

Wang, Shu Feng; Lee, Hyo-Jeong

Article

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Can Short-Selling Alleviate the Underpricing?

Shu-Feng Wang^a, Hyo-Jeong Lee^b

^aAssistant Professor, Department of Finance, National Central University, Taoyuan, Taiwan

^bAssistant Professor, Division of Business Administration, Kwangwoon University, Seoul, Republic of Korea

ABSTRACT

This paper investigates whether short-selling facilitates arbitrage activity and mitigates the positive post-earnings announcement drift (PEAD), the well-known underpricing anomaly. Using the quarterly earnings announcement of the Korean Stock Exchange KOSPI200 composite stocks, we find that the positive earnings stock in a difficult-to-short industry experiences the larger and more persistent underpricing after earnings announcement than those in an easy-to-short industry; and that the severe underpricing in a difficult-to-short industry is associated with the short-sale constraint, not with their illiquidity or information inefficiency. We also find that the inverse relationship between the positive PEAD and its industry's short-ability is stronger during the inactive ELW trade period, weaker during the active ELW trade period. Our findings suggest that short-selling help not only the overpriced stocks but also the underpriced stocks revert back to its fundamental value by facilitating arbitrage activities.

Keywords: Short-selling, Underpricing, Post-earnings announcement drift, Arbitrage, ELW.

1. Introduction

The primary question considered by previous researches is whether the short-sellers make overpriced stocks revert to their fundamental value by their intensive selling activities based on their private information. Some researches (Rubinstein, 2004; Boehmer, Jones, and Zhang, 2008; Dechow et al., 2001) examined the impact of short-selling on the price of the shorted stocks and showed that short-selling allows negative information to be incorporated into

the stock prices. However, short-selling need not affect only the stocks being shorted. In this paper, we examine the impact of short-selling on the pricing of stocks other than the shorted stocks and investigate whether short-selling help the underpriced stock to revert back to its fundamental value.

The idea is as follows. If a stock in a given industry is underpriced, then arbitrageurs buy that stock and sell it back when its price reverts to the fundamental value. In this case, they generally sell short other stocks in the same industry to hedge the industry risk. Accordingly, if the industry has a large pool of stocks available to short-selling without limit of arbitrage, then the underpriced stocks in that industry can return to its fundamental value in a very short time owing to the aggressive arbitrage. However, if short-selling activity of the industry is constrained

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† Hyo-Jeong Lee

Division of Business Administration, Kwangwoon University, 20 Kwangwoonro, Nowon-Gu, Seoul 139-70, Republic of Korea.
Tel. +82-2-940-8262 E-mail: leehj@kw.ac.kr

for some reasons, then stocks in that industry cannot revert back to fundamental value quickly, because the difficult hedging via substitute stocks cause arbitrageurs to trade less aggressively. In other words, short-selling can alleviate the mispricing of underpriced stock by facilitating arbitrage activities.

This paper investigates this issue by analyzing the positive post-earnings announcement drift (PEAD), the well-known underpricing anomaly.¹⁾ The scholars supporting Behavior Finance argue that the positive PEAD phenomenon attributes to some irrational trading and the limit of arbitrage. According to this view, uninformed traders who misinterpret earnings information²⁾ and impatiently sell their stocks with earnings surprise would cause the underpricing; and the constraints on arbitrage activity would prevent the underpricing from being resolved quickly (Shleifer and Vishny, 1997).

This phenomenon provides the test set for investigating whether short-selling can alleviate the mispricing of underpriced stocks by facilitating arbitrage activities. In an easy-to-short (ETS) industry, since hedging the industry risk via substitute stocks is easy, arbitrageurs can exploit the temporarily underpriced stocks aggressively. Thus, the positive PEAD would be weaker and less persistent. However, in a difficult-to-short (DTS) industry, since hedging via substitutes is difficult, arbitrageurs buy the underpriced stocks less aggressively. This would slow down their price response to good news and the elimination of underpricing. We predict that the underpriced stocks in an ETS industry have the less delayed price response, in both magnitude and persistence, than those in a DTS industry.

Using the quarterly earnings announcements of KOSPI200 composite stocks between January 2006 and December 2013, we examine the average

cumulative abnormal returns (CARs) following the positive earnings announcement in both ETS and DTS industries. The results show that the average $CAR_{[0,19]}$ in a DTS industry is significantly higher than that in an ETS industry. Moreover, in a DTS industry, 33.0% and 43.6% of the total underpricing disappear during 1 day and 10 days following the announcement day, respectively. However, in an ETS industry, 66.1% and 112.9% get resolved during the same period. The results are robust to control the other variables that potentially affect the stock returns following the earnings announcements.

To confirm that the severe underpricing in a DTS industry is associated with the short-sale constraint, not with their illiquidity or informational inefficiency, we examine whether the relationship between the positive PEAD and its industry's short-ability is maintained after controlling for *amihud* measure, size, and volatility. In all subgroups with different levels of liquidity and informational efficiency, DTS portfolios consistently show higher CARs and lower *Frac*s than ETS portfolios. We also examine the price reaction to negative earnings announcement. If the underpricing observed in a DTS industry comes from their illiquidity or informational inefficiency, then we should also observe more sluggish price reversals for the overpriced stocks. We cannot find a greater negative PEAD in a DTS than in an ETS industry, thereby suggesting that the illiquidity or information inefficiency hypotheses may not be the case.

Lastly, we examine whether the inverse relation between the positive PEAD and its industry's short-ability varied depending on equity-linked warrant (ELW) trading volume. If arbitrageurs can freely use the put-ELWs instead of actual short sales, the difference of the positive PEAD between DTS and ETS industries could be small. Actually, the difference in the positive PEAD between two groups becomes more prominent during the inactive ELW trade period and gets blurred during the active ELW trade period. This result suggests that short-selling alleviates the mispricing of underpriced stocks by facilitating arbitrage activities (not by the other channels), also it implies that the ELW act as an alternative to short

1) Financial researchers point to positive PEAD and underpricing in the IPO market as a representative example of underpricing anomaly. (Tan and Kim, 2016) The study of the effect of short selling on the underpricing in the IPO is an interesting topic, but we will try to cover it in the next opportunity.

2) The information in the disclosures of earnings seems to be ambiguous and sometimes difficult to interpret. (Ji, 2016; Nguiyet, 2017)

trades when short-selling constrained.

This paper examines the impact of shorting on the industry's peer stocks, rather than the stock being shorted itself.³⁾ By using this new approach, we shed light on a different dimension of short-selling, that is, short-selling induces not only overpriced stocks but also underpriced stocks to revert back to their fundamentals. This paper also presents the new evidences that arbitrageurs use a long-short strategy to exploit the positive PEAD phenomenon in the Korean stock market.

Our findings suggest the important insights to the policy makers who formulate and implement the regulations related to short selling and ELW. Since short selling help not only the overpriced stocks but also the underpriced stocks revert back to its fundamental value, the restrictions on short selling can severely weakens the price discovery function of the stock market. Also, since ELWs are actively used as hedging instruments, the excessive regulation restricting ELW trading could hamper hedge and arbitrage activity as well as speculative activity.

The rest of this paper is organized as follows. In section 2, there is a summary of the previous studies on short-selling. Section 3 describes the dataset and the main variables for investigating the issue raised. Section 4 provides the empirical results on the hypotheses covered in this study. Section 5 is the conclusion.

2. The Literature Review

The main question of previous studies is whether short-selling makes the overpriced stocks revert to their fundamental values. The empirical studies showed that the increases in short interest or short volume lead to the declines in stock returns (Diether et al., 2009a; Dechow et al., 2001; Asquith and

Meulbroek, 1996; Conrad, 1994; Figlewski and Webb, 1993; Senchack and Starks, 1993).

Academics also have studied the effect of the short-selling constraints on the asset prices. Miller (1977) theoretically suggested that the short constraints impeded negative information from being incorporated into the stock price. Diamond and Verrechia (1987) showed that short-selling constraints could impede the efficient price discovery by eliminating certain informed traders.

There are also many studies investigating how the short-selling ban affects the stock market. Diether et al. (2009b) examined how the SHO regulation affects the market quality. Boulton and Braga-Alves (2009), and Boehmer et al. (2008) examined the impact of the short-ban during 2008 global financial crisis and found that the ban on short-selling worsens the market's liquidity and price discovery. Kolasinski et al. (2010), Choe and Lee (2012) studied whether the short restriction and the short ban would influence on stock market differently. They found that the ban decreased the liquidity and increased the informativeness of trades much more, compared with the restriction.

Hwang et al. (2017) argued that short sales may help to correct not only the overpricing but also the underpricing. Utilizing the institutional feature of the Hong Kong market where only the stocks on the designated short-sale list announced quarterly can be shorted, they found that when stock i is designated as the shortable stocks, other stocks that exist in the same industry earned positive abnormal returns. Similar to Hwang et al. (2017), this paper examines whether the short-selling facilitates the arbitrage activities and mitigates the positive PEAD, the well-known underpricing anomaly.

3. Data and Sample

3.1. Data

Using the quarterly earnings announcements of KOSPI200 composite stocks⁴⁾ between January 2006

³⁾ A large body of literature examines the effect of shorting on the shorted stock, except one paper (Hwang et al., 2017).

and December 2013, we examine the average *CAR* following the positive earnings announcement in DTS and ETS industries. To alleviate survivorship bias, we include the stocks dropped from KOSPI200 during the sample period in our sample.⁵⁾ We exclude the global financial crisis period (Oct. 1, 2008-May 31, 2009) and the European financial crisis period (Aug 10, 2011-Nov. 10, 2011) from the sample period because the South Korean financial authority banned short sales during these periods.

We collect the short sales data for each sample stock from the Korea Stock Exchange (KSE) and extract its financial and market information from TS-2000 (a database operated by Korea Listed Companies Association, KLCA). We resort to DataGuide (a database maintained by FnGuide, one of the biggest data vendor in Korea) to collect the daily trading volumes of ELWs. We identify the earnings announcement day for each stock-earnings sample by using KIND (Korea Investor’s Network for Disclosure System), which is the electronic disclosure platform operated by KSE. Because the firms usually announce their tentative earnings via various types of disclosures before the final annual report disclosure, we manually collect the date of the first time when the earnings-related information is substantially announced in a given quarter.⁶⁾ We change the date of an earnings announcement revealed after the official market-closing time (2:50 PM) to the next trading day.⁷⁾

4) We restrict the sample to the KOSPI200 stocks because arbitrage trades are mostly performed by institutional and foreign investors who usually trade the stocks with large market capitalization.
 5) The total number of sample stocks is 275.
 6) For 4th quarter earnings announcement, we pick the calendar date of the earliest one among five announcements: the fair disclosure on business performance, the report of sales change greater than 30%, the report of audit, the notice for convocation of meeting of shareholders, and the annual stockholders’ meeting. For 1st, 2nd, and 3rd quarter earnings announcements, we pick the calendar date of the earlier one of two events: the temporary earnings announcement and the quarterly report disclosure. We do not regard the tentative earnings disclosure without the full contents including the net income as the quarterly earnings announcement.
 7) In South Korea, since trade cannot occur during the last 10 minutes for each trading day, 14:50–15:00, the information

3.2. Main variables

We define the samples with standardized unexpected earning (*SUE*) values greater than the upper 20% as positive earnings stocks, and those with *SUE* values less than the bottom 20% as negative earnings stocks. *SUE* is a standardized difference between reported earnings and expected earnings, where expected earnings are modeled based on the assumption that the earnings follows a seasonal random walk with a trend.⁸⁾ The *SUE* for quarter *t* is defined as equation (1). In equation (1), $Q_{i,t-4}$ is the reported earnings for quarter *t-4* and δ is the average trend. We can compute *SUE* for 7,144 stock-earning observations out of our total sample.⁹⁾ Of these, positive earnings stocks with *SUEs* greater than the upper 20% are 1,949 and negative earnings stocks with *SUE* less than the bottom 20% are 1,940.

$$SUE_{i,t} = \frac{Q_{i,t} - E(Q_{i,t})}{\sigma(Q_{i,t} - E(Q_{i,t}))} \tag{1}$$

Where $E(Q_{i,t}) = \delta_i + Q_{i,t-4}$

Some studies define the earnings surprise measure as the difference between actual earnings and average analysts’ forecast just before the earnings announcement for each stock. This measure has the advantage of eliminating the noises caused by the business structural change but it has the disadvantage of reducing the sample size, since the Korean broker firms generally cover less than 100 stocks and sometimes present yearly basis forecasts, rather than quarterly basis forecasts. Thus, we use the *SUE* estimated by the accounting information as the earnings surprise measure.

Fortunately, our *SUE* seems to measure adequately the degree of the earnings surprise. According to Table

about earnings announcement cannot be reflected during the last 10 minutes.
 8) Our definition of *SUE* is same as that in Foster et al. (1984), Bernard and Thomas (1989, 1990).
 9) Because we require the 16 quarterly earnings information prior to the earnings announcement in order to estimate the earnings trend, the number of samples decreases. Also, we trim the samples with *SUE* values greater than +5 or less than -5, to reduce the influence of outliers.

Table 1. Summary statistics for SUE deciles

This table shows the average SUE and CAR around earnings announcement day for each of ten SUE portfolios. For each quarter, we rank all sample stocks according to their SUE and then assign them to one of ten equally sized portfolios. The decile 1 contains the stocks with extreme negative earnings news, while the decile 10 contains the stocks with extreme positive earnings news.

<i>SUE</i> deciles	N	<i>SUE</i>	$CAR_{[0,19]}$	$CAR_{[1,19]}$	$CAR_{[0,0]}$
1	959	-2.385	-0.0166	-0.0095	-0.0075
2	981	-1.200	-0.0165	-0.0109	-0.0049
3	980	-0.705	-0.0117	-0.0097	-0.0017
4	982	-0.378	-0.0011	0.0007	-0.0021
5	976	-0.124	-0.0093	-0.0083	-0.0014
6	985	0.101	0.0009	-0.0006	0.0018
7	985	0.342	0.0062	0.0048	0.0016
8	977	0.646	0.0051	-0.0009	0.0054
9	984	1.117	0.0120	0.0067	0.0064
10	965	2.307	0.0245	0.0138	0.0107

1, there exists the positive relationship between *SUE* deciles and $CAR_{[0,0]}$ which reflect the immediate market response to the earnings information. The average $CAR_{[0,0]}$ are -0.75% for D1 and 1.07% for D10, increasing from D1 to D10 monotonically. Also, we find the positive relationship between *SUE* deciles and $CAR_{[1,19]}$ which reflect the delayed price response to the earnings information. The average $CAR_{[1,19]}$ are -0.95% for D1 and 1.38% for D10, increasing from D1 to D10 mostly. It means that the prices drift upward following the good earnings news and downward following the bad earnings news. In short, our *SUE* reflects the market response to earnings news consistent with the prior research.

We measure the degree of the positive PEAD by the average *CAR* during the specified period following (including) the earnings announcement day. *CAR* is defined as equation (2)

$$CAR_{i,[t_1, t_2]} = R_{i,[t_1, t_2]} - R_{m,[t_1, t_2]} \quad (2)$$

Where $R_{i,[t_1, t_2]}$ = raw return for firm *i* during a period $[t_1, t_2]$

$R_{m,[t_1, t_2]}$ = mean return for equally-weighted portfolio of all sample stocks

during a period $[t_1, t_2]$

We measure the persistency of the PEAD by $Frac_n$, which is the proportion of the drift resolved during *n* days adjacent the earnings day in the total PEAD.

$\left(Frac_n = \frac{CAR_{[0,n]}}{CAR_{[0,19]}}, n = 1, 3, 5, 10 \right)$. The higher

$Frac_n$ means that the large parts of the delayed price response are observed within the *n* days just after the earnings announcement.

3.3. Summary statistics of sample stocks

To examine the effect of short sales on the underpriced stocks, we divide total sample into two groups; stocks in a DTS industry and stocks in an ETS industry, and investigate the difference in the positive PEAD between these two groups. We categorize our sample stocks into fifteen industries based on KSIC (Korean Standard Industrial Classification) and compute the each industry's *shorted firm ratio* for each quarter, which is the number of stocks with nonzero shorting volumes during the quarter divided by the total number of stocks in a given industry. Stock *i* is categorized as being in a DTS industry

Table 2. Summary statistics for quarterly short-sale activities of 15 industries

The sample stocks are categorized into fifteen different industries based on KSIC. The table presents the details of our industry classification and the summary statistics for short-sale activities of 15 industries. We compute quarterly *shorted firm ratios* for each industry and estimate time-series distribution of its *shorted firm ratio* during the entire sample period (32 quarters). For each industry, we calculate the number of quarters belonging to the bottom 50% based on its industry's *shorted firm ratio* of the entire 32 quarters (# of quarters belonging to DTS industry).

Class	Industry name	# of stocks	Industry's' shorted firm ratio					Autocorr	# of quarters belonging to DTS industry
			Avg	Std	Min	Med	Max		
1	Utility	6	0.714	0.200	0.167	0.667	1.000	0.316	25
2	Manufacturing (material)	60	0.798	0.207	0.083	0.889	0.951	0.567	25
3	Manufacturing (industrial goods)	33	0.801	0.167	0.250	0.875	0.968	0.718	29
4	Manufacturing (consumer goods)	33	0.799	0.201	0.303	0.879	1.000	0.805	20
5	Manufacturing (essential consumer goods)	26	0.801	0.217	0.038	0.846	1.000	0.676	23
6	Manufacturing (medical goods)	19	0.810	0.233	0.000	0.895	1.000	0.541	20
7	Manufacturing(IT)	27	0.824	0.170	0.296	0.852	1.000	0.662	17
8	Construction	14	0.967	0.109	0.429	1.000	1.000	0.387	0
9	Wholesale and retail	10	0.775	0.217	0.222	0.800	1.000	0.873	16
10	Transportation	7	0.881	0.216	0.143	1.000	1.000	0.624	4
11	Education and leisure	6	0.943	0.197	0.000	1.000	1.000	0.353	1
12	Media	4	0.703	0.233	0.000	0.750	1.000	0.290	25
13	Telecommunications	3	1.000	0.000	1.000	1.000	1.000	1.000	0
14	IT service(industrial goods)	21	0.827	0.158	0.143	0.857	0.952	0.511	24
15	Finance	6	0.784	0.241	0.167	0.833	1.000	0.500	17
Total		275	0.828	0.208	0.000	0.893	1.000		32

if it belongs to the bottom 50% group based on its industry's *shorted firm ratio*; otherwise, it is categorized as coming from an ETS industry.

Table 2¹⁰) presents the details of the industry classification and the time-series distribution for the *shorted firm ratios* of 15 industries. The number of stocks for each industry varies from 3 (telecommunication) to 60 (material manufacturing). The average *shorted firm ratio* ranges between 0.7 and 1 across 15 industries. Media, utility, and wholesale and retail exhibit the low average *shorted firm ratio*, whereas telecommunications, construction, and education and leisure exhibit the high average *shorted firm ratio*. Almost all of industries exhibit large gaps between

the minimum and maximum, thereby suggesting that there are considerable variations in the *shorted firm ratio* across 32 quarters for each industry (except for Media). For each industry, we also calculate the number of quarters in which that industry belongs to the bottom 50% group based on the quarterly *shorted firm ratio*, that is, the DTS group. Industrial goods manufacturing, material manufacturing, utility, and media belong to the DTS group in more than 25 quarters of 32 quarters. However, telecommunications and construction never belong to the DTS during the sample periods.¹¹⁾

Table 3 presents the summary statistics of *SUE*

10) In Table 2, we do not exclude the global financial crisis period (Oct. 1, 2008–May 31, 2009) and the European financial crisis period (Aug. 10, 2011–Nov. 10, 2011) from the sample period to provide the whole picture of the short-selling activities in our sample.

11) We also calculate the cross-sectional average and standard deviation of the *shorted firm ratios* for each quarter, and examine their historical trends. The average *shorted firm ratio* increase steadily and the standard deviation of that decrease consistently during the sample period. The result is available upon request.

Table 3. Summary statistics for DTS and ETS industries

This table presents the summary statistics of *SUE* and firm characteristics for DTS and ETS industries. *N* is number of stock-quarters in a given industry during the entire sample period. *SUE* is an earnings surprise measure which is defined in Ball and Brown (1986). We define samples with *SUE* values greater than the upper 20% as positive earnings stocks, and those with *SUE* less than bottom 20% as negative earnings stocks. *ln(BM)* and *ln(Size)* are log book-to-market ratio and log market capitalization at the end of previous year, respectively. *Vol* is the stock return volatility defined as the standard deviation of daily returns and *Turn* is the turnover defined as the daily trading volume divided by the outstanding shares. *Vol* and *Turn* are calculated by daily trading data of the previous quarter. The *, **, and *** denote the statistically significance at 10%, 5% and 1% levels, respectively.

Panel A. All sample stocks

Variables	ETS (1)	DTS (2)	Diff (1)-(2)	
<i>N</i>	2645	4499		
<i>SUE</i>	0.037	0.036	0.001	
<i>ln(BM)</i>	0.245	0.066	0.179	***
<i>ln(Size)</i>	27.471	26.947	0.524	***
<i>Vol</i>	0.252	0.254	-0.001	
<i>Turn</i>	0.081	0.071	0.010	***

Panel B. Positive earnings stocks

Variables	ETS (1)	DTS (2)	Diff (1)-(2)	
<i>N</i>	507	861		
<i>SUE</i>	1.764	1.763	0.001	
<i>ln(BM)</i>	0.226	0.005	0.222	***
<i>ln(Size)</i>	27.332	26.829	0.503	***
<i>Vol</i>	0.265	0.258	0.006	
<i>Turn</i>	0.088	0.070	0.018	**

Panel C. Negative earnings stocks

Variables	ETS (1)	DTS (2)	Diff (1)-(2)	
<i>N</i>	642	1009		
<i>SUE</i>	-1.601	-1.748	0.147	***
<i>ln(BM)</i>	0.290	0.188	0.102	***
<i>ln(Size)</i>	27.571	27.075	0.497	***
<i>Vol</i>	0.253	0.254	-0.001	
<i>Turn</i>	0.085	0.072	0.013	*

and firm characteristics for DTS and ETS industries. As shown in Panel A, about 63% (4,499 observations) and 37% (2,645 observations) of the stock-earnings sample belong to a DTS industry and an ETS industry, respectively. The stocks in a DTS industry have a lower book-to-market ratio, a smaller size, and a lower turnover than those in an ETS industry, thereby suggesting that there exist some differences in other firm characteristics as well as short sales restriction

between two industry groups. We calculate the summary statistics in the same way for the positive and negative earnings sample. The results (Panels B-C) are similar to that of total sample.

4. Empirical Analysis

4.1. Delayed price response for positive earnings announcement

We examine the difference in the degree and the persistency of the positive PEAD between DTS and ETS industries. We measure the degree of the drift by the average $CAR_{[0,19]}$ and the persistency by $Frac_n$. If the stocks i experience more severe underpricing, then it shows a larger $CAR_{[0,19]}$ (especially larger $CAR_{[1,19]}$), and a lower $Frac_n$. We hypothesized that the stocks in a DTS industry suffer a larger and more persistent positive PEAD because of the limited arbitrage activities. If our hypothesis is correct, we should observe a higher average $CAR_{[0,19]}$ and a lower average $Frac_n$ in a DTS industry than in an ETS industry¹²⁾.

For positive earnings stocks, the average $CAR_{[0,19]}$ in a DTS industry (2.31%) is higher than that in an ETS industry (0.36%), as can be ascertained from Panel A of Table 4. This difference is derived from $CAR_{[1,19]}$, which is the delayed price response, rather than $CAR_{[0,0]}$, which is the immediate price response to earnings information. The average $CAR_{[1,19]}$ is significantly higher in a DTS industry (1.53%) than in an ETS industry (-0.09%). However, there is no difference in the average $CAR_{[0,0]}$ between two groups. The average $Frac_1$ and $Frac_{10}$ in a DTS industry are 33% and 43.6%, respectively, however, those in an ETS industry are 66.1% and 112.9%, respectively, as can be seen in Panel B. It means that the large part of the total positive PEAD is resolved in the initial stage after the earnings announcement in an ETS industry, but only small part is mitigated in the same period in a DTS industry. However, the

differences of $Frac_1$, $Frac_3$, and $Frac_5$ between the two groups are not statistically significant in this univariate analysis. Overall, the result implies that the positive PEAD is larger and more persistent in a DTS industry than in an ETS industry. It is the evidence supporting our hypothesis that short selling can alleviate the mispricing of underpriced stock by facilitating arbitrage activities.

To confirm that the results are robust after controlling other variables that may affect the stock returns following earnings announcement, we run the multiple regressions of which dependent variables are $CARs$ and $Frac_s$. We transform $CARs$ and $Frac_s$ into a decile rank between 0 and 1 to facilitate the interpretation and to reduce the influence of outliers. The main explanatory variable is $Difficult_{i,q-1}$, which equals one when stock i belongs to a DTS industry in the quarter $q-1$, and zero otherwise.¹³⁾ We include $Shorted_{i,q-1}$, which equals one if stock i itself has a nonzero shorting volume in the quarter $q-1$, and zero otherwise. The coefficients of $Difficult$ and $Shorted$ present the impact of its affiliated industry's short-ability and its own short-ability on the PEAD, respectively. In order to control the price pressure of short trading¹⁴⁾, we include the $SS.Vol$, which is shorted volume to total trading volume ratio during each period corresponding with each dependent variable ($CAR_{[0,19]}$, $CAR_{[0,0]}$, $CAR_{[1,19]}$, and $Frac_{n,s}$). We control firm's book-to-market ratio ($ln(BM)$), size ($ln(Size)$), return volatility (Vol), turnover ($Turn$), and lagged return (Mom). These variables have been considered as relevant factors that can affect the firms' PEAD. To control for the differences across industries, we also include the volatility (Vol_{ind}) and the turnover ($Turn_{ind}$) of the industry that each stock belongs to. We add a year-quarter dummy to control for possible variation in the degree of a PEAD phenomenon over time. Standard errors are adjusted by considering the clustering in year-quarter. We estimate the

12) For the analysis of $CARs$, we use the total positive earnings stocks (stocks with SUE greater than upper 20%), however, for the analysis of $Frac_s$, we limit the sample to the positive earnings stocks with a positive PEAD (stocks with SUE greater than upper 20% and positive $CAR_{[0,19]}$). Since the persistency analysis is valid only for the stocks experiencing positive PEADs after their positive earnings announcement, we add this restriction when investigating the persistency of the positive PEAD ($Frac_n$).

13) To eliminate the reverse causality effect, we defined the DTS industry based on the ranks of previous quarter.

14) Figlewski (1981) and Desai et al. (2002) showed that a high fraction of shares shorted precedes low future returns.

Table 4. The PEAD for DTS and ETS industries

We classify sample stocks into DTS and ETS industries based on their industry's *shorted firm ratios* and examine the return movement around the earnings announcements for each group. For analysis of *CARs*, we use the total positive (negative) earnings stocks, however, for analysis of *Frac_s*, we limit our sample to the positive (negative) earnings stocks with a positive (negative) PEAD. The *, **, and *** denote the statistical significance at 10%, 5% and 1% levels, respectively.

Panel A. The magnitude of PEAD (*CARs*)

Variables	Class	Positive earnings stocks			Negative earnings stocks		
		N	Mean	<i>t</i> -stat	N	Mean	<i>t</i> -stat
<i>CAR</i> _[0,19]	ETS(1)	499	0.0036		875	-0.0140	
	DTS(2)	835	0.0231		1436	-0.0132	
	Diff (1)-(2)		-0.0195	-3.10 ***		-0.0007	-0.17
<i>CAR</i> _[1,19]	ETS(1)	501	-0.0009		884	-0.0104	
	DTS(2)	840	0.0153		1445	-0.0083	
	Diff (1)-(2)		-0.0163	-2.80 ***		-0.0021	-0.51
<i>CAR</i> _[0,0]	ETS(1)	499	0.0048		875	-0.0038	
	DTS(2)	835	0.0078		1436	-0.0046	
	Diff (1)-(2)		-0.0030	-1.61		0.0008	0.60

Panel B. The persistency of PEAD (*Frac_s*)

Variables	Class	Positive earnings stocks			Negative earnings stocks		
		N	Mean	<i>t</i> -stat	N	Mean	<i>t</i> -stat
<i>Frac</i> ₁	ETS(1)	256	0.661		519	0.281	
	DTS(2)	460	0.330		827	0.048	
	Diff (1)-(2)		0.331	1.03		0.233	1.32
<i>Frac</i> ₃	ETS(1)	256	0.552		522	0.452	
	DTS(2)	462	0.375		831	0.151	
	Diff (1)-(2)		0.176	0.48		0.301	1.61
<i>Frac</i> ₅	ETS(1)	256	0.735		522	0.549	
	DTS(2)	462	0.402		831	0.301	
	Diff (1)-(2)		0.332	0.79		0.247	1.25
<i>Frac</i> ₁₀	ETS(1)	256	1.129		522	0.600	
	DTS(2)	462	0.436		831	0.624	
	Diff (1)-(2)		0.693	1.75*		-0.023	-0.08

following specification.

$$\begin{aligned}
CAR_{i,q} = & \beta_0 + \beta_1 Difficult_{i,q-1} \\
& + \beta_2 Shorted_{i,q-1} + \beta_3 SS.Vol_{i,q} \\
& + \beta_4 \ln(BM)_i + \beta_5 \ln(Size)_i \\
& + \beta_6 Vol_{i,q-1} + \beta_7 Turn_{i,q-1} \\
& + \beta_8 Mom_{i,q-1} + \beta_9 Vol_{IND_{i,q-1}} \\
& + \beta_{10} Turn_{IND_i}
\end{aligned} \quad (3)$$

$$Frac_{i,q} = \beta_0 + \beta_1 Difficult_{i,q-1}$$

$$\begin{aligned}
& + \beta_2 Shorted_{i,q-1} + \beta_3 SS.Vol_{i,q} \\
& + \beta_4 \ln(BM)_i + \beta_5 \ln(Size)_i \\
& + \beta_6 Vol_{i,q-1} + \beta_7 Turn_{i,q-1} \\
& + \beta_8 Mom_{i,q-1} + \beta_9 Vol_{IND_{i,q-1}} \\
& + \beta_{10} Turn_{IND}
\end{aligned} \quad (4)$$

$$\begin{aligned}
CARs \in & \{CAR_{[0,19]}, CAR_{[1,19]}, CAR_{[0,0]}\} \\
Frac_s \in & \{Frac_1, Frac_3, Frac_5, Frac_{10}\}
\end{aligned}$$

If the more severe underpricing phenomenon

Table 5. The relationship between the positive PEAD and industry's short-ability (Regression analysis)

The table presents the results of regression analysis of the relationship between the positive PEAD and its industry's short-ability. Dependent variables are *CARs* and *Frac_s*. *Difficult* is a dummy variable that equals to one if the stock belongs to a DTS industry in the quarter *q-1*, and zero otherwise. *Shorted* is a dummy variable that equals to one if the stocks itself have nonzero shorting volume during the quarter *q-1*, and zero otherwise. *SS.Vol* is shorted volume to total trading volume ratio during each period corresponding with the dependent variables (*CAR*_[0,19], *CAR*_[0,0], *CAR*_[1,19], and *Frac_s*). *ln(BM)* and *ln(Size)* are the log book-to-market ratio and the log market capitalization at the end of previous year, respectively. *Vol* is the stock return volatility defined as the standard deviation of daily returns and *Turn* is the turnover defined as the daily average trading volume divided by the outstanding shares. *Mom* is the lagged returns adjusted by the market portfolio returns. *Vol_{ind}* and *Turn_{ind}* are measured as the average *Vol* and *Turn* across all stocks in a given industry, respectively. The *, **, and *** denote the statistical significance at 10%, 5% and 1% levels, respectively.

Panel A. The magnitude of PEAD (*CARs*)

Variables	<i>CAR</i> _[0,19]			<i>CAR</i> _[1,19]			<i>CAR</i> _[0,0]		
	Coef	<i>t</i> -stat		Coef	<i>t</i> -stat		Coef	<i>t</i> -stat	
<i>Intercept</i>	4.28	2.52	**	3.10	1.82	*	6.65	3.99	***
<i>Difficult</i>	0.35	2.11	**	0.32	1.94	*	0.14	0.85	
<i>Shorted</i>	-0.40	-1.65	*	-0.37	-1.52		-0.29	-1.18	
<i>SS.Vol</i>	-2.85	-0.78		-3.91	-1.10		-3.23	-1.23	
<i>ln(BM)</i>	-0.07	-0.57		-0.16	-1.37		0.05	0.39	
<i>ln(Size)</i>	0.04	0.62		0.08	1.23		-0.06	-0.98	
<i>Vol</i>	-4.81	-4.00	***	-3.93	-3.26	***	-2.34	-1.92	*
<i>Turn</i>	1.33	1.79	*	1.61	2.16	**	0.06	0.08	
<i>Mom</i>	0.27	0.70		-0.08	-0.21		0.44	1.16	
<i>Vol_{ind}</i>	2.38	1.11		1.89	0.88		0.86	0.40	
<i>Turn_{ind}</i>	-1.39	-0.73		-0.67	-0.35		0.80	0.41	
<i>Obs.</i>	1303			1303			1303		
<i>Fvalue</i>	3.39 ***			2.81 ***			2.39 **		
<i>Adj.R²</i>	0.025			0.021			0.011		

Panel B. The persistency of PEAD (*Frac_s*)

Variables	<i>Frac</i> ₁			<i>Frac</i> ₃			<i>Frac</i> ₅			<i>Frac</i> ₁₀		
	Coef	<i>t</i> -stat		Coef	<i>t</i> -stat		Coef	<i>t</i> -stat		Coef	<i>t</i> -stat	
<i>Intercept</i>	0.54	2.32	**	0.89	3.81	***	0.64	2.75	***	0.69	2.89	***
<i>Difficult</i>	-0.02	-1.02		-0.04	-1.73	*	-0.04	-1.56	*	-0.04	-1.84	*
<i>Shorted</i>	-0.02	-0.52		0.02	0.63		0.01	0.22		-0.03	-0.98	
<i>SS.Vol</i> _[0,n]	0.26	0.68		0.78	2.00	**	0.39	0.93		0.51	1.07	
<i>ln(BM)</i>	0.01	0.49		0.02	0.92		-0.02	-1.17		0.01	0.26	
<i>ln(Size)</i>	0.00	-0.20		-0.02	-1.87	*	-0.01	-0.74		-0.01	-0.61	
<i>Vol</i>	-0.14	-0.82		-0.05	-0.27		0.08	0.45		-0.23	-1.38	
<i>Turn</i>	0.01	0.09		0.00	-0.03		0.04	0.46		0.09	0.94	
<i>Mom</i>	0.18	3.25	***	0.06	1.11		-0.02	-0.37		0.03	0.60	
<i>Vol_{ind}</i>	0.45	1.53		0.41	1.37		0.32	1.10		0.47	1.57	
<i>Turn_{ind}</i>	-0.12	-0.42		0.04	0.13		-0.08	-0.30		-0.15	-0.55	
<i>Obs.</i>	698			698			698			698		
<i>Fvalue(Pr>F)</i>	1.79 **			1.73 *			0.96			1.76 **		
<i>Adj.R²</i>	0.020			0.020			0.014			0.011		

emerges in a DTS than in an ETS industry, then β_1 in equation (3) should be positive. If the underpricing is more persistent in a DTS industry than in an ETS industry, then β_1 in equation (4) should be significantly negative. As expected, there is a strong positive relationship between $CAR_{[0,19]}$ and *Difficult*, as shown in Panel A of Table 5. When using $CAR_{[1,19]}$ instead of $CAR_{[0,19]}$ as the dependent variable, the positive relation is maintained. However, when using $CAR_{[0,0]}$ as dependent variable, *Difficult* does not have a meaningful coefficient any longer. This result strongly supports our hypothesis that the positive earnings stocks in a DTS industry experience a greater delayed price response than those in an ETS industry. When using *FracS* as dependent variables (Panel B), *Difficult* exhibit significantly negative coefficients. The results suggest that positive PEADs of stocks in a DTS industry tend to be resolved more slowly than those in an ETS industry. The coefficients of *Shorted* and *SS.Vol* are mostly insignificant, implying that the stocks' own short-ability and the price pressure of shorting activity do not influence the positive PEAD phenomenon.

We performed some robustness tests¹⁵).

First, we investigated whether the relationship between the positive PEAD and its industry's short-ability is monotonic. According to our hypothesis, that is, as short selling becomes more restrictive, arbitrage activities could be more limited, causing the stock underpricing more severe. Thus, we should find a monotonic relationship between the positive PEAD and its industry's short-ability. We divide 15 industries into three, four, and five equally sized groups (rather than splitting into two) and examine the return movement around the earnings announcement for each group. In all of tercile, quartile, and quintile analyses, *CARs* monotonically increase and *FracS* monotonically decrease from the most easy-to-short (ETS) portfolio to the most difficult-to-short (DTS) portfolio, meaning that the more restrictive the short-sales, the higher the *CARs* and the smaller the *FracS*.

Second, we examined the robustness of our results to a different measure of the industry's short-ability. For each industry, we calculate the *shorting volume ratio*, which is the weighted average of each stock's shorting volume relative to its total trading volume. We classified sample stocks into DTS and ETS industries based on their industry's *shorting volume ratio* and then compare the return movements around the earnings announcements. The results are very similar to the above.

Third, we check the possibility that the difference observed in the positive PEAD phenomenon between two groups results from the sample stocks having no short-selling activities. In order to eliminate this possibility, we exclude the stocks with zero short volumes during 20 days after earnings announcement day from our sample and perform the above regression. The signs of the main coefficients are the same as those shown in Table 5, suggesting that our results are not driven by stocks with zero short volumes. We check the possibility that our results are derived from some industries which have the small samples. According to Table 2, the industries with small number of firms tend to exhibit the extreme short selling activities in both directions. Thus, we exclude the industries with the less than 10 firms from our sample and perform the same analysis. The results are very similar.

4.2. Some discussions

In general, stocks with illiquidity and information inefficiency tend to revert back to their fundamental values more slowly. Since the stocks in the DTS industry would be smaller, and less liquid, as shown in Table 3, it is possible that the severe underpricing in a DTS industry comes from their illiquidity or information inefficiency, not from short-sales constraints. Thus, we further investigate whether the observed underpricing in a DTS industry is associated with short-sale constraint, not with their illiquidity or information inefficiency.

We examine whether the above relationship between

15) The results of these robustness tests are available on request.

Table 6. The relationship between the positive PEAD and industry’s short-ability after controlling for liquidity and information efficiency

This table presents the relationship between the positive PEAD and its industry’s short-ability after controlling for their liquidity and information efficiency. We categorize sample stocks into three groups (low, medium, and high) based on Amihud measure, size, and volatility for each quarter. And then we calculate the excess returns of an ETS over a DTS portfolio and the difference of $Frac_{10}$ between ETS and DTS portfolios for each of nine groups. We calculate the daily Amihud measure as an absolute daily return scaled by the daily trading volume and average this daily measure to the quarterly frequency. Size is a quarterly market capitalization, and volatility is a standard deviation of daily returns on a quarterly basis. The *, **, and *** denote the statistical significance at 10%, 5% and 1% levels, respectively.

Variable	Low		Medium		High	
Amihud measure						
$CAR_{[0,19]}(ETS - DTS)$	-0.0287	**	-0.0086		-0.0167	*
$CAR_{[1,19]}(ETS - DTS)$	-0.0195	*	-0.0093		-0.0157	*
$CAR_{[0,0]}(ETS - DTS)$	-0.0081	**	0.0012		-0.0018	
$Frac_{10}(ETS - DTS)$	0.0043		0.7507		1.3594	**
Size						
$CAR_{[0,19]}(ETS - DTS)$	-0.0172	*	-0.0140		-0.0384	***
$CAR_{[1,19]}(ETS - DTS)$	-0.0082	*	-0.0092		-0.0363	***
$CAR_{[0,0]}(ETS - DTS)$	-0.0084	**	-0.0037		-0.0013	
$Frac_{10}(ETS - DTS)$	0.5325	*	-0.0291		0.6664	*
Volatility						
$CAR_{[0,19]}(ETS - DTS)$	-0.0057		-0.0358	***	-0.0121	*
$CAR_{[1,19]}(ETS - DTS)$	-0.0071		-0.0305	***	-0.0076	*
$CAR_{[0,0]}(ETS - DTS)$	0.0014		-0.0044		-0.0050	
$Frac_{10}(ETS - DTS)$	0.8153		0.1299		1.1198	*

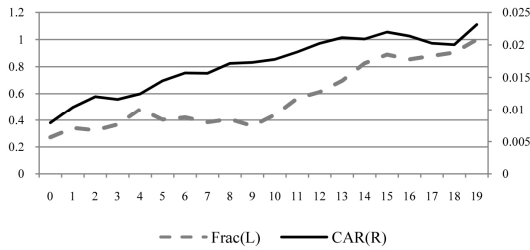
the positive PEAD and industry’s short-ability would be maintained after controlling for liquidity and information efficiency. We use an Amihud measure as a liquidity proxy, a size as an information efficiency proxy, a volatility as a composite measure that reflects both liquidity and information efficiency. We categorize sample stocks into three groups (low, medium, and high) based on Amihud measure, size, and volatility for each quarter. And then we calculate the average excess returns of an ETS portfolio over a DTS portfolio and the average difference of $Frac_{10}$ between DTS and ETS portfolios for each of nine groups. As Table 6 shows, $CAR_{[0,19]}$ and $CAR_{[1,19]}$ of a DTS portfolio are greater than those of an ETS portfolio in all nine subgroups. $Frac_{10}$ is higher for an ETS portfolio than for a DTS portfolio in eight subgroups. It means that the relationship between

the positive PEAD and short-ability of the industry is maintained after controlling for liquidity and information efficiency.

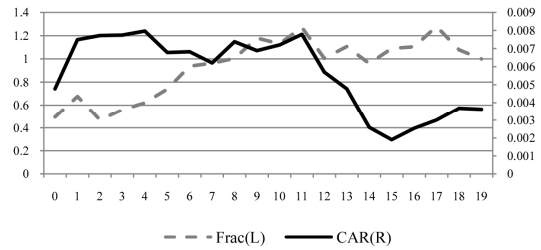
We also check this issue by using the negative earnings sample. If the larger underpricing in a DTS industry comes from their illiquidity and information inefficiency, then we should find a more sluggish stock price correction for negative earnings stocks (overpriced stocks) in a DTS industry. In other words, for negative earnings sample, we should observe the lower average $CAR_{[0,19]}$ and $Frac_n$ in a DTS industry than in an ETS industry. However, as reported in Table 4, for negative earnings stocks, there are no differences between the two groups in CAR and $Frac_s$, suggesting that there is no greater negative PEAD in a DTS industry than in an ETS industry¹⁶). Therefore,

16) We run the same multiple regressions using the negative

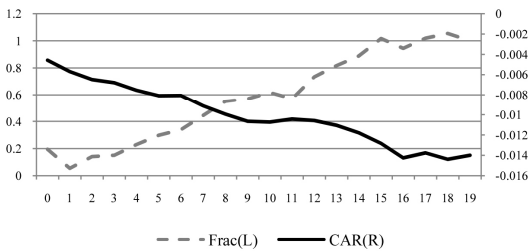
Panel A. Positive earnings stocks in the DTS industry



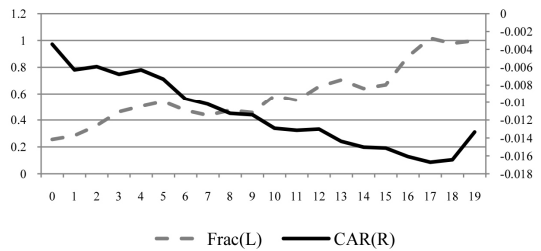
Panel B. Positive earnings stocks in the ETS industry



Panel C. Negative earnings stocks in the DTS industry



Panel D. Negative earnings stocks in the ETS industry



The figure presents *CARs* around the earnings announcement day of DTS and ETS industries. Panels A and B shows *CARs* following the earnings day of the positive earnings stocks in two groups. Panels C and D presents *CARs* following the earnings day of the negative earnings stocks in two groups. The definitions of variables are the same as Table 4.

Figure 1. *CARs* around the earnings announcement day of DTS and ETS industries

the illiquidity and information inefficiency story are not supported in this study.

Figure 1, which presents *CARs* around the earnings announcement day, shows the similar patterns. For the positive earnings stocks (Panels A-B), the average *CAR* in a DTS industry increase gradually after earnings day, the average $CAR_{[0,19]}$ reaching 2.31%, whereas the average *CAR* in an ETS industry moves at random during the same period, the average $CAR_{[0,19]}$ reaching 0.36%. The *Frac* in a DTS industry gradually increases and reaches 1 at 20 trading days, whereas the *Frac* in an ETS industry reaches 1 at 12 trading days. However, for the negative earnings stocks (Panels C-D), we cannot find any different patterns between the two groups. It means that there exist the greater positive PEAD but do not exist the greater negative PEAD in a DTS industry, compared in an

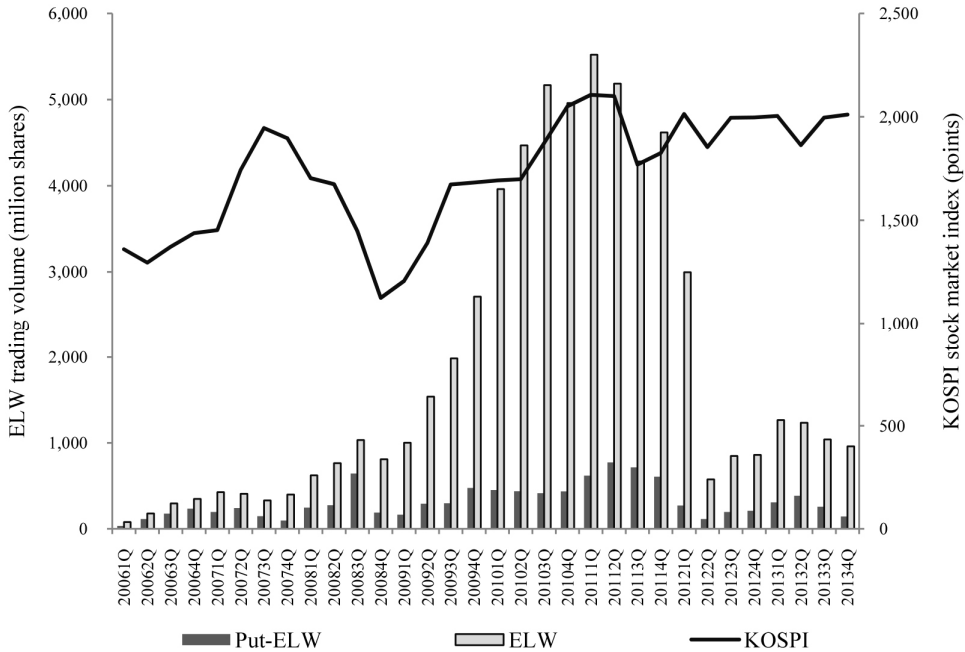
ETS industry. The evidence confirms that the observed underpricing in a DTS industry is associated with the short-sale constraint, not with their illiquidity or informational inefficiency.

4.3. The impact of the ELW on the relation between the positive PEAD and the industry's short-ability

The short position can be synthesized by using the ELWs.¹⁷⁾ For example, the aforementioned industry long-short arbitrage strategy is performed by buying the underpriced stocks and buying the put-ELWs of the relatively overpriced stocks belonging to the same industry. Based on these characteristics of the ELW, we investigate whether the inverse relation between the positive PEAD and its industry's

earnings sample. *Difficult* has no significant relations with both *CARs* and *Frac*s for negative earnings stocks. It means that the negative PEAD in a DTS industry is not larger and more persistent than those in an ETS industry, unlike positive PEAD.

17) Since the availability of the put options for individual stocks are very low in the Korean stock market, we perform the analysis by using the put ELWs.



The figure shows the time-series relationship among daily average put-ELW trading volume, all ELW trading volume and KOSPI stock market index for each quarter from January, 2006 to December, 2013.

Figure 2. ELW trading volume and KOSPI stock market index

short-ability varies depending on ELW trading volume. During the inactive ELW trade period, the short-sale is the only available means to arbitrageurs, so the short constraints in a DTS industry strongly suppress the arbitrage activities, thereby intensifying the positive PEAD. Thus, the difference of the positive PEAD between DTS and ETS industries may be larger in this period. However, during the active ELW period, the arbitrageur can freely use put-ELWs instead of actual short-sales, so the positive PEAD in a DTS industry becomes weaker. Thus, the difference of the positive PEAD between two industry groups may be smaller in this period.

According to Figure 2, the trading volumes of the ELW (excluding ELW of which underlying asset is KOSPI200 index) fluctuated violently between 2006 and 2013. The average daily trading volume was 13 million contracts in January 2005 when the ELW market newly opened, and then increased sharply, reaching to 5.17 billion contracts in September 2010. However, the persistent unfair market practices,

such as large losses of individual investors, lawsuits against the scalper, and the large unfair spread offered by liquidity providers caused the South Korean financial authority to enact several regulations, which in turn significantly reduced the ELW trading volumes. After April 2012, the daily trading volume dropped to 1 billion contracts, recording an 80% decrease from the same period the year before¹⁸⁾. We find similar patterns in the put-ELWs.

We divide the entire sample quarters into three groups (active, normal, and inactive ELW trade periods) based on the daily average ELW trading volume, and examine in which group the inverse relation between the positive PEAD and its industry's short-ability is stronger. We run multiple regressions by using the interaction variables between Difficult and ELW trading activeness (*Difficult xInactive* and *Difficult xActive*) as the main explanatory variables. *Difficult* is one if the stock belongs to a DTS industry,

18) Capital market weekly, No 44, 2012

and zero otherwise. *Inactive* (*Active*) is one if the quarter is inactive (active) ELW trade period, and zero otherwise. The definitions of dependent variables and other control variables are the same as Table 5. The regression models are as follows.

$$\begin{aligned}
 CARs_{i,q} = & \beta_0 + \beta_1 Difficult_{1,q-1} + \beta_2 Inactive_q \\
 & + \beta_3 (Difficult_{1,q-1} \times Inactive_q) \\
 & + \beta_4 Active_q \\
 & + \beta_5 (Difficult_{i,q-1} \times Active_q) \\
 & + \beta_6 \times Controls_{i,q} + \epsilon_{i,q} \quad (5) \\
 Fracs_{i,q} = & \beta_0 + \beta_1 Difficult_{1,q-1} + \beta_2 Inactive_q
 \end{aligned}$$

$$\begin{aligned}
 & + \beta_3 (Difficult_{1,q-1} \times Inactive_q) \\
 & + \beta_4 Active_q \\
 & + \beta_5 (Difficult_{i,q-1} \times Active_q) \\
 & + \beta_6 \times Controls_{i,q} + \epsilon_{i,q} \quad (6) \\
 CARs \in & \{CAR_{[0,19]}, CAR_{[1,19]}, CAR_{[0,0]}\} \\
 Fracs \in & \{Frac_1, Frac_3, Frac_5, Frac_{10}\}
 \end{aligned}$$

If short-selling mitigates the underpricing anomaly in the positive earnings samples, then β_1 has a positive value in equation (5) and a negative value in equation (6). Furthermore, if this effect is strong for the inactive ELW period, then β_3 s have the same signs with β_1 s

Table 7. The impact of the ELW trading on the relation between the positive PEAD and industry’s short-ability

We divide the entire sample periods into three groups; active, normal, and inactive ELW trade periods and examine in which period the inverse relation between the positive PEAD and its industry’s short-ability is stronger. We calculate the daily average ELW trading volume for each quarter, by using trading data of individual ELWs (except index ELWs). If the quarter belongs to the bottom (upper) 30% based on the daily average ELW trading volume, we define it as inactive (active) ELW trade period. We run multiple regressions where dependent variables are *CARs* and *Frac*s, controlling for a variety of firm characteristics. The main explanatory variables are the interaction variables created by multiplying *Difficult*_{*i,q*} with *Inactive*_{*q*} and *Active*_{*q*}, respectively. (*Difficult x Inactive*, and *Difficult x Active*) *Difficult* is one if the stock belongs to a DTS industry and zero otherwise. *Inactive* (*Active*) is one if the quarter is inactive (active) ELW trade period and zero otherwise. The definitions of dependent variables and other control variables are the same as Table 5. The *, **, and *** denote the statistically significance at 10%, 5% and 1% levels, respectively.

Panel A. The magnitude of PEAD (*CARs*)

Variables	<i>CAR</i> _[0,19]		<i>CAR</i> _[1,19]		<i>CAR</i> _[0,0]		
	Coef	<i>t</i> -stat	Coef	<i>t</i> -stat	Coef	<i>t</i> -stat	
Intercept	2.56	1.51	1.62	0.96	5.86	3.52	***
<i>Difficult</i>	0.60	1.88	* 0.56	1.75	0.10	0.31	
<i>Inactive</i>	-0.24	-0.67	-0.15	-0.42	-0.34	-0.95	
<i>Difficult x Inactive</i>	0.16	0.38	0.06	0.15	0.34	0.79	
<i>Active</i>	0.40	1.29	0.31	0.99	0.13	0.42	
<i>Difficult x Active</i>	-0.70	-1.70	* -0.61	-1.57	-0.13	-0.30	
<i>Shorted</i>	-0.41	-1.63	* -0.36	-1.46	-0.31	-1.24	
<i>SS.Vol</i>	-4.37	-1.18	-4.99	-1.38	-3.95	-1.48	
<i>ln(BM)</i>	-0.16	-1.31	-0.25	-2.03	** 0.01	0.08	
<i>ln(Size)</i>	0.10	1.53	0.13	2.01	** -0.03	-0.53	
<i>Vol</i>	0.00	0.99	0.00	1.19	0.00	0.97	
<i>Turn</i>	-0.13	-0.19	0.44	0.68	-0.68	-1.04	
<i>Mom</i>	-0.12	-0.32	-0.41	-1.08	0.27	0.72	
<i>Vol_{ind}</i>	-2.07	-1.12	-1.73	-0.94	-1.02	-0.55	
<i>Turn_{ind}</i>	0.38	0.20	0.85	0.44	1.34	0.69	
<i>Obs.</i>		1299		1299		1299	
<i>Fvalue</i>		1.74 **		1.59 *		0.95	
<i>Adj.R²</i>		0.018		0.017		0.010	

Panel B. The persistency of PEAD (*Frac*s)

Variables	<i>Frac</i> ₁			<i>Frac</i> ₃			<i>Frac</i> ₅			<i>Frac</i> ₁₀		
	Coef	<i>t</i> -stat		Coef	<i>t</i> -stat		Coef	<i>t</i> -stat		Coef	<i>t</i> -stat	
Intercept	0.55	2.29	**	0.88	3.70	***	0.72	2.99	***	0.83	3.37	***
<i>Difficult</i>	-0.04	-1.18		-0.04	-1.67	*	-0.03	-1.04		-0.04	-1.24	
<i>Inactive</i>	0.04	0.71		0.10	1.76	*	0.08	1.53		0.06	1.00	
<i>Difficult x Inactive</i>	-0.04	-0.68		-0.11	-1.66	*	-0.10	-1.69	*	-0.07	-1.14	
<i>Active</i>	0.01	0.16		0.00	0.09		0.01	0.10		-0.02	-0.40	
<i>Difficult x Active</i>	-0.01	-0.11		0.01	0.21		0.00	0.06		0.05	0.74	
<i>Shorted</i>	-0.02	-0.51		0.01	0.40		0.00	-0.12		-0.04	-1.10	
<i>SS. Vol</i> _[0,n]	0.71	1.63	*	1.39	3.26	***	0.83	1.67	*	0.56	1.04	
<i>ln(BM)</i>	0.00	-0.15		0.01	0.60		-0.01	-0.45		0.02	1.29	
<i>ln(Size)</i>	0.00	-0.14		-0.02	-1.80	*	-0.01	-1.02		-0.01	-1.13	
<i>Vol</i>	0.00	1.22		0.00	0.39		0.00	0.21		0.00	0.44	
<i>Turn</i>	-0.08	-0.81		-0.09	-0.90		-0.06	-0.57		-0.02	-0.20	
<i>Mom</i>	0.15	2.57	***	0.06	1.06		0.02	0.40		0.04	0.64	
<i>Vol_{ind}</i>	0.33	1.19		0.37	1.36		0.44	1.58		0.23	0.83	
<i>Turn_{ind}</i>	-0.30	-1.03		-0.04	-0.15		-0.25	-0.85		-0.08	-0.28	
<i>Obs.</i>	621			621			621			606		
<i>Fvalue</i>	1.53 *			1.68 **			1.86 **			0.72		
<i>Adj. R²</i>	0.026			0.036			0.019			0.016		

in both equations, however, if the effect becomes weak for the active ELW period, then β_5 s have the opposite signs with β_1 s.

According to Panel A of Table 7, the coefficient of *difficult* is positive and that of *Difficult x Active* is negative when using $CAR_{[0,19]}$ and $CAR_{[1, 19]}$ as dependent variables. Both coefficients are statistically significant. It means that during the active ELW trade period, the difference in the magnitude of PEAD between two groups gets blurred, compared with the other two periods. The coefficient of *difficult* and *Difficult x Inactive* is significantly negative when using $Frac_3$ and $Frac_5$ as dependent variables, as shown in Panel B. During the inactive ELW trade period, the difference in the speed of alleviation of the underpricing between the two groups tends to be more prominent.

In sum, there exists the inverse relation between the positive PEAD and its industry's short-ability; and this relation become stronger during the inactive

ELW trade period and weaker during the active ELW trade period. The results are consistent with our hypothesis, that is, since the arbitrageur can freely use put-ELWs instead of actual short-sales during the active ELW trade period, the difference of the positive PEAD between the two groups would be small; however, since the arbitrageur cannot use put-ELWs as substitutes of short sales during the inactive ELW trade periods, the difference of the positive PEAD between the two groups would be large. It is the indirect evidence supporting that short-selling alleviates the underpricing by facilitating arbitrage activities (not by the other channels); it also implies that the ELWs act as alternatives for short trades when short-selling is constrained.¹⁹⁾

19) We repeat the above analysis by using the put-ELW trading volume to focus on the impact of the put-ELW, which is the direct substitution of short-sales. The results are very similar to Table 7.

5. Conclusion

We examine whether short-selling facilitates the arbitrage activities and alleviates the stock underpricing by using the positive PEAD as the natural experiment. If the industry has a large pool of stocks available to short-selling and there is no limit to arbitrage, then the underpriced stocks can return to its fundamental value in a very short time owing to the aggressive arbitrage. However, if short-selling activity of the industry is constrained for some reason, stocks in that industry cannot revert back to fundamental value because the difficult hedging via the substitute stocks prevents arbitrageurs from trading aggressively.

Using the quarterly earnings announcement of KOSPI200 composite stocks between January 2006 and December 2013, we find that positive earnings stocks in a DTS industry suffer the larger and more persistent delayed price response than those in an ETS industry. The inverse relationship between the positive PEAD and its industry's short-ability is maintained after controlling liquidity and information asymmetry. Interestingly, this relation is stronger during the inactive ELW trade period, whereas it is weaker during the active ELW trade period.

This result presents that short-selling alleviates the underpricing by facilitating the arbitrage activities and the ELWs play important role as a hedging instrument to replace short selling. Our findings suggest the important insight to the policy makers who formulate and implement the regulations related to short selling and ELW. Since short-selling help not only the overpriced stocks but also the underpriced stocks revert back to its fundamental value, the restrictions on short selling can severely weakens the price discovery function of the stock market. Similarly, since ELWs are actively used as hedging instruments, the excessive regulation restricting ELW trading could hamper hedge and arbitrage activity as well as speculative activity.

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