Global Journal of Business Research
Vol. 13, No. 1, 2019, pp. 15-22
ISSN: 1931-0277 (print)
ISSN: 2157-0191 (online)

www.theIBFR.com

AN INVESTIGATION OF TRACKING ERRORS OF LEVERAGED AND INVERSE ETFS IN TAIWAN

Han Ching Huang, Chung Yuan Christian University
Lin Jiun Tsai, Chung Chung Yuan Christian University

ABSTRACT

The purpose of this paper is to investigate the tracking error of leveraged and inverse ETFs. Single-day tracking performances of the Taiwan 50 Bull 2X ETF and Taiwan 50 Bear -1X ETF were tested to investigate whether there are structural changes of tracking performances during the bull and bear markets. The result shows that single-day performances of the two ETFs are significantly different from their targets. The positive and negative effects of single-day performance are asymmetric. When the market moves from bull to bear, there is a structural change in the two ETFs' returns. Nonetheless, there is a structural change only in Taiwan 50 Bear -1X ETF returns when the market moves from bear to bull.

JEL: G11, G12

KEYWORDS: Tracking Error, Leveraged ETF, Inverse ETF, Structural Change

INTRODUCTION

Leveraged and inverse ETFs first appeared in the market about 20 years ago. Since their inception, they have grown rapidly throughout the world. Some research examines the product character and tracking performance of leveraged and inverse ETFs (e.g. Lu, Wang and Zhang, 2009; Bansal and Marshall, 2015; Sherrill, Shirley, and Stark, 2017; Lundström and Peltomäki, 2018). For example, Lu et al. (2009) examined leveraged ETFs, which are designed to provide double (or double the opposite) the performance of the benchmark on a daily basis. Over holding periods no greater than one month, an investor can safely assume that both ETFs would provide double the return (or double the negative return) of the underlying benchmark. Nevertheless, most of them focus on America or other countries. In Taiwan, there are several papers exploring the tracking performance and arbitrage of traditional ETFs (Lu, 2008; Luo and Chang, 2009). Since leveraged and inverse ETFs were introduced only two years ago in Taiwan, there are not many papers discussing them. The relevant papers examine mostly foreign leveraged and inverse ETFs (Trainor and Gregory, 2016; Giannetti, 2017). The papers about leveraged and inverse ETFs in Taiwan focus on the long and short term of tracking performance and the factor affecting tracking performance (e.g. Su, 2015).

Fund managers experience different operating performance in bull and bear markets (Chu, 2000). Additionally, there are some structural changes in funds with the changes of bull and bear markets, (Lin, 2011). Therefore, this study explores whether there is a structural change in tracking performance of leveraged and inverse ETFs in different markets. The remainder of this paper is organized as follows. In the literature review section, related research and literature highlighting key data and analysis are presented. The data and methodology section describes the data and defines the variables used. In the results and discussion section, the regression results and discussion of specific aspects can be found before the concluding comments section.

LITERATURE REVIEW

Lu et al. (2009) studied leveraged ETFs, in particular Ultra ETFs and UltraShort ETFs from the ProShares family. These ETFs are designed to provide double (double the opposite) the performance of the benchmark

on a daily basis. Over holding periods no greater than one month, an investor can safely assume that both ETFs would provide double the return (or double the negative return) of the underlying benchmark. Su (2015) examines long-term and short-term tracking performances of four leveraged and inverse ETFs listed on the stock exchange in Taiwan. The daily tracking performance of the leveraged and inverse ETFs significantly deviate from the investment objectives of the funds at the 1% level. Lin (2016) examines the tracking performance of leveraged and inverse ETFs in Asia. He explores whether the leveraged and inverse ETFs can reach their goal to provide the promised return in the short- and long-term.

Fabozzi and Francis (1977) provide three kinds of definitions of bull and bear markets to estimate the single-index market model (SIMM). They find that the SIMM is unaffected by the three different bull and bear market conditions delineated in their research. Chu (2000) finds that the higher internal locus of control fund managers and higher risk-taking fund managers both experience better fund performance, especially in the bull market. Chen (2007) uses the data envelopment analysis (DEA) approach to evaluate the performance of 132 Taiwan stock mutual funds from 2001 to 2006. He shows that mutual funds have better performance in bull markets. Chang and Huang (2010) test local open-end stock funds from January 1999 to December 2008. They find that local open-end stock funds can be affected by the bullish or bearish performance of the local stock market; fund performance and turnover rates also moved up and down in the same direction as the rise and fall of the local stock market. Lin (2011) investigates the interaction of Taiwan ETFs and related financial assets in the bull and bear markets. It was found that there exists a long-term equilibrium relationship between ETFs and related financial assets.

Kao (2006) applies clustering analysis to detect the structural changes in the Taiwan Weighted Stock Index (TAIEX). From 1990 to 2004 there were three structural changes and several transient structural changes detected along with some important events during the structural change period. Chen (2010) applies the "extreme value theory" to investigate both whether the risk indices of 26 industries in Taiwan's stock market and whether the tail risk and tail quantile index significantly changed due to the 921 Earthquake. The results indicate that the 921 Earthquake caused a structural change on indices for most industries. According to Lu et al. (2009), Su (2015), and Lin (2016), there exists tracking performance error in both leveraged and inverse ETFs. They show that there is an obvious difference between tracking performance and target remuneration, even in a single day. As Chen (2007) and Chung and Huang (2010) point out that in bull markets, the performance of funds are higher than the market index remuneration, in bear markets, the performance of funds are much more defensive. Therefore, in both bull and bear markets, there is a different level of effectiveness and performance. According to Lin (2011), there exists structural changes in Taiwan's 50 funds with the changes in bull and bear markets. Since the underlying stocks of traditional ETFs are the same as the leveraged and inverse ETFs, it is inferred that the tracking performance of the leveraged and inverse ETFs would have structural changes along with the changes in bull and bear markets. Therefore, the following hypotheses have been formulated.

Hypothesis 1: The intercepts of the tracking performances in leveraged and inverse ETFs have structural changes along with the bull and bear markets.

Hypothesis 2: The return terms of the tracking performances in leveraged and inverse ETFs have structural changes along with the bull and bear markets.

DATA AND METHODOLOGY

This study uses the leveraged (T502X) and inverse ETFs (T50R) in Taiwan as a sample. The sample period is from October 31, 2014 (listing day) to February 24, 2017. According to Fabozzi and Francis (1977), the division of the stock market is determined by the markets' moving average. The bull market period is from October 31, 2014 to April 30, 2015 and from February 1, 2016 to February 24, 2017. The total number of trading days is 567 and the frequency of observations in our data is daily. The bear market is from May 1, 2015 to January 31, 2016. The source of data is TEJ and CMoney. Since the target returns for leveraged and inverse ETFs are based on one day, it would deviate the target return over one day owing to the compound interest effect. Therefore, they are suitable for short term operation rather than long term.

According to Su (2015), the compound interest effect by two-day period is explained as an example. First, the single-day returns of the subject index are defined, double leveraged ETF and doubled inverse ETF as r_t^B 、r_t^L 、r_t^I. Then, the two-day returns of the subject index are defined, double leveraged ETF and doubled inverse ETF as R_{t2}^B 、R_{t2}^L 、R_{t2}^I.

$$r_t^L = 2r_t^B \quad (1)$$

$$r_t^I = -r_t^B \quad (2)$$

$$R_{t2}^B = \left(1 + r_t^B\right)\left(1 + r_{t+1}^B\right) - 1 = r_t^B + r_{t+1}^B + r_t^B r_{t+1}^B \quad (3)$$

$$R_{t2}^L = \left(1 + 2r_t^B\right)\left(1 + 2r_{t+1}^B\right) - 1 = 2r_t^B + 2r_{t+1}^B + 4r_t^B r_{t+1}^B \quad (4)$$

$$R_{t2}^I = \left(1 - r_t^B\right)\left(1 - r_{t+1}^B\right) - 1 = -r_t^B - r_{t+1}^B + r_t^B r_{t+1}^B \quad (5)$$

$$R_{t2}^L = 2R_{t2}^B + 2r_t^B r_{t+1}^B \quad (6)$$

$$R_{t2}^I = -R_{t2}^B + 2r_t^B r_{t+1}^B \quad (7)$$

According to the above formula, the two-day accumulated returns of the leveraged and inverse ETFs would deviate 2-times and -1-time from the subject index. The longer period held is associated with the greater deviation from the target return. When the tracking target index continues rising or falling, the term of $r_t^B r_{t+1}^B$ is positive, implying that the returns of the leveraged and inverse ETFs exceed the target returns. When the tracking target index is bumpy, the term of $r_t^B r_{t+1}^B$ is be negative, implying that the returns of the leveraged and inverse ETFs do not reach target returns. This paper investigates whether single-day tracking performances of leveraged and inverse ETFs have reached the target performance. Based on Su (2015), returns in the holding period are calculated by overlapping data to minimize the loss on the number of sample.

$$r_{n-day} = \frac{P_{t+n} - P_t}{P_t} \quad (8)$$

where P_t is defined as net asset value (NAV) when the return for funds is calculated; P_t is defined as the index of closing price when the return for index is calculated.

The relationship between the return of leveraged and inverse ETFs in the holding period and the return of the target index in the corresponding period. The dependent variable is the return of leveraged and inverse ETFs and the independent variable is the return of the target index. The regression model is as follows:

$$Y_i = \alpha + \beta \cdot X_i + \varepsilon_i \quad (9)$$

where Yi is the return of leveraged and inverse ETFs, X_i is the return of the target index. The Wald test is used to examine single-day tracking performance of the leveraged and inverse ETFs. The higher value of the Wald test is associated with more accurate tracking performance. The above relationship is examined using the hypotheses

$H_0: C(2) = 2$ and $H_0: C(2) = -1$.

Moreover, this research examines the symmetry of return. That is, an investigation of whether there is a different between positive and negative effects of tracking performance is carried out. In linear regression, an intersection term of the return for tracking subject index is added and the dummy variable, D, which is equal to one if the return for index, is positive or zero otherwise. If β_2 is significantly different from zero, it can be concluded that there is a different between positive and negative effects of tracking performance.

$$Y_i = \alpha + \beta_1 \cdot X_i + \beta_2 \cdot D_i \cdot X_i + \varepsilon \quad (10)$$

whereY_i is the return for leveraged and inverse ETFs, X_i is the return for tracking index. D_t is equal

to one if the return for tracking index is positive, zero otherwise. If the return of the subject index is positive, the tracking performance would be $\beta_1 + \beta_2$. If the return of the subject index is negative, the tracking performance would be β_1. If β_2 is significantly different from zero, this research argues that the tracking performance is asymmetric. This research examines whether there are some structural changes in the tracking performance for leveraged and inverse ETFs during bull and bear markets. The bull and bear markets are separated according to the research of Fabozzi and Francis (1977). By taking the structural change of two-period time intervals as an example, the sample is split into two parts and it is examined whether there is a structural change at point T_1. The regression is as follows.

$$Y_t = \alpha + \beta X_t + \lambda_1 D_t + \lambda_2 X_t D_t + \varepsilon_t \quad (11)$$

where D_t is equal to one if there is after T_1, zero otherwise.
If λ_1, λ_2 are significantly different from zero, it is argued that there exists a structural change.

RESULTS AND DISCUSSION

Table 1 presents the descriptive statistics of Taiwan 50 ETF, T502X and T50. The mean, median, maximum, or minimum value of return of T502X are not two times greater than those of T50ETF. In addition, the return of inverse T50 is not negative one times as big as those of T50ETF. Thus, there should be some reasoning for them not to reach the return of the target index. Table 2 presents the tracking performance rate in single-day leveraged and inverse ETFs and the tracking performance rate in the single-day tracking index ETF. The coefficients of return of T502X and inverse T50 ETFs are 1.8910 and -0.9076, which are significantly different from 2 and -1 at the 1 % level, respectively. It shows that the lack of performance of the return of T502X and inverse T50 ETFs are tracking the target return of Taiwan 50 ETF.

Table 1: Descriptive Statistics of Tracking Index, Leveraged and Reversed ETFs

	Taiwan50 ETF	**T502X**	**T50R**
Mean	0.0377%	0.0725%	-0.0419%
Median	0%	0.0822%	-0.0493%
Maximum	4.3938%	9.3936%	5.8364%
Minimum	-3.8462%	-10.5882%	-4.8654%
Std. Error	0.9687%	1.8852%	0.9227%
# of data	567	567	567

This table shows the descriptive statistics of tracking index, leveraged and reversed ETF from 2014/10/31 to 2017/02/24.

Table 2: The Tracking Performance in One-Day Leveraged and Reversed ETFs

	Coefficient	**Std.Error**	**t-Value**	**p-Value**	**Adjusted R^2**
Panel A: T502X					
Intercept	0.00001	0.0002	0.0594	0.9527	0.9441
X	1.8910***	0.0193	97.7541	0.0000	
Panel B: T50 reversed					
Intercept	-0.00008	0.0001	-0.6526	0.5143	0.9078
X	-0.9076***	0.0122	-74.6452	0.0000	

We use the following regression to calculate the tracking performance of these ETFs.
*$Y_i = \alpha + \beta \cdot X_i + \varepsilon$ where Y_i is the return rate of leveraged ETF or reversed ETF and X_i is the return rate of tracking index ***, ** and * denote statistical significance at 1 percent, 5 percent and 10 percent level respectively.*

In Table 3, the Wald Test is used to examine the null hypothesis C(2)=2 for T502X and C(2)= -1 for inverse T50. The result shows that the null hypotheses must be rejected in T502X and inverse T50, indicating that these two ETFs' single-day returns deviate from the corresponding multiple target return of the tracking index ETF. Therefore, it is argued that the reactions of single-day T502X and inverse T50 returns lack the multiple target return of Taiwan 50 ETF.

Table 3: The Tracking Performance in One-Day Leveraged and Reversed ETFs in Wald Test

Test Statistic	Value	df	p-Value
Panel A: T502X			
t- statistic	-5.6354***	565	0.0000
f- statistic	31.7576***	(1,565)	0.0000
Chi-square	31.7576***	1	0.0000
Panel B: T50 Reversed			
t- statistic	7.5987***	565	0.0000
f- statistic	57.7402***	(1,565)	0.0000
Chi-square	57.7402***	1	0.0000

*We use Wald Test to examine the tracking performance of these ETFs. ***, ** and * denote statistical significance at 1 percent, 5 percent and 10 percent level respectively.*

Table 4 shows the symmetry of return in leveraged and inverse ETFs. The coefficients of return in leveraged and inverse ETFs (β_2) are significantly different from 2 and -1 at the 1% level, suggesting that the effects of single-day T502X and inverse T50 returns are not symmetric. The β_2 in T502X is negative. It means that when return rises, T502X's return would deviate from the target return rate. The β_2 in inverse T50 is positive, indicating when return rises, the inverse T50 would deviate from its target return.

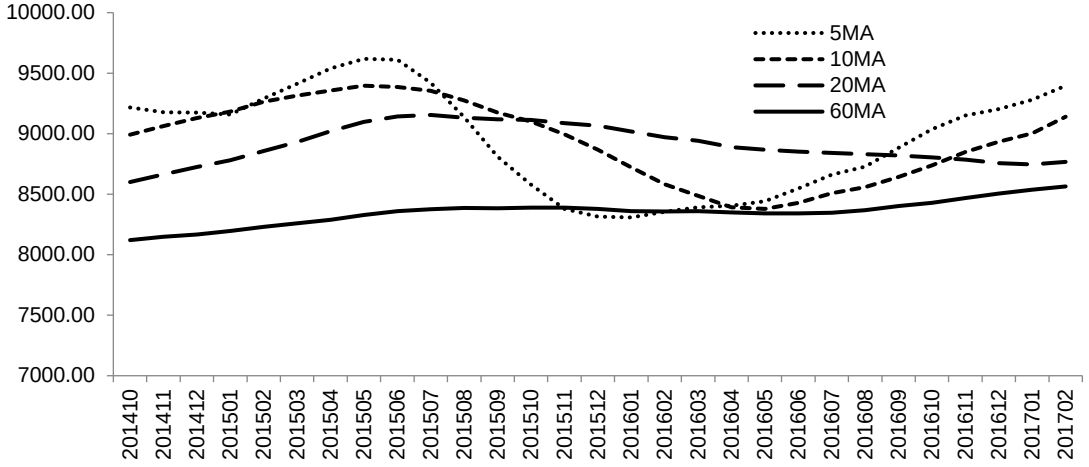
Table 4: The Symmetry of Return in Leveraged and Reversed ETFs

	Coefficient	Std.Error	t-Value	p-Value	Adjusted R^2
Panel A: T502X					
Intercept	0.0007	0.0003	2.6998	0.0071	0.9453
X	1.9985***	0.0350	57.0436	0.0000	
DX	-0.0020***	0.0006	-3.6632	0.0003	
Panel B: T50 reversed					
Intercept	-0.0005	0.0002	-2.7845	0.0055	0.9093
X	-0.9670***	0.0221	-43.7963	0.0000	
DX	0.0011***	0.0004	3.2130	0.0014	

*We use the following regression to examine the symmetry in tracing performance of these ETFs. $Y_i = \alpha + \beta_1 \cdot X_i + \beta_2 \cdot D \cdot X_i + \varepsilon$ where Y_i is the return of leverage ETF or reversed ETF, X_i is the return of tracking target index, D is Dummy variable. If $X_i > 0$ then D=1. If $X_i \leq 0$ then D=0. ***, ** and * denote statistical significance at 1 percent, 5 percent and 10 percent level respectively.*

This study explores whether there is a structural change of tracking performance rates of single-day leveraged and inverse ETFs during the different market situations. Figure 1 is a monthly chart of the Taiwanese stock market (2014/10/31-2017/02/24). According to the research of Fabozzi and Francis (1977), the period from 2014/10/31 to 2015/04/30 is set as a bull market and changes to bear market beginning May, 2015, and changes back to bull market on 2016/01/31 and continues until 2017/02/24.

Figure 1: The Monthly Chart of Taiwanese Stock Market 2014/10/31- 2017/02/24



The picture shows the monthly line of Taiwanese stock market from 2014/10/31 to 2017/02/24. We set two dotted lines to separate the bull and bear markets. The source of data is from CMoney.

Table 5 shows the result of structural changes of leveraged and inverse ETFs during bull and bear markets. In Panels A and C, it can be seen that the coefficient of return terms of leveraged and inverse ETFs are significantly different from zero at the 1% level, indicating that there is a structural change when the bull market changes to bear market. Panel D presents that the coefficient of return term of the inverse ETF is significantly different from zero at the 1% level, whereas Panel B presents that the coefficient of return term of the leveraged ETF is not significantly different from zero. It indicates that there are structural changes in two ETFs when the bear market changes to bull market. As for the intercept, there is no structural change in the two ETFs during either situation. Therefore, Hypothesis 2 is accepted, implying the return terms of the tracking performances in leveraged and inverse ETFs have structural changes along with the bull and bear markets. Nonetheless, Hypothesis 1 is rejected, indicating the intercepts of the tracking performances in leveraged and inverse ETFs do not have structural changes along with the bull and bear markets.

Table 5: Structural Change of Leveraged and Reversed ETFs During Bull and Bear Markets

	Coefficient	Std.Error	t-Value	p-Value	Adjusted R^2
Panel A: T502X Bull to Bear					
Intercept	0.0002	0.0005	0.3694	0.7121	0.9399
D	-0.0002	0.0006	-0.3594	0.7195	
X	1.6584	0.0530	31.3095	0.0000	
DX	0.0029***	0.0006	4.7691	0.0000	
Panel B: T502X Bear to Bull					
Intercept	-4.03E-05	0.0003	-0.1219	0.9030	0.9475
D	-0.0001	0.0004	0.2713	0.7863	
X	1.9525	0.0291	67.01559	0.0000	
DX	-0.0004***	0.0004	-2.8516	0.0950	
Panel C: T50 Reversed		**Bull to Bear**			
Intercept	-0.0002	0.0003	-0.6144	0.5394	0.9073
D	0.0001	0.0004	0.3133	0.7543	
X	-0.7450	0.0330	-22.5957	0.0000	
DX	-0.0024***	0.0004	-6.1829	0.0000	
Panel D: T50 Reversed		**Bull to Bear**			
Intercept	-6.04E-05	0.0002	-0.2926	0.7699	0.9161
D	-0.0001	0.0003	-0.4051	0.6856	
X	-0.9823	0.0182	-53.9921	0.0000	
DX	0.0010***	0.0003	3.5613	0.0004	

We use the following regression to examine whether the tracking performance has structural changes during the bull and bear markets. $Y_t = (\alpha + \lambda_1 D) + \beta X_i + \lambda_2 D X_i + \varepsilon_t$ *where* Y_i *is the return of leveraged and reversed ETF.* X_i *is the return of tracking index. D is a dummy variable, which indicates different conditions. The transition time from bull to bear is 2014/10/31~2016/01/31, the turning point is 2015/04/30; and the time from bear to bull market again would be 2016/01/31. ***, ** and * denote statistical significance at 1 percent, 5 percent and 10 percent level respectively.*

CONCLUDING COMMENTS

This paper explores the tracking performance of leverage and inverse ETFs. Single-day tracking performances of the Taiwan 50 Bull 2X ETF and Taiwan 50 Bear -1X ETFs are tested to investigate whether there are structural changes of tracking performances during the bull and bear markets. The findings are as follows. Single-day performances of T502X and inverse T50 are significantly different from their target multiple. The results are similar when the Wald test is used. The coefficients of return in leveraged and inverse ETFs are significantly different from 2 and -1 at the 1% level, suggesting that the effects of single-day T502X and inverse T50 returns are not symmetric. When the returns rise, the returns of T502X and the inverse T50 would deviate from the target return rate. Moreover, the coefficient of return terms of leveraged and inverse ETFs are significantly different from zero at the 1 % level, indicating that there is a structural change when a bull market changes to bear market. The coefficient of return term of the inverse ETF is significantly different from zero at the 1 % level, implying that there are structural changes in two ETFs when the bear market changes to bull market. As for the intercept, there is no structural change in the two ETFs during either situation.

This study only focuses on the Taiwanese ETF market. Future research could examine other ETF markets to explore whether the results of this research could be different due to the specifics of Taiwan's financial system and the maturity of the market. It is suggested that future researchers explore possible factors that might influence tracking performance and take more Taiwanese of the markets' leveraged and inverse ETFs into consideration.

REFERENCES

Bansal, V. K. & Marshall, J. F. (2015) "A tracking error approach to leveraged ETFs: Are they really that bad?" *Global Finance Journal*, vol. 26, p.47-63.

Chang, L. C. & Huang, P. C. (2010), "A study for the cross-sectional and time serial performance of mutual funds" *Taiwan Bank Quarterly,* vol. 61(4), p.257-293.

Chen, K. F. (2007) "Mutual fund performance-SBM Super DEA Model" Working Paper, *Soochow University*.

Chen, S. Y. (2010) "Does 921 Earthquake Have Asymmetric and Structural Change on Taiwan's Stock Market? " Working Paper, *National Cheng Kung University*.

Chu, Y. H. (2000) "The Study of the Relationship between Mutual-Fund Manager's Personality Traits and Stock Holding Strategy in Different Stock Market Conditions" Working Paper, *National Taipei University*.

Doris, D. & Marco, A. (2012) "Structural Slippage of Leveraged ETFs" Working Paper, *New York University*.

Fabozzi, F.J. & J.C. Francis (1977)"Stability Tests for Alphas and Betas Over Bull and Bear Market Conditions." *Journal of Finance*, vol. 32, p.1093-1099.

Giannetti, A. (2017) "The dynamics of leveraged ETFs returns: a panel data study." Q*uantitative Finance*, vol. 17(5), p.745-761.

Kuo, T. T. (2006) "A Study of Structural Changes in Taiwan Stock Index by Clustering Analysis" Working Paper, *Feng Chia University*.

Lin, C. C. (2016) "Leveraged and Inverse ETF in Taiwan, Japan and Korea and the Source of Tracking Error" Working Paper, *National Taiwan University.*

Lin, W. C. (2011) "The Analysis of the Interaction of ETF and related Financial Assets in the Bull and Bear Markets—Polaris Taiwan Top 50 Tracker Fund" Working Paper, *National Taiwan University*.

Lu, C. H. (2008) "Essays on Exchange-Traded Funds (ETFs): The Impacts of Trading Mechanisms on Performance of ETFs, and The Investment Behavior and Performance of ETFs among Various Investor Types" Working Paper, *National Chung Cheng University.*

Lu, L., Wang, J. & Zhang, G. (2009)," Long Term Performance of Leveraged ETFs," Working Paper, *University of Manitoba*.

Lundström, C., Peltomäki, J. (2018) "Optimal embedded leverage" *Quantitative Finance*, vol. 18(7), p.1077-1085.

Luo, W. C. & Chang, W. C. (2009) "Spread arbitrage between ETFs" *Performance and Strategy Research*, vol. 7(2), p.1-18.

Sherrill, D. E., Shirley, S. E. & Stark, J. R. (2017). Actively managed mutual funds holding passive investments: What do ETF positions tell us about mutual fund ability? *Journal of Banking & Finance*, vol. 76, p.48-64.

Su, T. F. (2015) “An Investigation of Short- and Long-term Tracking Performance of Leveraged and Inverse ETFs” Working Paper, *National Taiwan University*.

Trainor, W. & Gregory, R. (2016), "Leveraged ETF option strategies", *Managerial Finance*, vol. 42(5), p.438-448

BIOGRAPHY

Han-Ching Huang, corresponding author, is Professor of Finance and Director of International Master of Business Administration at Chung Yuan Christian University. His research appears in journals such as *Journal of Banking and Finance, Pacific Basin Finance Journal, and Quarterly Review of Economics and Finance*. Professor Huang can be contacted at Business Building 404A, 4/F, Chung Yuan Christian University, 200, Chung Pei Road, Chung Li District, Taoyuan City, Taiwan (R.O.C.), 32023, Tel: 886-32655710, Fax: 886-32655749.

Linjiun Tsai is the master of Department of Finance at Chung Yuan Christian University.