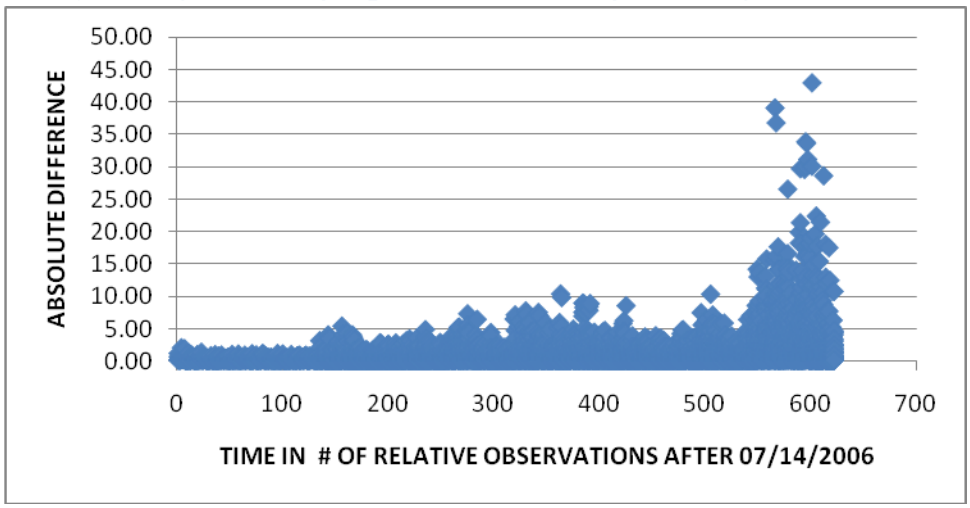
Analysis Figure V: Expected - Actual Inverse Leveraged ETF Returns Plot



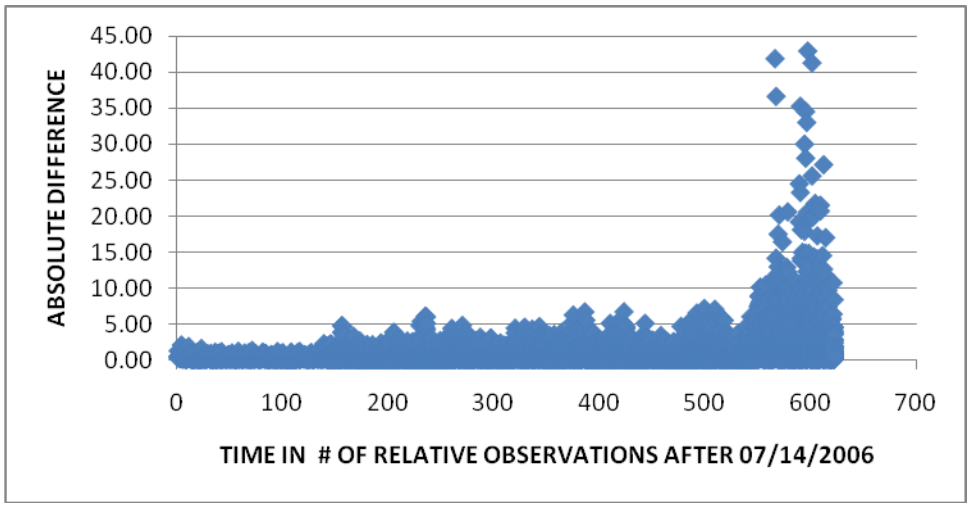
Analysis Figure VI: Actual Paired Difference ETF Returns Plot



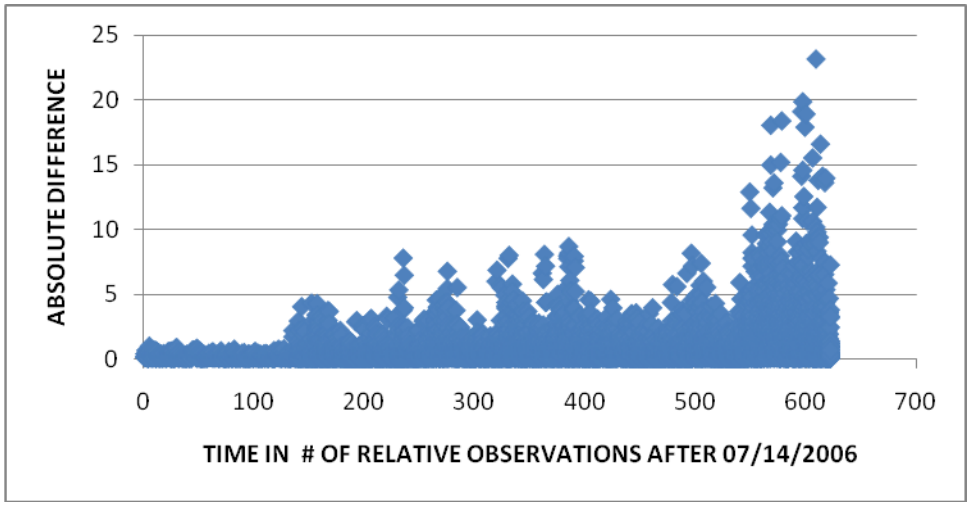
Analysis Figure VII: |Expected – Actual| Leveraged ETF Returns Plot



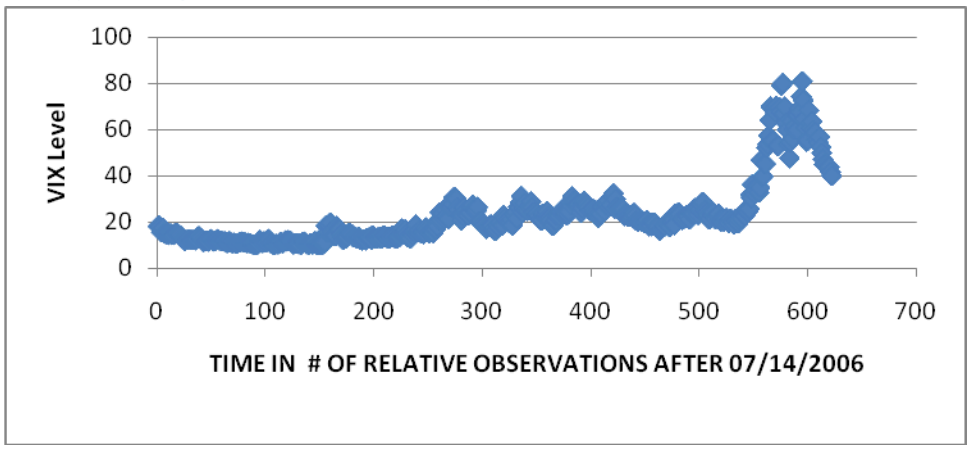
Analysis Figure VIII: |Expected – Actual| Inverse Leveraged ETF Returns Plot



Analysis Figure IX: | Actual Paired Difference| ETF Returns Plot



Analysis Figure X: VIX Volatility Index Movement



Analysis Figure XI: VIX v. |Expected – Actual| Leveraged ETF Returns

Regression Statistics	
Multiple R	0.400646354
R Square	0.160517501
Adjusted R Square	0.160452445
Standard Error	1.756421004
Observations	12906

ANOVA

	df	*SS*	*MS*	*F*
Regression	1	7611.88716	7611.88716	2467.374647
Residual	12904	39809.03024	3.085014743	
Total	12905	47420.9174		

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	-0.309242696	0.031022873	-9.96821583	2.54952E-23
VIX	0.049829286	0.001003153	49.67267505	0

Analysis Figure XII: VIX v. |Expected – Actual| Inverse Leveraged ETF Returns

Regression Statistics	
Multiple R	0.395642
R Square	0.156533
Adjusted R Square	0.156467
Standard Error	1.68275
Observations	12906

ANOVA

	df	*SS*	*MS*	*F*
Regression	1	6781.106	6781.106	2394.756
Residual	12904	36539.58	2.831648	
Total	12905	43320.69		

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	-0.3194	0.029722	-10.7465	7.99E-27
VIX	0.047031	0.000961	48.93624	0

Analysis Figure XIII: VIX v. |Actual Paired Difference| ETF Returns

Regression Statistics	
Multiple R	0.384858829
R Square	0.148116318
Adjusted R Square	0.148050301
Standard Error	1.204542213
Observations	12906

ANOVA

	df	*SS*	*MS*	*F*
Regression	1	3255.299959	3255.299959	2243.607917
Residual	12904	18722.69675	1.450921943	
Total	12905	21977.99671		

	Coefficients	*Standard Error*	*t Stat*	*P-value*
	-		-	
Intercept	0.066467357	0.021275287	3.124158005	0.001787096
VIX	0.032586221	0.000687956	47.36673851	0

Analysis Figure XIV: Average Absolute Deviation by VIX Percentile Rank

Row Labels	Average of ABS_LONG	Average of ABS_SHORT	Average of ABS_LS
1	0.406171379	0.417886941	0.369444761
2	0.608535579	0.555278513	0.501326365
3	0.767724971	0.683148236	0.632236758
4	0.941825456	0.788941366	0.796295188
5	2.418439012	2.2706345	1.742996033
Aggregate	**1.026741198**	**0.941566822**	**0.807208949**

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