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Volume-Return Relationship in ETF Markets: A Reexamination of the Costly Short-Sale Hypothesis

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Abstract

This study aims to investigate whether the costly short-sale theory is responsible for the volume-return relationship in Taiwan's ETF market. Through a model specification, we demonstrate that trading volume and returns for ETFs and their underlying assets exhibit an asymmetric relationship with significantly larger volume associated with negative returns than with non-negative returns, a finding that verifies the prediction of the costly short-sale hypothesis. Using quantile regression, we also find that the magnitudes of the volume-return correlations and subsequent asymmetric effects vary with the ETF volume levels. The asymmetric effects are more obvious at the volume quantiles that are higher than the median level and at the extrema quantiles. Notably, that the strongest asymmetric relationship occurs at the extrema quantiles for both ETFs may stem largely from the sharp increases in the correlations between volume and negative underlying index returns for the extrema quantiles. We try to use the hybrid effects, complementary and substitute effects for both ETF and spot investors, to explain this phenomenon.

JEL classification numbers: G10, G12
Keywords: ETF, Costly short-sale hypothesis, Asymmetric volume-return relationship, Quantile regression

1 Introduction

The relationship between trading volume and returns in various financial markets continues to be of exceptional importance and interest for investors seeking to understand information dynamics and efficiency. The past literature has focused their attention on the volume-return (V-R) relationship in equity or futures markets. This paper examines the V-R relationship for exchange-traded funds (ETFs) and their underlying markets. There are two main hypotheses related to V-R behavior that were investigated in early literature,

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the sequential information model (SIM) (Copeland, 1976; Jennings et al., 1981) and the mixture of distribution hypothesis (MDH) (Clark, 1973; Epps and Epps, 1976; Tauchen and Pitts, 1983; Harris, 1986). The SIM implies a positive correlation between volume and absolute price changes. As Harris (1986) demonstrated, the MDH also suggests a positive relationship between volume and price changes.

In the subsequent literature, the V-R linkage has continued to be debated (e.g., Gallant *et al*., 1992; Campbell *et al.*, 1993; Blume *et al.*, 1994; Wang, 1994; Assogbavi *et al*., 1995; Kocagil and Shachmurov, 1998; Chordia and Swaminathan, 2000; Suominen, 2001; Ackert and Athanassakos, 2005; Chuang *et al*., 2009.) The studies of the V-R relationship have mostly examined the intra-market associations of different return types with trading volume, and have discovered that a strong relationship exists between volume and absolute or signed returns in equity markets but that no significant correlation exists between volume and signed returns (V-SR) in futures markets. More specifically, most of the empirical results for equity markets have documented an asymmetric V-R relationship[2]. This, as argued by Karpoff (1987), implies one of the following: a significant positive V-SR correlation or a significant positive volume and non-negative returns (V-R^+) correlation together with a significant negative volume and negative returns (V-R^-) correlation in which the magnitudes of the two correlations are different. Either of the two above would constitute an asymmetric V-R relationship. In general, in equity markets, the V-R^+ correlation is greater than the V-R^- correlation (or the positive V-SR correlation), which means that a significantly greater volume will accrue from a price increase as compared to a price decrease. To explain this asymmetric relationship, Jennings *et al.* (1981) first proposed the “costly short-sale hypothesis”, which attributes the asymmetry to the higher transaction costs associated with short positions as compared to long positions. That is, to the extent the costly short-sale restrictions (which are prevalent in most markets) constrain the use of short positions, the volume associated with a price decrease may be smaller than that associated with a price increase.

Further tests of the costly short-sale hypothesis have been conducted to examine if this theory also predicts or explains the V-R relationship in futures markets. Since the costs associated with long and short positions are identical in futures markets, the costly short-sale hypothesis would predict a zero V-SR correlation or a symmetric V-R relationship in futures markets. In fact, a series of empirical evidences regarding the V-R relationship in various futures markets did not indicate the existence of an asymmetric effect (e.g., Karpoff, 1988; McCarthy and Najand, 1993; Kocagil and Schachmurove, 1998); rather, they suggested that a symmetric V-R relationship should exist as predicted by the hypothesis.[3]

Puri and Philippatos (2008), however, observed the inter-market V-R relationship and provided evidence against costly short-sale hypothesis. They chose interest rate and currency futures traded on the London International Financial Futures and Options Exchange (LIFFE) as the subject of their study since neither these futures nor their underlying assets have short-sale restrictions that would generate different transaction costs for long and short positions. Thus, if the costly short-sale hypothesis is true, the volume and returns for these futures and their underlying assets should not exhibit an asymmetric relationship. However, Puri and Philippatos (2008) found a strong

[2]See Karpoff (1987) for a survey up to 1987.
[3]See Puri and Philippatos (2008) for a concise summary of the literature.

asymmetric V-R relationship, stating that the volume associated with negative returns was significantly larger than that associated with non-negative returns. The costly short-sale hypothesis was, therefore, rejected.

Inspired by Puri and Philippatos (2008), we make use of the current status that the restrictions on short sales and the associated costs for Taiwan ETFs and their underlying markets are different, putting the hypothesis to a test again. In Taiwan, ETFs have lower restrictions on short sales and lower associated transaction costs than their underlying assets[4]; extra trading in ETFs should occur when the market is on a decline as traders will wish to avoid the additional costs and restrictions associated with the underlying market. Under the costly short-sale hypothesis, we predict an asymmetric V-R relationship for Taiwan ETFs, with significantly larger volume associated with negative returns than with non-negative returns.

ETFs are known as one of the most successful financial innovations of the 1990s; they decrease selection and allocation efforts, make it possible to diversify risk effectively, efficiently track certain indexes without incurring high transaction costs, and are traded conveniently like stocks on exchanges. Investors can invest in index portfolios indirectly by holding beneficiary certificates or depositary receipts issued by ETFs; ETFs are traded on stock exchanges after the issuance. The Taiwan Stock Exchange Corporation (TWSE) launched its first ETF, the Taiwan Top 50 Tracker Fund (Taiwan 50 ETF), on June 30, 2003, and the second ETF, the Polaris Taiwan Mid-Cap 100 Tracker Fund (Mid-Cap 100 ETF), on August 31, 2006. The two ETFs with relatively higher trading volume contain much more information and hence are used as the main samples of this study. The market capitalization and the number of listings that Taiwan ETFs have achieved during the last eight years, together with their reduced restrictions on short sales and lower associated costs, making them an appropriate focus for the present study. Another reason to consider Taiwan ETFs is that the V-R relationship has not been studied in this context.

This study is distinct in four ways. First, whereas earlier papers mostly examined the intra-market V-R relationship, we observe the inter-market V-R relationship for the underlying and derivative markets. Second, whereas previous papers primarily used returns as the dependent variable in examining the V-R relationship, we use ETF volume as the dependent variable to determine its connection to the lagged returns of the underlying assets. Such arrangement allows us to avoid distorted results that occur, especially at the extremist return quantiles due to the price limits in Taiwan's markets.[5] Third, whereas other papers mostly used signed returns directly or divided returns into two groups, negative or non-negative, to determine the V-R relationship, we follow the model setting of Puri and Philipatos (2008) to distinguish between non-negative and negative returns. More specifically, Puri and Philipatos (2008) introduced a dummy to distinguish negative returns from non-negative returns and compared the slope coefficients of them to measure the asymmetric V-R relationship. Finally, whereas earlier papers mostly examined the "average" V-R relationship through linear regression (ordinary least square, OLS, method), we analyze the V-R relationship across quantiles

[4]The trading tax while selling is 0.1% for ETFs and 0.3% for their underlying assets. In addition, ETFs are exempted from the ban on short selling stocks whose prices are below their closing prices of the previous trading day (which requires that short sales take place at no lower than the closing price for the previous trading day.)

[5]Refer to Chuang and Kuan (2005).

using quantile regression. The combination of the particular model setting and the usage of quantile regression allow us to determine not only how ETF volume is related to the upward or downward movements of the underlying index (that is, if exists asymmetric relationship), but also how such connections vary across various volume quantiles. Accordingly, this paper not only contributes to the understanding of the costly short-sale hypothesis, but also helps further understanding of the V-R relationship in ETFs and the hybrid links between the ETFs and their underlying assets.

The results indicate a strong and unique asymmetric V-R relationship in ETFs, mostly consistent with what the costly short-sale hypothesis predicts. The asymmetry is stronger for Taiwan 50 ETF in the quantiles that are higher than the median level and the extrema quantiles; similarly, it is also stronger for the Mid-Cap 100 ETF in the extrema quantiles. The positive, concave relationship that reflects the effect of non-negative index returns on ETF volume is different from the V-shaped V-R^+ relationship that exists in the American and British equity markets (Chuang *et al*., 2009); and the effect of sensitivity to negative returns on ETFs volume becomes more powerful at extrema quantiles, especially the 1^{st}, 5^{th}, 15^{th}, 95^{th} and 99^{th} quantiles. Both effects thus jointly bring out the unique asymmetry in V-R relationship for ETFs and their underlying assets. We argue that investors regard ETFs as complements when the spot (underlying) market is on a rise but regard them as legitimate substitutes when the spot market is on a decline; the hybrid of the two effects, the complementary and substitute effects, leads to the formation of the asymmetry.

The remainder of this paper will proceed as follows. Section 2 describes the details of the model, including the quantile regression and the setting of the empirical model. Section 3 describes the data source, the summary statistics, the empirical results and their implications. Finally, the concluding section summarizes the findings and analysis.

2 Methodology

We employ quantile regression to observe the V-R relationship across different volume levels. In addition, to distinguish between negative and non-negative returns and to make a direct comparison between the slope coefficients associated with negative and non-negative returns, we use the model setting proposed by Puri and Philipatos (2008). The empirical method and model specification are described as below.

2.1 Quantile Regression

Koenker and Bassett (1978) and Koenker and Hallock (2001) proposed the quantile regression model. Quantile regression generalizes the concept of an unconditional quantile to a quantile that is conditional on one or more covariates. This method estimates conditional quantile (percentile) functions by minimizing the weighted absolute deviations of the quantile regression model. Unlike classical OLS, quantile regression can be used not just to estimate the average relationship of variables, but also to provide more complete information on the relationship of variables regarding any point in the distribution of the dependent variable. Through employing quantile regression and regarding ETF volume as the dependent variable, we can obtain a clearer V-R relationship across the distribution of the ETF trading volume.

Quantile regression minimizes the weighted sum of the absolute residuals rather than the sum of the squared residuals.

$$\min_{\{b_j\}_{j=0}^{k}} \sum_{t=1}^{T} \left| y_t - \sum_{j=0}^{k} b_j x_{j,t} \right| \theta_t \tag{1}$$

Where y_t is the dependent variable at observation t, $x_{j,t}$ is the j th independent variable at observation t, b_j are estimates of the model's j th regression coefficients, and T is the total observations. The weight θ_t is described as $\theta_t = 2q$ if the residual of the t th observation is positive or as $\theta_t = 2 - 2q$ if the residual of the t th observation is negative or zero. The variable q is the quantile to be estimated, and the value of q lies in between 0 and 1. For example, the median regression (q =0.5) uses symmetric weights, and all other quantiles regressions (e.g., q =0.1, 0.2, …) use asymmetric weights.

We employ bootstrapping to estimate the standard errors of the coefficient estimates following Gould (1992, 1993). The bootstrapping technique is less sensitive to heteroskedasticity (Rogers, 1992).

2.2 Model Specifications

This paper investigates asymmetric V-R linkages in Taiwan's ETF market under the costly short-sale hypothesis. As the prior section has described, we uniquely use the ETF volume as the dependent variable to regress it against the return of the underlying index. We also follow Puri and Philippatos (2008) to distinguish between non-negative and negative returns and use quantile regression to examine the V-R relationship across quantiles. By doing so, we not only identify whether there is any asymmetric effect of negative and non-negative returns on volume but also determine the V-R correlation across various levels of volume, and thus can compare these findings to the conditional mean relationship found in previous studies.

The V-R relationship associated with period t is expressed as[6]

$$EV_t = \beta_0 + \beta_1 SR_{t-1} + \beta_2 DUMMY_{t-1} + \beta_3 (DUMMY_{t-1} \times SR_{t-1}) + \varepsilon_t \tag{2}$$

where EV_t denotes the volume variables for the ETFs, including the natural log of the trading share ($EVOL_t$), and the natural log of the trading value ($EVAL_t$) at period t. This study defines the logarithmic return of the underlying index at period $t-1$ as $SR_{t-1} = (\ln S_{t-1} - \ln S_{t-2}) \times 100$, where S_{t-1} is the underlying index at period $t-1$. $DUMMY_{t-1}$ denotes the dummy variable, which equals unity for negative returns for the underlying index and zero for non-negative returns at period $t-1$. ε_t is the error term

[6]We also regressed the ETF trading volume against the contemporary underlying index returns and against the returns with two-period lag for robust checks. However, the results are similar to those presented in this paper.

at period t. Therefore, β_0, β_1, β_2, and β_3 are the estimated parameters of the regression.

This specification enables us to inspect the asymmetric relationship between ETF volume and lagged underlying index returns of a different direction as measured by the slope coefficients β_1 for the non-negative, and ($\beta_1 + \beta_3$) for the negative returns, respectively. If β_1 and β_3 are both significant, the asymmetric V-R correlation exists, and the costly short-sale hypothesis is confirmed.

3 Empirical Results and Analysis

3.1 Data Description and Summary Statistics

This paper uses daily data to analyze the relationship between ETF volume and the underlying index returns in Taiwan. Two ETFs, the Taiwan 50 ETF and the Mid-Cap 100 ETF are examined; their underlying indexes are the Taiwan 50 Index and the Taiwan Mid-Cap 100 Index (Mid-Cap 100 index), respectively. Again, these two ETFs feature relatively higher trading volume and considerably more information are available about them; these data will reveal the characteristics of the V-R relationships and illustrate more fundamental linkages in the Taiwan ETF market; hence they are used as the main samples in this study. The Taiwan 50 ETF and Mid-Cap 100 ETF were launched on June 30, 2003 and August 31, 2006, respectively. Therefore, the sample data for the Taiwan 50 ETF and its underlying index are from the period of June 30, 2003 through December 30, 2011, which provides a total of 2,121 observations. Correspondingly, the sample data for the Mid-Cap 100 ETF and its underlying index are from the period of August 31, 2006 to December 30, 2011, which provides a total of 1,330 observations. All of the daily data for the ETFs and the underlying indexes are taken from the Taiwan Economic Journal (TEJ) database.

For the price series, daily returns are defined as the logarithm difference in the prices on trading days t and $t-1$. Two types of trading volume are calculated using the natural log of trading shares and trading value. The basic statistical characteristics of the Taiwan 50 ETF, Mid-Cap 100 ETF, Taiwan 50 index, and Mid-Cap 100 index return and trading volume series for the sample period are summarized in Table 1. The means for the Taiwan 50 ETF, Mid-Cap 100 ETF, Taiwan 50 index, and Mid-Cap 100 index returns are 0.0139 ± 1.5166, 0.0029 ± 1.8222, 0.0140 ± 1.4588, and -0.0086 ± 1.7484, respectively. We observe that the Taiwan 50 ETF and its underlying index have more similar means and lower standard deviations than the Mid-Cap 100 ETF and its underlying index. These findings imply that a closer relationship exists between the Taiwan 50 ETF and its underlying index in terms of both returns and risks. The mean and maximum statistics for ETF trading volume and value show that the Taiwan 50 ETF is traded consistently more actively than the Mid-Cap 100 ETF. Hence, we can infer that the information transmission efficiency is better in the Taiwan 50 ETF market than in Mid-Cap 100 ETF market because the volume and associated prices can convey a lot of things to the market (Blume *et al*., 1994).

The descriptive statistics in Table 1 also indicate that all return series are left skewed and that both of the return series for the ETFs are leptokurtic. The trading volume series of the underlying indexes are more leptokurtic than those of the ETFs. The JB normality tests significantly reject the hypothesis of normality for all the variables. Table 2 shows the correlations between the variables. The findings indicate that a negative or approximately zero correlation exists between ETF volume and the underlying index returns. This, in turn, implies that some investors, who originally traded in spot markets, transfer their investments to the ETF market when the spot market is on a decline. Finally, the graphs of the daily trading volume and returns for the two ETFs are illustrated in Figure 1.

Table 1: Summary statistics

Variables	Mean	Std.	Max.	Min.	Skewness	Kurtosis	JB
1. Taiwan 50 ETF: Taiwan Top 50 Tracker Fund (June 30, 2003 to December 30, 2011)							
ER	0.0139	1.5166	6.7648	-9.3509	-0.2639***	4.6787***	1958.2562***
EVOL	8.9740	0.7900	11.8327	6.3244	-0.1495***	-0.1389	9.6037***
EVAL	12.9069	0.7924	15.7770	10.3573	-0.1702***	-0.1179	11.4643***
2. Taiwan 50 Index: Taiwan 50 Index (June 30, 2003 to December 30, 2011)							
SR	0.0140	1.4588	6.5077	-6.9181	-0.2368***	2.5509***	594.6084***
SVOL	13.8257	0.3677	15.2943	12.5649	0.4032***	0.3049***	65.6532***
SVAL	17.6021	0.3520	18.9266	16.1332	-0.0638	0.6292***	36.4082***
3. Mid-Cap 100 ETF: Polaris Taiwan Mid-Cap 100 Tracker Fund (August 31, 2006 to December 30, 2011)							
ER	0.0029	1.8222	6.7619	-7.2266	-0.2407***	3.1399***	558.7750***
EVOL	5.5993	1.0114	9.5062	2.5649	0.3688***	0.2228*	32.8771***
EVAL	8.9341	1.0405	12.7905	5.9610	0.3755***	0.0912	31.6917***
4. Mid-Cap 100 Index: Taiwan Mid-Cap 100 Index (August 31, 2006 to December 30, 2011)							
SR	-0.0086	1.7484	6.4858	-6.8924	-0.5527***	2.0649***	303.7651***
SVOL	13.7585	0.3580	14.9178	12.6933	0.4490***	0.3473***	51.3328***
SVAL	17.1715	0.3668	18.3745	15.3929	-0.5577***	1.3959***	176.7927***

Notes: 1. *, ** and *** denote significance at the 10%, 5% and 1% levels, respectively. 2. The Kurtosis presents the coefficient of excess kurtosis. 3. JB represents the statistics for the normal distribution test developed by Jarque-Bera. 4. ER, $EVOL$, and $EVAL$ are the returns, the natural log of the trading share, and the natural log of the trading value for ETFs; SR, $SVOL$, and $SVAL$ are the returns, the natural log of the trading share, and the natural log of the trading value for the underlying index, respectively. 5. The units for ER and SR are percentages; the units for $EVOL$ and $SVOL$ are thousands of shares; the units for $EVAL$ and $SVAL$ are thousands of dollars.

Table 2: Correlation analysis

Taiwan 50 ETF & Taiwan 50 Index	*ER*	*EVOL*	*EVAL*	*SR*	*SVOL*	*SVAL*
ER	1.0000					
EVOL	-0.0210	1.0000				
EVAL	-0.0318	0.9798	1.0000			
SR	0.0409	-0.0411	-0.0384	1.0000		
SVOL	0.0171	0.3667	0.3211	0.0853	1.0000	
SVAL	-0.0138	0.3945	0.4645	0.0848	0.7559	1.0000
Mid-Cap 100 ETF & Mid-Cap 100 Index	***ER***	***EVOL***	***EVAL***	***SR***	***SVOL***	***SVAL***
ER	1.0000					
EVOL	0.0573	1.0000				
EVAL	0.0479	0.9774	1.0000			
SR	0.1047	0.0101	0.0132	1.0000		
SVOL	0.0658	0.2851	0.3025	0.0927	1.0000	
SVAL	0.0250	0.0944	0.2207	0.1034	0.7814	1.0000

Notes: 1. ER, $EVOL$, and $EVAL$ are the returns, the natural log of the trading share, and the natural log of the trading value for ETFs; SR, $SVOL$, and $SVAL$ are the returns, the natural log of the trading share, and the natural log of the trading value for the underlying index, respectively. 2. The units for ER and SR are percentages; the units for $EVOL$ and $SVOL$ are thousands of shares; the units for $EVAL$ and $SVAL$ are thousands of dollars.

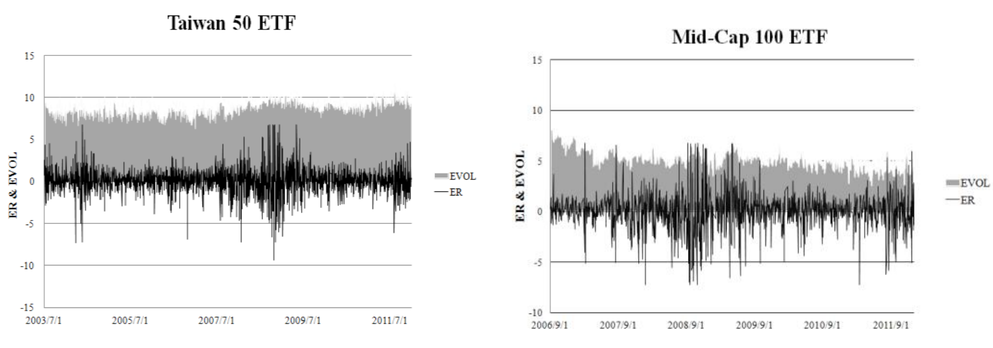

Figure 1: Volume and returns of the two ETFs

3.2 Quantile Regression Analysis of the ETF V-R Correlation

Tables 3 to 6 detail the coefficients for the quantile regression models when the ETF volume variables are regressed against the returns for the underlying indexes. To determine the V-R relationship across quantiles, we estimate twenty-one quantile regressions, including quantiles = 0.01, 0.05, 0.10, …, and 0.99, using STATA software.

The standard errors of the coefficient estimates are simulated using the bootstrapping method with 1000 replications. We also use OLS method to estimate the "average" coefficients for V-R correlation for comparison.

First, Tables 3 to 6 and Figures 2 to 5 present the slope coefficients in general. β_1 is statistically significantly positive for all quantiles except the higher quantiles for the Mid-Cap 100 ETF, indicating that a strong positive relationship exists between the ETF volume and the non-negative underlying index returns. However, such positive relationship weakens for both ETFs as the quantile increases. That is the sensitivity of ETF volume to the non-negative index returns decreases as the ETF trading volume increases. The positive, concave style that displays the property of the effect of non-negative index returns on ETFs volume is different from the V-shaped V-R relationship that exists in the American and British equity markets (Chuang *et al*., 2009). The OLS results for β_1 are all significantly positive documenting again the positive relationship between the ETF volume and the non-negative returns.

Next, for the negative index returns for the Taiwan 50 ETF, the slope coefficient ($\beta_1 + \beta_3$) estimates are negative, and their absolute values ($|\beta_1 + \beta_3|$) are usually larger than the slope coefficients β_1 across almost all quantiles, indicating that an asymmetric effect exists in the ETF V-R relationship. Additionally, the asymmetric V-R relationship became stronger for the volume quantiles that are above the median (quantile = 0.5) as indicated by the statistically significant coefficient estimates β_2 and β_3. For the Mid-Cap 100 ETF, the asymmetric effect also appears and is more obvious for the extrema (i.e., lower or higher) volume quantiles especially the higher quantiles. These outcomes can also be verified in Figures 2 to 5 in which the asymmetric effects are displayed by the shaded regions. Regarding the OLS results, all the β_3 are negative and statistically significant while the slope coefficients ($\beta_1 + \beta_3$) are all negative indicating the "average" negative correlations between the ETF volume and non-negative index returns; Yet, the asymmetric effect measured by $|\beta_1 + \beta_3| - \beta_1$ is more significant for the Taiwan 50 ETF. The results of asymmetric V-R relationship described above are consistent with what the costly short-sale hypothesis predicts: an asymmetric V-R relationship with significantly larger volume associated with negative returns than with non-negative returns, and thus lend support to the hypothesis for the Taiwan ETF market.

In particular, we find that the magnitudes of the correlations between ETF volume and non-negative index returns attain their highest level at the lower volume quantiles, and then decrease with the increase of the volume quantile. On the other hand, we find that the magnitudes of the negative correlations between ETF volume and negative index returns at the 5th and 95th quantiles for the Taiwan 50 ETF are much higher, as are the corresponding correlations for the 1st (15th for the Mid-Cap 100 ETF's trading value) and 99th quantiles for the Mid-Cap 100 ETF, indicating that the correlations between ETF volume and the negative returns become stronger at the extrema quantiles. We interpret these outcomes by the argument that there are two effects, complementary and substitute effects, for the ETFs to investor. When the market is on the rise, ETFs are complements to investors; when the market is on a decline, on the contrary, ETFs are substitutes to investors. The conditions that the complementary effect is stronger for the lower volume and then decay with the increase of the volume quantile, and that the substitute effect is stronger for both the lower and higher volume jointly constitute the results of the correlations and the correspondingly asymmetric V-R relationship described above.

Based on the empirical results presented above, three implications can be inferred. First, investors in spot markets regard ETFs as complements when the underlying index markets are on the rise, especially when the ETF volume is at a lower level; thus the slope coefficients between ETF volume and non-negative returns has its relatively higher value around the lower volume quantiles. Second, when the underlying index market is on a decline, given the costs of short-sales in the spot markets, spot investors transfer their trades to similar ETF markets, especially when the ETF volume is at an extreme (higher or lower) level. ETFs are now regarded as substitutes for the underlying stocks, and the costly short-sale hypothesis is hence confirmed. In summary, two effects, complementary and substitute effects, influence the magnitudes of the V-R correlations and the correspondingly asymmetric V-R relationship; that is why we can observe that the asymmetric V-R relationship for the Taiwan 50 ETF became stronger for the volume quantiles that are above the median, especially the higher quantiles, as did the corresponding relationship for the Mid-Cap 100 ETF for the extrema quantiles especially the higher quantiles.

Third, the slope estimates of the quantile regressions for the negative index returns are apparently larger at the extrema quantiles. We try to explain this phenomenon from two kinds of situations. First, when the spot markets are on a decline and have lower trading volume, the complementary effect for ETF investors dominates their substitute effect, and thus ETF investors may reduce their trades in the ETF markets while spot investors still turn their short selling to the ETF markets. Therefore, the volume of the ETF markets will increase at this time point just due to the transferred trades of spot investors. Second, when the spot markets are on a decline and have higher trading volume, spot traders are not the only ones who may increase their ETF trades; In addition, ETFs investors may also increase their ETF trades if the substitute effect for ETFs investors dominates the complementary effect.

Table 3: Estimation results of quantile regression for the trading volume of Taiwan 50 ETF

Dependent variable: *EVOL*					
Estimated regression parameter			Estimated regression parameter		
Quantile		Estimates	Quantile		Estimates
0.01	β_0	6.8917*** (0.1408)	0.99	β_0	10.4514*** (0.0955)
	β_1	0.2783*** (0.0927)		β_1	0.1044*** (0.0374)
	β_2	0.0993 (0.1462)		β_2	-0.2040* (0.1119)
	β_3	-0.4746** (0.1615)		β_3	-0.3684*** (0.0734)
0.05	β_0	7.4481*** (0.1019)	0.95	β_0	9.8647*** (0.0639)
	β_1	0.2922*** (0.0827)		β_1	0.2125*** (0.0379)
	β_2	-0.2202* (0.1127)		β_2	-0.1570 (0.1197)
	β_3	-0.7136*** (0.1098)		β_3	-0.6000*** (0.0756)

0.10	β_0	7.6478*** (0.0575)	0.90	β_0	9.7022*** (0.0460)
	β_1	0.3760*** (0.0455)		β_1	0.1822*** (0.0355)
	β_2	-0.0101 (0.0867)		β_2	-0.1307** (0.0645)
	β_3	-0.7313*** (0.0609)		β_3	-0.4735*** (0.0465)
0.15	β_0	7.8581*** (0.0522)	0.85	β_0	9.5165*** (0.0344)
	β_1	0.3374*** (0.0296)		β_1	0.2185*** (0.0224)
	β_2	-0.0015 (0.0759)		β_2	-0.1369*** (0.0410)
	β_3	-0.6646*** (0.0436)		β_3	-0.5236*** (0.0361)
0.20	β_0	8.0071*** (0.0507)	0.80	β_0	9.3871*** (0.0471)
	β_1	0.3185*** (0.0269)		β_1	0.2256*** (0.0276)
	β_2	-0.0126 (0.0951)		β_2	-0.1129** (0.0513)
	β_3	-0.6437*** (0.0413)		β_3	-0.5163*** (0.0430)
0.25	β_0	8.1332*** (0.0777)	0.75	β_0	9.2682*** (0.0423)
	β_1	0.3086*** (0.0368)		β_1	0.2376*** (0.0261)
	β_2	0.0083 (0.1151)		β_2	-0.1244** (0.0615)
	β_3	-0.6284*** (0.0344)		β_3	-0.5327*** (0.0345)
0.30	β_0	8.2898*** (0.0741)	0.70	β_0	9.1767*** (0.0448)
	β_1	0.2965*** (0.0347)		β_1	0.2247*** (0.0316)
	β_2	-0.0463 (0.1149)		β_2	-0.1339** (0.0654)
	β_3	-0.6316*** (0.0368)		β_3	-0.5220*** (0.0347)
0.35	β_0	8.4299*** (0.0750)	0.65	β_0	9.0784*** (0.0578)
	β_1	0.2759*** (0.0378)		β_1	0.2453*** (0.0289)
	β_2	-0.0480 (0.0930)		β_2	-0.1564** (0.0772)
	β_3	-0.5940*** (0.0371)		β_3	-0.5536*** (0.0327)
0.40	β_0	8.5451*** (0.0673)	0.60	β_0	8.9587*** (0.0578)
	β_1	0.2720*** (0.0380)		β_1	0.2671*** (0.0283)
	β_2	-0.1029 (0.0845)		β_2	-0.1421* (0.0858)
	β_3	-0.6014*** (0.0420)		β_3	-0.5961*** (0.0283)

0.45	β_0	8.6487*** (0.0667)	0.55	β_0	8.8561*** (0.0487)
	β_1	0.2669*** (0.0379)		β_1	0.2566*** (0.0291)
	β_2	-0.0866 (0.0814)		β_2	-0.1352** (0.0659)
	β_3	-0.5876*** (0.0402)		β_3	-0.5979*** (0.0371)
0.50	β_0	8.7565*** (0.0643)	OLS	β_0	8.7093*** (0.0321)
	β_1	0.2580*** (0.0393)		β_1	0.2660*** (0.0231)
	β_2	-0.1179 (0.0836)		β_2	-0.0907** (0.0457)
	β_3	-0.5845*** (0.0465)		β_3	-0.5887*** (0.0314)

Estimated asymmetric parameter

Quantile	β_1	β_3	$\lvert\beta_1+\beta_3\rvert$	$\lvert\beta_1+\beta_3\rvert - \beta_1$
0.01	0.2783	-0.4746	0.1963	-
0.05	0.2922	-0.7136	0.4214	+
0.10	0.3760	-0.7313	0.3553	-
0.15	0.3374	-0.6646	0.3272	-
0.20	0.3185	-0.6437	0.3252	+
0.25	0.3086	-0.6284	0.3198	+
0.30	0.2965	-0.6316	0.3351	+
0.35	0.2759	-0.5940	0.3181	+
0.40	0.2720	-0.6014	0.3294	+
0.45	0.2669	-0.5876	0.3207	+
0.50	0.2580	-0.5845	0.3265	+
0.55	0.2566	-0.5979	0.3413	+
0.60	0.2671	-0.5961	0.3290	+
0.65	0.2453	-0.5536	0.3083	+
0.70	0.2247	-0.5220	0.2973	+
0.75	0.2376	-0.5327	0.2951	+
0.80	0.2256	-0.5163	0.2907	+
0.85	0.2185	-0.5236	0.3051	+
0.90	0.1822	-0.4735	0.2913	+
0.95	0.2125	-0.6000	0.3875	+
0.99	0.1044	-0.3684	0.2640	+
OLS	0.2660	-0.5887	0.3227	+

Notes: 1. *, ** and *** denote significance at the 10%, 5% and 1% levels, respectively. 2. The numbers in parentheses are the standard errors, which are simulated using the bootstrap method with 1000 replications. 3. The empirical models are expressed as follows:

$$EV_t = \beta_0 + \beta_1 SR_{t-1} + \beta_2 DUMMY_{t-1} + \beta_3 (DUMMY_{t-1} \times SR_{t-1}) + \varepsilon_t$$

where EV_t denotes the volume variables for the Taiwan ETFs, including the natural log of the trading share ($EVOL_t$) and the natural log of the trading value ($EVAL_t$) at period t. SR_{t-1} represents the logarithmic returns for the underlying index at period $t-1$. $DUMMY_{t-1}$ denotes the dummy variable, which equals unity for negative returns for the underlying index and zero for non-negative returns at period $t-1$.

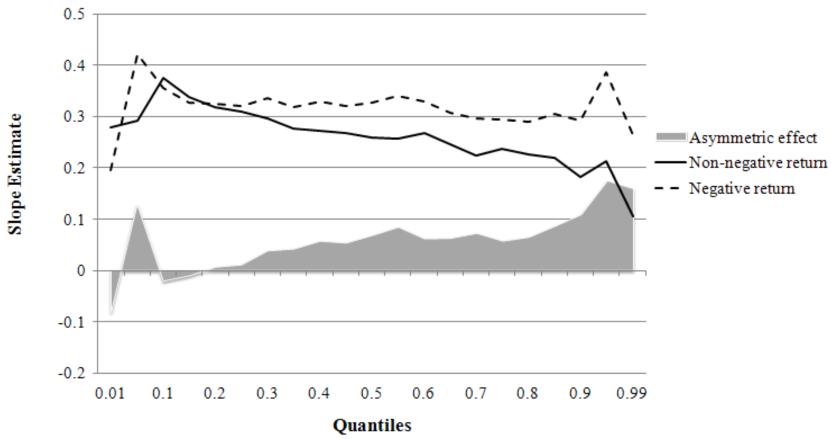

Figure 2: Slope comparison and asymmetric V-R effects for the trading volume of the Taiwan 50 ETF. The slope estimate for non-negative returns is β_1, and that for negative returns is $|\beta_1+\beta_3|$. The asymmetric effect is measured by $|\beta_1+\beta_3|-\beta_1$ and displayed by the shaded region.

Table 4: Estimation results of quantile regression for the trading value of Taiwan 50 ETF

Dependent variable: *EVAL*

Estimated regression parameter			Estimated regression parameter		
Quantile		Estimates	Quantile		Estimates
0.01	β_0	10.7147*** (0.1311)	0.99	β_0	14.3614*** (0.1044)
	β_1	0.2903*** (0.0723)		β_1	0.1489** (0.0684)
	β_2	0.2079 (0.1602)		β_2	-0.0715 (0.1317)
	β_3	-0.4761*** (0.1117)		β_3	-0.4217*** (0.0909)
0.05	β_0	11.3932*** (0.0628)	0.95	β_0	13.8357*** (0.0621)
	β_1	0.2933*** (0.0419)		β_1	0.1568*** (0.0537)
	β_2	-0.2704* (0.1397)		β_2	-0.0998 (0.1122)
	β_3	-0.6575*** (0.0679)		β_3	-0.5057*** (0.0675)
0.10	β_0	11.6520*** (0.0667)	0.90	β_0	13.6376*** (0.0416)
	β_1	0.2998*** (0.0441)		β_1	0.1718*** (0.0302)
	β_2	-0.0914 (0.0860)		β_2	-0.1177 (0.0828)
	β_3	-0.6547*** (0.0638)		β_3	-0.4516*** (0.0562)
0.15	β_0	11.8166*** (0.0505)	0.85	β_0	13.4968*** (0.0352)
	β_1	0.3063*** (0.0392)		β_1	0.1820*** (0.0284)

	β_2	-0.0473 (0.0684)		β_2	-0.1243* (0.0695)
	β_3	-0.6236*** (0.0515)		β_3	-0.4555*** (0.0593)
0.20	β_0	11.9720*** (0.0529)	0.80	β_0	13.3843*** (0.0319)
	β_1	0.3069*** (0.0279)		β_1	0.1656*** (0.0327)
	β_2	-0.0546 (0.0629)		β_2	-0.1420** (0.0612)
	β_3	-0.6299*** (0.0487)		β_3	-0.4438*** (0.0439)
0.25	β_0	12.0998*** (0.0450)	0.75	β_0	13.2957*** (0.0282)
	β_1	0.2960*** (0.0291)		β_1	0.1642*** (0.0220)
	β_2	0.0261 (0.0570)		β_2	-0.2058*** (0.0406)
	β_3	-0.6088*** (0.0408)		β_3	-0.4581*** (0.0360)
0.30	β_0	12.2314*** (0.0447)	0.70	β_0	13.1825*** (0.0289)
	β_1	0.2839*** (0.0288)		β_1	0.1861*** (0.0181)
	β_2	-0.0053 (0.0567)		β_2	-0.2193*** (0.0402)
	β_3	-0.5711*** (0.0427)		β_3	-0.4825*** (0.0275)
0.35	β_0	12.3751*** (0.0450)	0.65	β_0	13.0635*** (0.0369)
	β_1	0.2628*** (0.0227)		β_1	0.2034*** (0.0227)
	β_2	-0.0397 (0.0452)		β_2	-0.1894*** (0.0504)
	β_3	-0.5527*** (0.0330)		β_3	-0.5017*** (0.0288)
0.40	β_0	12.5040*** (0.0357)	0.60	β_0	12.9392*** (0.0384)
	β_1	0.2479*** (0.0208)		β_1	0.2152*** (0.0194)
	β_2	-0.0750** (0.0365)		β_2	-0.1758*** (0.0450)
	β_3	-0.5260*** (0.0340)		β_3	-0.5204*** (0.0288)
0.45	β_0	12.6269*** (0.0300)	0.55	β_0	12.8502*** (0.0338)
	β_1	0.2353*** (0.0207)		β_1	0.2210*** (0.0161)
	β_2	-0.1411*** (0.0355)		β_2	-0.1760** (0.0371)
	β_3	-0.5415*** (0.0280)		β_3	-0.5366*** (0.0297)
0.50	β_0	12.7459*** (0.0298)	OLS	β_0	12.6752*** (0.0327)
	β_1	0.2162*** (0.0157)		β_1	0.2379*** (0.0234)

β_2	-0.1474*** (0.0302)	β_2	-0.1062** (0.0464)
β_3	-0.5141*** (0.0274)	β_3	-0.5400*** (0.0318)

Estimated asymmetric parameter

Quantile	β_1	β_3	$\lvert\beta_1+\beta_3\rvert$	$\lvert\beta_1+\beta_3\rvert - \beta_1$
0.01	0.2903	-0.4761	0.1858	-
0.05	0.2933	-0.6575	0.3642	+
0.10	0.2998	-0.6547	0.3549	+
0.15	0.3063	-0.6236	0.3173	+
0.20	0.3069	-0.6299	0.3230	+
0.25	0.2960	-0.6088	0.3128	+
0.30	0.2839	-0.5711	0.2872	+
0.35	0.2628	-0.5527	0.2899	+
0.40	0.2479	-0.5260	0.2781	+
0.45	0.2353	-0.5415	0.3062	+
0.50	0.2162	-0.5141	0.2979	+
0.55	0.2210	-0.5366	0.3156	+
0.60	0.2152	-0.5204	0.3052	+
0.65	0.2034	-0.5017	0.2983	+
0.70	0.1861	-0.4825	0.2964	+
0.75	0.1642	-0.4581	0.2939	+
0.80	0.1656	-0.4438	0.2782	+
0.85	0.1820	-0.4555	0.2735	+
0.90	0.1718	-0.4516	0.2798	+
0.95	0.1568	-0.5057	0.3489	+
0.99	0.1489	-0.4217	0.2728	+
OLS	0.2379	-0.5400	0.3021	+

Notes: 1. *, ** and *** denote significance at the 10%, 5% and 1% levels, respectively. 2. The numbers in parentheses are the standard errors, which are simulated using the bootstrap method with 1000 replications. 3. The empirical models are expressed as follows:

$$EV_t = \beta_0 + \beta_1 SR_{t-1} + \beta_2 DUMMY_{t-1} + \beta_3 (DUMMY_{t-1} \times SR_{t-1}) + \varepsilon_t$$

where EV_t denotes the volume variables for the Taiwan ETFs, including the natural log of the trading share ($EVOL_t$) and the natural log of the trading value ($EVAL_t$) at period t. SR_{t-1} represents the logarithmic returns for the underlying index at period $t-1$. $DUMMY_{t-1}$ denotes the dummy variable, which equals unity for negative returns for the underlying index and zero for non-negative returns at period $t-1$.

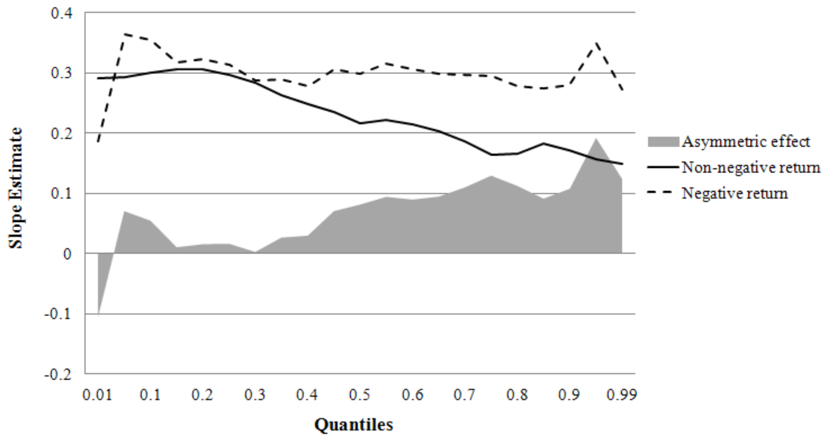

Figure 3: Slope comparison and asymmetric V-R effects for the trading value of the Taiwan 50 ETF. The slope estimate for non-negative returns is β_1, and that for negative returns is $|\beta_1 + \beta_3|$. The asymmetric effect is measured by $|\beta_1 + \beta_3| - \beta_1$ and displayed by the shaded region.

Table 5: Estimation results of quantile regression for the trading volume of Mid-Cap 100 ETF

Dependent variable: *EVOL*					
Estimated regression parameter			Estimated regression parameter		
Quantile		Estimates	Quantile		Estimates
0.01	β_0	3.2644*** (0.1303)	0.99	β_0	8.4515*** (0.1912)
	β_1	0.3090*** (0.0920)		β_1	-0.1206 (0.1059)
	β_2	-0.2357 (0.3292)		β_2	-0.3372 (0.2874)
	β_3	-0.6307*** (0.1230)		β_3	0.2000* (0.1174)
0.05	β_0	3.9787*** (0.1531)	0.95	β_0	7.6395*** (0.1413)
	β_1	0.2082** (0.0872)		β_1	-0.0674 (0.0787)
	β_2	-0.2790* (0.1663)		β_2	-0.2635 (0.1828)
	β_3	-0.4486*** (0.0911)		β_3	0.1321* (0.0778)
0.10	β_0	4.2307*** (0.0633)	0.90	β_0	6.9342*** (0.1220)
	β_1	0.2109*** (0.0643)		β_1	0.0380 (0.0595)
	β_2	-0.3101*** (0.0992)		β_2	-0.1388 (0.1479)
	β_3	-0.4787*** (0.0814)		β_3	0.0138 (0.0638)
0.15	β_0	4.4096*** (0.0709)	0.85	β_0	6.6337*** (0.0950)

	β_1	0.2135*** (0.0557)		β_1	0.0455 (0.0575)
	β_2	-0.1365 (0.1238)		β_2	-0.0298 (0.1823)
	β_3	-0.4636*** (0.0779)		β_3	-0.0512 (0.0562)
0.20	β_0	4.5631*** (0.0654)	0.80	β_0	6.2722*** (0.0875)
	β_1	0.2300*** (0.0470)		β_1	0.1205* (0.0665)
	β_2	-0.1517* (0.0872)		β_2	-0.0664 (0.1670)
	β_3	-0.4860*** (0.0618)		β_3	-0.1885*** (0.0666)
0.25	β_0	4.7394*** (0.0858)	0.75	β_0	6.0894*** (0.0768)
	β_1	0.2171*** (0.0511)		β_1	0.1025** (0.0442)
	β_2	0.1823* (0.1096)		β_2	-0.1514 (0.1085)
	β_3	-0.4549*** (0.0634)		β_3	-0.2108*** (0.0521)
0.30	β_0	4.8531*** (0.0575)	0.70	β_0	5.8811*** (0.0514)
	β_1	0.2451*** (0.0409)		β_1	0.1163*** (0.0294)
	β_2	-0.0851 (0.0868)		β_2	-0.0973 (0.1010)
	β_3	-0.4524*** (0.0605)		β_3	-0.2333*** (0.0437)
0.35	β_0	4.9639*** (0.0350)	0.65	β_0	5.7149*** (0.0823)
	β_1	0.2363*** (0.0194)		β_1	0.1474*** (0.0327)
	β_2	-0.0742 (0.0708)		β_2	-0.1100 (0.1276)
	β_3	-0.4368*** (0.0308)		β_3	-0.2826*** (0.0413)
0.40	β_0	5.0496*** (0.0367)	0.60	β_0	5.5030*** (0.0582)
	β_1	0.2440*** (0.0223)		β_1	0.1839*** (0.0306)
	β_2	-0.0330 (0.0652)		β_2	-0.0350 (0.1021)
	β_3	-0.4343*** (0.0315)		β_3	-0.3399*** (0.0400)
0.45	β_0	5.1601*** (0.0419)	0.55	β_0	5.4059*** (0.0468)
	β_1	0.2315** (0.0199)		β_1	0.2030*** (0.0211)
	β_2	-0.0548 (0.0681)		β_2	-0.0856 (0.0891)
	β_3	-0.4170*** (0.0325)		β_3	-0.3841** (0.0307)
0.50	β_0	5.2772*** (0.0556)	OLS	β_0	5.4644*** (0.0533)

β_1	0.2136*** (0.0205)	β_1	0.1568*** (0.0352)
β_2	-0.0374 (0.0846)	β_2	-0.1136 (0.0785)
β_3	-0.3950*** (0.0380)	β_3	-0.2994*** (0.0455)

Estimated asymmetric parameter

Quantile	β_1	β_3	$\lvert\beta_1+\beta_3\rvert$	$\lvert\beta_1+\beta_3\rvert - \beta_1$
0.01	0.3090	-0.6307	0.3217	+
0.05	0.2082	-0.4486	0.2404	+
0.10	0.2109	-0.4787	0.2678	+
0.15	0.2135	-0.4636	0.2501	+
0.20	0.2300	-0.4860	0.2560	+
0.25	0.2171	-0.4549	0.2378	+
0.30	0.2451	-0.4524	0.2073	-
0.35	0.2363	-0.4368	0.2005	-
0.40	0.2440	-0.4343	0.1903	-
0.45	0.2315	-0.4170	0.1855	-
0.50	0.2136	-0.3950	0.1814	-
0.55	0.2030	-0.3841	0.1811	-
0.60	0.1839	-0.3399	0.1560	+
0.65	0.1474	-0.2826	0.1352	+
0.70	0.1163	-0.2333	0.1170	+
0.75	0.1025	-0.2108	0.1083	+
0.80	0.1205	-0.1885	0.0680	-
0.85	0.0455	-0.0512	0.0057	-
0.90	0.0380	-0.0138	0.0242	+
0.95	-0.0674	-0.1321	0.1995	+
0.99	-0.1206	-0.2000	0.3206	+
OLS	0.1568	-0.2994	0.1426	-

Notes: 1. *, ** and *** denote significance at the 10%, 5% and 1% levels, respectively. 2. The numbers in parentheses are the standard errors, which are simulated using the bootstrap method with 1000 replications. 3. The empirical models are expressed as follows:

$$EV_t = \beta_0 + \beta_1 SR_{t-1} + \beta_2 DUMMY_{t-1} + \beta_3 (DUMMY_{t-1} \times SR_{t-1}) + \varepsilon_t$$

where EV_t denotes the volume variables for the Taiwan ETFs, including the natural log of the trading share ($EVOL_t$) and the natural log of the trading value ($EVAL_t$) at period t. SR_{t-1} represents the logarithmic returns for the underlying index at period $t-1$. $DUMMY_{t-1}$ denotes the dummy variable, which equals unity for negative returns for the underlying index and zero for non-negative returns at period $t-1$.

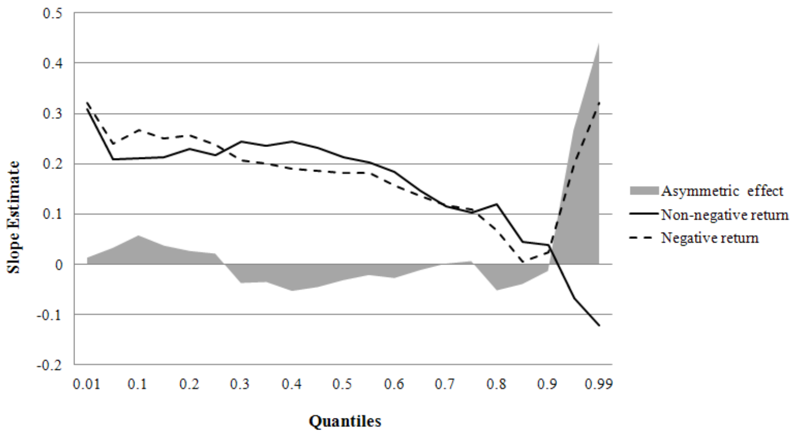

Figure 4: Slope comparison and asymmetric V-R effects for the trading volume of the Mid-Cap 100 ETF. The slope estimate for non-negative returns is β_1, and that for negative returns is $|\beta_1+\beta_3|$. The asymmetric effect is measured by $|\beta_1+\beta_3|-\beta_1$ and displayed by the shaded region.

Table 6: Estimation results of quantile regression for the trading value of Mid-Cap 100 ETF

Dependent variable: *EVAL*					
Estimated regression parameter			Estimated regression parameter		
Quantile		Estimates	Quantile		Estimates
0.01	β_0	6.5873*** (0.1455)	0.99	β_0	11.8237*** (0.1871)
	β_1	0.2650*** (0.0690)		β_1	-0.1407 (0.0860)
	β_2	-0.1340 (0.2186)		β_2	-0.3008 (0.2723)
	β_3	-0.4812*** (0.0755)		β_3	0.3043*** (0.1063)
0.05	β_0	7.2232*** (0.1093)	0.95	β_0	11.0651*** (0.1181)
	β_1	0.1837*** (0.0376)		β_1	-0.1001 (0.0801)
	β_2	-0.0991 (0.1302)		β_2	-0.2629* (0.1603)
	β_3	-0.3315*** (0.0584)		β_3	0.1392 (0.0870)
0.10	β_0	7.5860*** (0.0447)	0.90	β_0	10.4174*** (0.1178)
	β_1	0.1665*** (0.0484)		β_1	-0.0283 (0.0672)
	β_2	-0.2894*** (0.0700)		β_2	0.0177 (0.1165)
	β_3	-0.3881*** (0.1001)		β_3	0.0735 (0.0762)
0.15	β_0	7.8047*** (0.0627)	0.85	β_0	10.1407*** (0.0645)

	β_1	0.1433** (0.0320)		β_1	-0.0259 (0.0406)
	β_2	-0.2017 (0.1241)		β_2	-0.0347 (0.1355)
	β_3	-0.3701*** (0.0633)		β_3	0.0702 (0.0533)
0.20	β_0	7.8880*** (0.0485)	0.80	β_0	9.7295*** (0.0921)
	β_1	0.1860*** (0.0379)		β_1	0.0574 (0.0363)
	β_2	-0.1485** (0.0750)		β_2	-0.0769 (0.1129)
	β_3	-0.4072*** (0.0486)		β_3	-0.0695* (0.0385)
0.25	β_0	8.0828*** (0.0633)	0.75	β_0	9.4861*** (0.0611)
	β_1	0.1528*** (0.0323)		β_1	0.0847** (0.0293)
	β_2	-0.1453 (0.0989)		β_2	-0.0740 (0.0729)
	β_3	-0.3421*** (0.0503)		β_3	-0.1323*** (0.0336)
0.30	β_0	8.2083*** (0.0794)	0.70	β_0	9.2880*** (0.0906)
	β_1	0.1429*** (0.0396)		β_1	0.1006*** (0.0367)
	β_2	-0.1053 (0.1043)		β_2	-0.1315 (0.1085)
	β_3	-0.3107*** (0.0558)		β_3	-0.1869*** (0.0481)
0.35	β_0	8.3570*** (0.0521)	0.65	β_0	9.0594*** (0.0683)
	β_1	0.1459*** (0.0275)		β_1	0.1221*** (0.0436)
	β_2	-0.0916 (0.1015)		β_2	-0.0345 (0.0815)
	β_3	-0.3042*** (0.0383)		β_3	-0.2254*** (0.0536)
0.40	β_0	8.4685*** (0.0500)	0.60	β_0	8.9024*** (0.0541)
	β_1	0.1521*** (0.0218)		β_1	0.1417*** (0.0296)
	β_2	-0.0320 (0.0844)		β_2	-0.0128 (0.0787)
	β_3	-0.2957*** (0.0311)		β_3	-0.2534*** (0.0471)
0.45	β_0	8.5851*** (0.0542)	0.55	β_0	8.8081*** (0.0386)
	β_1	0.1453** (0.0197)		β_1	0.1420*** (0.0255)
	β_2	-0.0517 (0.0763)		β_2	-0.0624 (0.0749)
	β_3	-0.2740*** (0.0303)		β_3	-0.2667*** (0.0378)
0.50	β_0	8.6729*** (0.0527)	OLS	β_0	8.8563*** (0.0553)

β_1	0.1497*** (0.0227)	β_1	0.1032*** (0.0366)
β_2	-0.0499 (0.0931)	β_2	-0.1045 (0.0815)
β_3	-0.2725*** (0.0336)	β_3	-0.2005*** (0.0472)

Estimated asymmetric parameter

Quantile	β_1	β_3	$\lvert\beta_1+\beta_3\rvert$	$\lvert\beta_1+\beta_3\rvert$ - β_1
0.01	0.2650	-0.4812	0.2162	-
0.05	0.1837	-0.3315	0.1478	-
0.10	0.1665	-0.3881	0.2216	+
0.15	0.1433	-0.3701	0.2268	+
0.20	0.1860	-0.4072	0.2212	+
0.25	0.1528	-0.3421	0.1893	+
0.30	0.1429	-0.3107	0.1678	+
0.35	0.1459	-0.3042	0.1583	+
0.40	0.1521	-0.2957	0.1436	-
0.45	0.1453	-0.2740	0.1287	-
0.50	0.1497	-0.2725	0.1228	-
0.55	0.1420	-0.2667	0.1247	-
0.60	0.1417	-0.2534	0.1117	-
0.65	0.1221	-0.2254	0.1033	-
0.70	0.1006	-0.1869	0.0863	-
0.75	0.0847	-0.1323	0.0476	-
0.80	0.0574	-0.0695	0.0121	-
0.85	-0.0259	0.0702	0.0443	+
0.90	-0.0283	0.0735	0.0452	+
0.95	-0.1001	0.1392	0.0391	+
0.99	-0.1407	0.3043	0.1636	+
OLS	0.1032	-0.2005	0.0973	-

Notes: 1. *, ** and *** denote significance at the 10%, 5% and 1% levels, respectively. 2. The numbers in parentheses are the standard errors, which are simulated using the bootstrap method with 1000 replications. 3. The empirical models are expressed as follows:

$$EV_t = \beta_0 + \beta_1 SR_{t-1} + \beta_2 DUMMY_{t-1} + \beta_3 (DUMMY_{t-1} \times SR_{t-1}) + \varepsilon_t$$

where EV_t denotes the volume variables for the Taiwan ETFs, including the natural log of the trading share ($EVOL_t$) and the natural log of the trading value ($EVAL_t$) at period t. SR_{t-1} represents the logarithmic returns for the underlying index at period $t-1$. $DUMMY_{t-1}$ denotes the dummy variable, which equals unity for negative returns for the underlying index and zero for non-negative returns at period $t-1$.

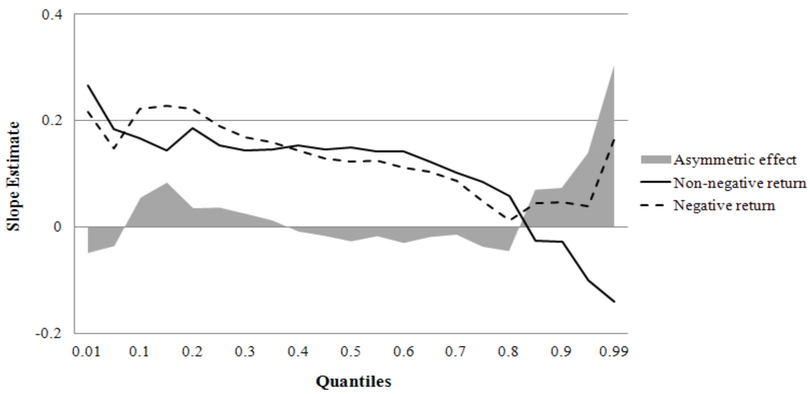

Figure 5: Slope comparison and asymmetric V-R effects for the trading value of the Mid-Cap 100 ETF. The slope estimate for non-negative returns is β_1, and that for negative returns is $|\beta_1+\beta_3|$. The asymmetric effect is measured by $|\beta_1+\beta_3|-\beta_1$ and displayed by the shaded region.

4 Concluding Remarks

This paper examines the V-R relationship between Taiwan ETFs and their underlying assets to re-test the costly short-sale hypothesis in this new context. In addition to the correlation measurements for V-R asymmetry, an additional measure of asymmetry is employed in which the slope coefficients associated with negative and non-negative returns are compared. Furthermore, to observe the V-R relationship across various volume levels, the quantile regression method is applied. The empirical results yield several essential findings. First, the strong, positive, but concave relationship between ETF volume and the non-negative underlying index returns demonstrates that spot investors may regard ETFs as complements when their underlying index markets are on a rise and especially when the ETF volume is at a lower level; the weakening of the positive relationship that occurs as the volume quantile increases demonstrates the decay of the complementary effect for spot investors. Second, the strong, negative relationship between ETF volume and negative underlying index returns indicates that because of the high short-sale costs in spot markets, spot investors may regard ETFs as substitutes and transfer their trades to the ETF markets when the underlying index market is on the decline (and especially when the ETF volume is at an extrema level.) Third, a direct comparison of the slope coefficients associated with negative and non-negative returns reveals that they are significantly different. The slope coefficients associated with negative returns exceeds that associated with non-negative returns especially for the Taiwan 50 ETF at the quantiles that are higher than the median level and for the Mid-Cap 100 ETF at the extrema quantiles. Thus, the ETFs are found to exhibit an asymmetric V-R relationship, and the costly short-sale hypothesis is confirmed. Moreover, since the negative correlations between ETF volume and negative index returns for both ETFs at the extrema quantiles increase sharply, we try to include the complementary and substitute effects for ETF investors, combined with the substitute effect of spot traders, to explain this phenomenon.

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