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AUTHORS	Feng-Yu Lin Cheng-Yi Chien Day-Yang Liu Yen-Sheng Huang

ARTICLE INFO	Feng-Yu Lin, Cheng-Yi Chien, Day-Yang Liu and Yen-Sheng Huang (2010). Short sales constraints and stock price behavior: evidence from the Taiwan Stock Exchange. *Investment Management and Financial Innovations*, *7*(2)
RELEASED ON	Friday, 23 April 2010
JOURNAL	"Investment Management and Financial Innovations"
FOUNDER	LLC “Consulting Publishing Company “Business Perspectives”

Feng-Yu Lin (Taiwan), Cheng-Yi Chien (Taiwan), Day-Yang Liu (Taiwan), Yen-Sheng Huang (Taiwan)

Short sales constraints and stock price behavior: evidence from the Taiwan Stock Exchange

Abstract

This paper examines the impact of short sales constraints on stock price behavior using data from the Taiwan Stock Exchange. The data involves 33 constituent stocks of the Taiwan 50 index fund over the 480 days in both the pre- and post-period surrounding the lift of the uptick rule effectively on May 16, 2005. The results indicate that the R^2 estimated from the market model is significantly higher in the pre-period than that in the post-period. Similarly, the cross-autocorrelation between the individual stock returns and the lagged market returns is significantly higher in the pre-period than that in the post-period. The results are consistent with the delayed price discovery hypothesis in that short sales constraints delay the incorporation of information into securities prices.

Moreover, there is no significant difference in the 3-day cumulative abnormal returns between the pre- and the post-period following large price declines. The results do not support the overvaluation hypothesis which predicts a significant overvaluation in the pre-period when the uptick rule is imposed. However, the empirical results indicate a significantly negative overnight abnormal return following the large price decline in the pre-period than that in the post-period, followed by a significantly positive trading-time abnormal return in the pre-period than that in the post-period. The results are consistent with the hypothesis that investors overreact to bad news in the presence of short sales constraints, followed by a price reversal in the subsequent trading-time period.

Keywords: short sales constraints, price discovery, overvaluation.
JEL Classification: G14, G15, G18.

Introduction

Short sales refer to the situation where investors borrow securities and sell them in the stock market. Short sellers hope that securities prices will drop so that they can benefit from buying back the borrowed securities at a lower price. If the securities prices go down as expected, short sellers reap a profit when they repay their borrowed securities. In a downward market, however, short sellers are criticized for exacerbating the market decline as well as causing market panics. Short sellers are also blamed for manipulating securities prices especially for smaller and illiquid stocks.

In response to these criticisms, regulators may restrict the practice of short sales. For example, short sales may be allowed only to a smaller subset of listed securities, typically larger and more liquid securities. Alternatively, regulators may impose an up-tick rule that allows the practice of short sales only in an upward market. The rational of restricting short sales to larger and more liquid securities is that these securities are less vulnerable to potential abuse of price manipulation. Similarly, the rational of restricting short sales in an upward market is that it avoids the additional selling pressure from short sellers in a downward market, which is considered a crucial factor that might exacerbate market panics during market decline.

However, the effectiveness of short sales constraints has been questioned since the imposition of short sales constraints is not without costs. One major concern is that short sales constraints might affect the efficiency of price discovery in securities markets. Diamond and Verrecchia (1987), among others, argue that the imposition of short sales constraints could reduce the information efficiency of price discovery in securities markets. Moreover, Miller (1977) argues that the imposition of short sales constraints results in overvaluation of securities prices. He hypothesizes that, in a market with diverse opinions among investors, the observed stock price will be biased toward the opinion of more optimistic investors in the presence of short sales constraints.

Empirical evidence on the price impact of short sales constraints is mixed, caused in part by both the cross-sectional variation among different stock exchanges as well as potential time-series confounding factors. For example, market structures vary widely among stock exchanges in the world. As such, empirical evidence drawn from different stock exchanges may be confounded by both the impact of short sales constraints as well as the unique market mechanisms. Moreover, regulation regarding short sales does not change frequently. As a result, empirical research that examines the impact of short sales using time-series data tends to be restricted by the limited number of independent sample observations.

Like many other stock exchanges in the world, the Taiwan Stock Exchange imposes short sales constraints. First, the Taiwan Stock Exchange requires that listed stocks must meet certain conditions in order to qualify for short sales. Among these conditions is the requirement that the firm must experience no cumulative net loss so that the total stockholder equity must not be lower than the par value of the stock. Moreover, prior to May 16, 2005, the Taiwan Stock Exchange imposes an uptick rule that allows short sales only at prices that are at least as high as the closing price in the previous trading day for all stocks eligible for short sales.

Effectively on May 16, 2005, the Taiwan Stock Exchange relaxes the uptick constraint by allowing short sales for a selected subset of listed stocks at prices lower than the closing price in the previous trading day. These selected stocks belong to the constituent stocks of the Taiwan 50 Exchange Traded Fund (ETF). The Taiwan 50 ETF is an index fund consisted of the 50 largest and actively traded stocks on the Taiwan Stock exchange. The index fund aims to trace the movement of the Taiwan Weighted Market Index, which is the most frequently cited market index in the Taiwan stock market. The rational for choosing these Taiwan 50 ETF constituent stocks is that these stocks are considered less vulnerable to potential abuse of price manipulation by short sellers.

The purpose of this paper is to examine the impact of short sales constraints on price behavior using data from the Taiwan Stock Exchange. Specifically, we examine the price behavior for the constituent stocks of the Taiwan 50 ETF in the pre- and post-period of the relaxation of the uptick regulation effectively on May 16, 2006. Two hypotheses are examined. The delayed price discovery hypothesis suggests that short sales constraints hinder the efficiency of price discovery (e.g., Diamond and Verrecchia, 1987). In addition, the overvaluation hypothesis suggests that short sales constraints are associated with overvaluation of stock prices (e.g., Miller, 1977).

The uptick rule in many other stock exchanges require short sales prices not lower than the most recent transaction price or the best current ask price (e.g., the U.S. stock markets). In contrast, the uptick rule imposed on the Taiwan Stock Exchange requires short sales prices not lower than the closing prices in the previous trading day. Empirical results from the Taiwan stock market provides further evidence regarding the validity of the above hypotheses regarding the impact of short-sales constraints.

Our empirical results indicate that short sales constraints delay the price discovery. The R^2 of the market model is significantly higher in the pre-period than that in the post-period. Further, the cross-autocorrelation between individual stock returns and lagged market returns is significantly higher in the pre-period than that in the post-period. However, the empirical results do not support the overvaluation hypothesis. There is no significant difference between the pre- and the post-period for the 3-day cumulative abnormal returns following large price decline. Instead, the results indicate an intraday overreaction in the pre-period relative to that in the post-period. When the day 1 abnormal returns are broken down into overnight and trading-time components, the results indicate an overreaction in the day 1 overnight period and a subsequent price reversal in the pre-period as compared to the post-period.

This paper contributes to the existing literature by examining the impact of short sales constraints on stock price behavior from the Taiwan Stock Exchange. We examine the stock price behavior for the constituent stocks of the Taiwan 50 ETF before and after the relaxation of the short sales constraints effectively on May 16, 2006. Previous studies focus mainly on stock exchanges such as the United States stock markets. Evidence from the Taiwan stock market could provide further insight into the effect of short sales constraints. Consistent with the previous research, our empirical results indicate that price discovery efficiency improves following the relaxation of short sales constraints. However, unlike previous studies, our results do not support the overvaluation hypothesis. There is no significant difference between the pre- and the post-period for the 3-day cumulative abnormal returns following a large price decline. This result indicates that stock prices need not be biased upward if short sales constraints are imposed. This may tend to be true if the stocks are traded heavily. Finally, our results indicate an intraday overreaction under the short sales constraints. Thus, stock prices may be more volatile under short sales constraints especially when the short sales constraints are binding.

The remainder of this paper is as follows. Section 1 provides literature review of previous research. Section 3 introduces the institutional background of the short sales constraints imposed on the Taiwan Stock Exchange and the hypotheses to be tested in this paper. Section 3 describes the data and methodology. Section 4 reports empirical results. The last Section concludes.

1. Literature review

One important issue regarding the impact of short sales constraints on price behavior is whether short sales constraints affect the efficiency of price discovery. Diamond and Verrecchia (1987) explore the effect of short sales constraints on the speed of price adjustment to private information. They propose that the price of a stock constrained by short sales adjusts more slowly to unfavorable private information than it does to favorable private information. That is, short sales constraints tend to delay the price discovery of negative private information.

Bris et al. (2007) examine the impact of short sales constraints on the price discovery efficiency using cross-sectional and time-series data from 46 equity markets around the world. They find that stock prices incorporate negative information more quickly in countries where short sales are allowed and practiced. Their empirical evidence is consistent with the delayed price discovery hypothesis in Diamond and Verrecchia (1987) which suggests a negative association between short sales restrictions and the incorporation of negative prices into prices.

Moreover, Bris et al. (2007) document evidence that short sales constraints are associated with less skewness in market returns. However, they note that although market returns are more negatively skewed in markets that permit short sales, negative extreme returns do not become more frequent. That is, short sales are associated with more negative returns, but not necessarily more frequent negative extreme returns. This evidence is consistent with the explanation that short sales may affect the skewness of market returns, but need not cause a market crash.

Another important issue is whether short sales constraints lead to overvaluation of securities prices. Miller (1977) proposes that short sales constraints have asymmetric impacts on investors with favorable and unfavorable information. He hypothesizes that when investors hold different views regarding the value of securities, the restriction of short sales results in overvaluation of security prices. The security prices tend to reflect more of the optimistic information than that of the pessimistic information when short sales are either prohibited or costly. Under this situation, the observed security prices will be upward biased if short sales are not allowed or very costly to practice. Moreover, the higher the degree of heterogeneous beliefs among investors, the larger the upward bias for the security valuation when short sales are constrained. Similarly, Figlewski (1981), Chen et al. (2002), among others, also document that short sales constraints are associated with overvaluation of security prices and lower future returns.

The systematic overvaluation of security prices, however, is inconsistent with the existence of rational investors who should eventually incorporate this market imperfection into consideration. Diamond and Verrecchia (1987) argue that, in an efficient market where security prices reflect all available information, investors will recognize this potential bias caused by short sales constraints. To correct the bias, investors may infer the unbiased valuation of securities through Bayesian estimation of securities value when the securities are subject to short sales constraints. With this Bayesian estimation, the potential upward bias caused by short sales constraints can be corrected. Thus, in a rational expectation framework, investors can adjust the potential bias caused by short sales constraints so that the eventual security prices represent an unbiased expectation of all available information.

Chang et al. (2007) examine the impact of short sales practices on stock valuation using data from the Hong Kong stock market. The Hong Kong Stock Exchange maintains a list of designated securities eligible for short sales. The empirical results indicate that the cumulative abnormal returns are significantly negative for securities made eligible for short selling over the window following the eligibility of short sales. The results are consistent with the overvaluation hypothesis in Miller (1977) with the presence of short sales constraints. Moreover, they document that the overvaluation effect is more dramatic for stocks with wider dispersion of investor opinions.

Recently, Berkman et al. (2009a) have examined the impact of differences of opinions on stock price behavior. Using five proxies for the difference of opinions, they examine price behavior over the 3-day window surrounding earnings announcements. They report that a narrower difference of opinions reduces the upward bias in stock prices. Similarly, Berkman et al. (2009b) examine the impact of dispersion of opinions on stock prices. They investigate intraday data for 3000 largest U.S. stocks over the period of 1996-2004. They document that the greater the dispersion of opinions near the open, the larger the magnitude of the positive overnight returns and trading day reversals. Zheng (2009) also investigates the relationship between short sales and earnings announcements. Using intraday data for 1883 NYSE-listed stocks from January 2005 through May 2007, Zheng (2009) finds that short sales increase immediately following both negative and positive earnings surprises. Following positive earnings surprises, short selling reverses stock prices back to fundamentals, which helps improve market efficiency. In contrast, short selling does not contribute to market efficiency following negative earnings announcements.

Diether et al. (2009) examine the daily short-selling activity for all NYSE and Nasdaq listed stocks during 2005. They find that short sellers tend to trade on short-term overreaction of stock prices. In particular, short sellers increase their short selling activity following periods of positive returns. Their evidence supports the notion that short sellers help correct short-term overreaction of stock prices. Cai et al. (2009) investigate the efficiency of stock market following the removal of short sale constraints in the Hong Kong stock market. They document that liquidity of the underlying stocks worsens, information asymmetry aggravates, and intraday return volatility reduces when short sales are allowed. Cai et al. (2009) propose that the lower market efficiency following the removal of short sale constraints is contributed by the situation where noise traders withdraw from the market to avoid trading with informed traders.

2. Institutional background and hypotheses

2.1. Institutional background. The Taiwan Stock Exchange stipulates that listed stocks must meet certain requirements in order to qualify for short selling. Among the requirements is the condition that the net worth of stockholder equity must exceed the par value of stockholder equity. However, prior to the relaxation of the short sales constraints effectively on May 16, 2005, short sales are subject to an uptick rule that all short sales prices must be at least as high as the closing price in the previous trading day. For example, assume the closing price for a particular stock is NT$100 on day -1. Suppose some negative information arrives on day 0, which is to cause the stock price to close at NT$93 if there were no short sales constraints. With the presence of the short sales constraint, however, the stock price might close at NT$95 due to the inability of potential short sellers to short the stock at prices below NY$100. The potential short sellers would have to wait until day 1 to short the stocks at prices below NT$100. As a result, the short sales constraints delay the selling pressure by these potential short sellers from day 0 to day 1. If so, the observed day 0 closing price will be biased upward relative to the "true" value of NT$93.

In an attempt to improve the efficiency of price discovery, the Taiwan Stock Exchange relaxed the uptick rule for certain designated stocks effectively on May 16, 2005. Specifically, starting from May 16, 2005, the Taiwan Stock Exchange relaxed the uptick rule by allowing the constituent stocks of the Taiwan 50 ETF to short sell at prices below the closing prices in the previous trading day. The Taiwan 50 ETF is an index fund that traces the movement of the widely cited broad market index of the Taiwan Weighted Market Index compiled by the Taiwan Stock Exchange. Since the constituent stocks of the Taiwan 50 ETF are among the largest and most actively traded stocks listed on the Taiwan Stock Exchange, these stocks are considered less vulnerable to potential price manipulation by short sellers.

The relaxation of the uptick rule for the Taiwan 50 constituent stocks provides an opportunity to examine the impact of short sales constraints on stock price behavior. Since the constituent stocks of the Taiwan 50 ETF are among the largest stocks on the Taiwan Stock Exchange, they are eligible for short sales from the beginning. However, prior to the relaxation of the uptick rule, these Taiwan 50 ETF constituent stocks are not allowed for short sales at prices below the closing price in the previous trading day. Following the relaxation of the uptick rule, short sellers can short these stocks at prices below the closing price in the previous trading day. The purpose of this paper is, therefore, to examine the impact of the relaxation of the uptick rule on the price behavior of the Taiwan 50 ETF constituent stocks. Specifically, we examine the impact of short sales constraints by comparing the price behavior before and after the relaxation of the uptick rule for the constituent stocks of the Taiwan 50 ETF.

2.2. Hypotheses. Following previous research (e.g., Chang et al., 2007; Bris et al., 2007), we examine whether price discovery is more efficient and unbiased following the relaxation of the uptick rule using data from the Taiwan Stock Exchange. Following Diamond and Verrecchia (1987), we hypothesize that price discovery should be more efficient following the relaxation of the short sales constraints. Similarly, following Miller (1977), we hypothesize that stock prices will tend to be overvalued prior to the relaxation of the short sales constraints. Specifically, we summarize the hypotheses to be tested as follows.

Hypothesis 1 (the delayed price discovery hypothesis of short sales constraints): Diamond and Verrecchia (1987) propose that price discovery efficiency should be higher in the absence of short sales constraints. Thus, we hypothesize that price discovery efficiency should be higher for the Taiwan 50 ETF constituent stocks in the post-period following the relaxation of the uptick rule effectively on May 16, 2005.

Hypothesis 2 (the overvaluation hypothesis of short sales constraints): Miller (1977) proposes that stock prices tend to be overvalued with the presence of short sales constraints. Thus, we hypothesize that the prices of the Taiwan 50 ETF constituent stocks will tend to be overvalued in the pre-period prior to the relaxation of the uptick rule effectively on May 16, 2005. The overvaluation of stock prices results from the inability of short sellers to short stocks with negative information.

3. Data and methodology

3.1. Data. To examine the price impact of short sales constraints, the price behavior for the Taiwan 50 constituent stocks is examined in the pre- and post-period surrounding the relaxation of the uptick rule on May 16, 2005. Daily stock returns are collected for the Taiwan 50 ETF constituent stocks in both the pre- and post-period. Both the pre- and post-periods involve 480 trading days (roughly 2 years), respectively, surrounding the event day of May 16, 2005. Daily return data are obtained from the database of the Taiwan Economic Journal with the stock returns adjusted for cash dividends, stock dividends, and stock splits. The length of the pre- and post-period is selected to balance sample size and potential changing market conditions. To examine the robustness of the empirical results, the impact of short sales constraints is also examined for a shorter period of 240 trading days for both the pre- and post-period surrounding the event day.

The Taiwan 50 ETF is an index fund that traces the movement of the widely cited broad market index of the Taiwan Weighted Market Index compiled by the Taiwan Stock Exchange. The constituent stocks of the Taiwan 50 ETF are among the largest and most actively traded stocks listed on the Taiwan Stock Exchange. These constituent stocks are chosen from different industries which fairly represent the whole market. In the sample period, the market value of the constituent stocks of Taiwan 50 ETF accounts for about 70% of the market capitalization of the Taiwan Stock Exchange. The correlation between the Taiwan 50 ETF and the Taiwan Weighted Market Index is estimated to be approximately 98%. Thus, the price movements of the Taiwan 50 ETF highly resemble that of the Taiwan Weighted Market Index.

Since the constituent stocks of the Taiwan 50 index fund are revised every quarter, only a total of 33 stocks remain on the list throughout the sample period. Thus, we focus on the price behavior of these 33 stocks. The Taiwan 50 index fund selects the constituent stocks every quarter mainly on the basis of the market value. The Taiwan 50 index fund selects the constituent stocks every quarter mainly on the basis of the market value. The 33 stocks tend to be larger in terms of market value. Moreover, the market value of these 33 stocks remains fairly stable throughout the sample period. A comparison of the price behavior for these firms in the pre- and post-period would be less affected by the changing market value in the sample period.

3.2. Methodology. *3.2.1. The efficiency of price discovery.* Following Bris et al. (2007), we test the delayed price discovery hypothesis by comparing R^2 and the cross-autocorrelation coefficients in the pre- and post-period:

- **R^2.** Mørck et al. (2000), Bris et al. (2007) suggest that less firm-specific negative information will be incorporated into stock prices in the presence of short sales constraints. If so, the co-movement of individual stock returns with the market returns will be higher when the short sales constraints are binding. Thus, the delayed price discovery hypothesis can be tested by examining the difference of the downside R^2 in the pre- and post-period. According to this hypothesis, the pre-minus-post downside R^2 should be significantly positive in the presence of short sales constraints. Bris et al. (2007) estimate the upside and downside R^2 coefficients conditional on the sign of the market returns.

The co-movement of individual stock returns and market returns is examined by estimating the market model. However, the uptick rule imposed on the Taiwan Stock Exchange requires that short sales prices be at least as high as the closing price in the previous trading day for individual stocks. Thus, unlike Bris et al. (2007) that estimate upside and downside R^2 coefficients conditional on the sign of market returns, we estimate the upside and the downside R^2 coefficients conditional on the sign of individual stock returns. Thus, for the upside R^2, the regression is estimated conditional on positive or zero individual stock returns, $r^+_{j,t}$. Similarly, for the downside R^2, the regression is estimated conditional on negative individual stock returns, $r^-_{j,t}$. Specifically, the following two market model regressions are estimated to measure the upside and downside R^2 as follows:

$$r^+_{j,t} = \alpha_j + \beta_j r_{m,t} + \varepsilon_{j,t} \quad (1)$$

$$r^-_{j,t} = \alpha_j + \beta_j r_{m,t} + \varepsilon_{j,t} \quad (2)$$

- **Cross-autocorrelation.** Diamond and Verrecchia (1987) hypothesize that prices will adjust slowly to negative information in the presence of short sales constraints. To examine this hypothesis, Hou and Moskowitz (2004) compare the R^2 of the regression of individual stock returns on lagged market returns, with the R^2 of the regression of individual stock returns on contemporaneous market returns. Similarly, Bris et al. (2007) examine this delayed price discovery hypothesis by examining the cross-autocorrelation conditional on the sign of market returns. They first estimate the upside cross-autocorrelation coefficient conditional on the lagged market returns being zero or positive, $\rho^+_j = corr(r_{j,t}, r^+_{m,t-1})$, and the downside cross-autocorrelation coefficient conditional on the lagged market returns being negative, $\rho^-_j = corr(r_{j,t}, r^-_{m,t-1})$. Then, they examine the significance of the difference between the upside and the downside cross-autocorrelation, coefficients $\rho^{diff}_j = (\rho^-_j - \rho^+_j)$.

Our cross auto-correlation is estimated between individual stock returns and lagged market returns. Since the uptick rule on the Taiwan Stock Exchange applies to transactions with negative individual stock returns, we estimate the upside and downside cross-autocorrelation coefficients conditional on the sign of individual stock returns as follows:

$$\rho^{+}_{j} = corr(r^{+}_{j,t}, r_{m,t-1}), \quad (3)$$

$$\rho^{-}_{j} = corr(r^{-}_{j,t}, r_{m,t-1}), \quad (4)$$

$$\rho^{diff}_{j} = (\rho^{-}_{j} - \rho^{+}_{j}). \quad (5)$$

3.2.2. The distribution of stock returns:

- **Skewness.** One frequently cited reason by regulators for the adoption of short sales constraints is that such constraints help to prevent financial market panics. One way to test the validity of this assertion is to examine the distribution of stock returns conditional on short sales constraints. If short sales constraints help to prevent market panics, the observed skewness of stock returns should be less negatively skewed in the presence of short sales constraints.

Following Bris et al. (2007), we examine the skewness of individual stock raw returns and individual stock abnormal returns. Individual stock raw returns primarily reflect systematic shocks. In contrast, individual stock abnormal returns estimated by the market-adjusted model remove the impact of market-wide shock and thus primarily reflect the impact of firm-specific information. Examination of return distribution provides a way to understand how short sales constraints might affect the price behavior from both market-wide shocks as well as firm-specific shocks.

- **Frequency of extreme negative returns.** Another way to examine the issue of whether short sales constraints reduce financial panics is by examining the frequency of extreme negative returns. This allows an evaluation of whether short sales constraints reduce the severity of a market crash. Following Bris et al. (2007), we estimate the frequency of extreme negative stock returns by calculating the frequency of stock returns below two standard deviations from the mean return. Moreover, we estimate the expected value of these extreme negative returns.

3.2.3. Abnormal returns following large price decline. The overvaluation hypothesis proposed in Miller (1977) suggests that stock prices tend to be overvalued in the presence of short sales constraints. Moreover, the hypothesis suggests that the overvaluation effect caused by short sales constraints is positively related to the degree of dispersion of opinions. That is, the more diverse the opinions among investors, the larger the degree of overvaluation. Chang et al. (2007) examine the overvaluation hypothesis of short sales constraints by examining the abnormal returns for stocks eligible for short sales.

Following Chang et al. (2007), we examine the price impact of short sales constraints by estimating the abnormal returns for stocks with and without short sales constraints. The price behavior for the Taiwan 50 ETF constituent stocks that experience large price declines (denoted as the event date 0) is compared between the pre- and the post-period for the 3-day event window.

To identify returns that experience large price decline, we screen daily return observations of the 33 constituent stocks in the sample period via a two-step procedure. First, we select return observations with negative daily raw returns from the sample stocks in both the pre- and post-period. Since the uptick rule imposed on the Taiwan Stock Exchange forbids short sales at prices lower than the closing price in the previous trading day, negative daily returns indicate a lower closing price than that in the previous trading day. Thus, the first screening process assures that the uptick rule is a binding constraint for these negative daily returns in the pre-period, but not in the post-period. Thus, comparison of price behavior for stocks experiencing the event of negative raw returns in the pre- and post-period allows us to examine the impact of short sales constraints.

Second, from the returns observations that pass the first-step screening criterion, we select the top 20% ranked by negative private information. Thus, we rank those negative raw returns obtained from step one by abnormal returns estimated by the market-adjusted model as follows:

$$AR_{it} = r_{it} - r_{mt}, \quad (6)$$

where r_{it} is the continuous daily return for stock i on day t, $r_{it} = \ln(p_{it} / p_{i,t-1})$; p_{it} and $p_{i,t-1}$ are the closing prices on days t and $t-1$ respectively. r_{mt} is the market return on day t based the value weighted index compiled by the Taiwan Stock Exchange. AR_{it} is the abnormal return estimated as the difference between the stock return and the market return.

This two-step procedure yields a total of 2279 daily observations in the pre- and post-period. We denote the day on which a selected daily return is ranked top 20% by abnormal returns as the event day 0. We then examine the price behavior over the event window from event day 1 through 3 for these stock returns. A significantly negative abnormal return in the 3-day event window in the pre-period, but not in the post-period, is consistent with the overvaluation hypothesis.

Moreover, abnormal returns in the event window are further broken down into overnight and trading-time components. For example, the day 1 overnight abnormal return, $AR_{i1,co}$, and the day 1 trading-time abnormal return, $AR_{i1,oc}$, are estimated as follows (Eqs. (2) and (3)):

$$AR_{i1,co} = r_{i1,co} - r_{m1,co}, \tag{7}$$

$$AR_{i1,oc} = r_{i1,oc} - r_{m1,oc}, \tag{8}$$

where $r_{i1,co}$ and $r_{m1,co}$ are the day 1 overnight returns for stock *i* and the market index, respectively. Similarly, $r_{i1,oc}$ and $r_{m1,oc}$ are the day 1 trading-time returns for stock *i* and the market index, respectively.

4. Empirical results

4.1. The efficiency of price discovery. Table 1 reports empirical results for the R^2 of the market model regression in the pre- and post-period. The results indicate that the R^2 is significantly higher in the pre-period than that in the post-period. For example, the downside R^2 of 0.35 in the pre-period is significantly higher than the corresponding 0.21 in the post-period. The difference of 0.14 between the pre- and post-period downside R^2 is significantly positive with a t-value of 6.72. Similarly, the overall R^2 is significantly higher in the pre-period than that in the post-period. These results are in line with those documented in Bris et al. (2007) and are consistent with the hypothesis that more firm-specific information is incorporated into stock prices in the post-period where short sales constraints are lifted. In additional to the method in Equations (1) and (2), we also estimate upside and downside R^2 coefficients conditional on the sign of market returns as in Bris et al. (2007), the results are qualitatively the same.

Table 1. The R^2 in the pre- and post-period

This table reports the R^2 in the pre- and post-period. The sample involves 33 constituent stocks of the Taiwan 50 Index fund. The R^2 is the average correlation coefficient for the 33 sample stocks. The market model is used as the appropriate model. The upside (downside) R^2 is estimated for positive (negative) individual stock returns against corresponding market returns.

	Pre-period	Post-period	Difference (t-value)
Overall R^2	0.4321	0.3126	0.1195 (8.78)***
Upside R^2	0.2430	0.1142	0.1287 (9.30)***
Downside R^2	0.3521	0.2148	0.1372 (6.72)***
Downside-minus-upside R^2	0.1091	0.1006	0.0085 (0.44)

Note: The asterisks *,**,*** indicate significance at 10%, 5%, and 1%, respectively. The values in parentheses are t-values.

Table 2 reports cross-sectional regression results of R^2 against the dummy variable, D_UpTick, and other control variables. The dummy variable assumes a value of one for the pre-period and zero for the post-period. The results indicate that the overall R^2, the upside R^2, and the downside R^2 are all positively correlated with trading volume and firm size. That is, the correlation coefficient between individual stock returns and the market returns tends to be higher for stocks with larger trading volume and larger firm size. Moreover, the coefficients for the dummy variable, D_UpTick, are significantly positive for the first three regressions. For the downside R^2, for example, the coefficient for the dummy variable, D_UpTick, is 0.129 with a t-value of 5.49. The results are consistent with those in Table 1 in that more private information is incorporated into stock prices in the post-period where short sales constraints are lifted.

Table 2. Cross-sectional regressions of R^2 against the short sales dummy variable and control variables

The table reports the cross-sectional regression results of R^2 against trading volume, firm size, and the dummy variable, D_UpTick. The dependent variable, R^2, is estimated from the market model over the 480 days before and after the event date of May 16, 2005 respectively. TradingVol is the daily trading volume (in 10 million shares) in the pre- and post-period. TURNOVER is the turnover ratio (in %), estimated by dividing the trading volume by total outstanding shares. FirmSize is the market value of sample firms (in NT$100 billions). D_UpTick is a dummy variable set to one in the pre-period where the short sales constraints are in effect, and zero in the post-period.

	Overall R^2	Upside R^2	Downside R^2	Downside-minus-upside
Intercept	0.248*** (11.40)	0.058*** (3.51)	0.157*** (7.06)	0.1*** (5.55)
TradingVol	0.02*** (3.52)	0.017*** (3.85)	0.016** (2.61)	-0.001 (-0.28)
FirmSize	0.009* (1.95)	0.008** (2.42)	0.01** (2.06)	0.001 (0.34)
D_UpTick	0.107*** (4.66)	0.119*** (6.84)	0.129*** (5.49)	0.01 (0.54)
N (obs)	66	66	66	66
R^2	0.443	0.578	0.449	0.006

Table 2 (cont.). Cross-sectional regressions of R^2 against the short sales dummy variable and control variables

	Overall R^2	Upside R^2	Downside R^2	Downside-minus-upside
Adj. R^2	0.416	0.557	0.423	-0.042
F-Statistic	16.432***	28.278***	16.866***	0.126

Note: The asterisks *,**,*** indicate significance at 10%, 5%, and 1%, respectively. The values in parentheses are t-values.

Table 3 reports the results for cross-autocorrelation, skewness, and extreme value. Panel A indicates that the cross-autocorrelations between individual stock returns and lagged market returns are in general higher in the pre-period than those in the post-period. This is especially true for the downside as well as the overall cross-autocorrelations. For example, the downside cross-autocorrelation of 0.084 in the pre-period is significantly higher than the corresponding 0.054 in the post-period. The difference between the pre- and post-period cross-autocorrelation is 0.030, which is significantly positive with a t-value of 1.91. Similarly, the overall cross-autocorrelation is significantly higher in the pre-period than that in the post-period. The results of higher pre-period cross-autocorrelation are consistent with the delayed price discovery hypothesis in that information is delayed in incorporating into prices with the presence of short sales constraints.

Table 3. The cross-autocorrelation, skewness, and frequency of extreme negative returns in the pre- and post-period

This table reports the cross-autocorrelation, skewness, and frequency of extreme negative returns in the pre- and post-period. The sample involves 33 constituent stocks of the Taiwan 50 Index fund. The cross-autocorrelation, skewness, and frequency of extreme negative returns are the average for the 33 sample stocks.

	Pre-period	Post-period	Difference (t-value)
Panel A. Cross-autocorrelation, $\rho_j = corr(r_{j,t}, r_{m,t-1})$			
Overall ρ	0.0086	-0.0328	0.0414 (3.99)***
Upside ρ	-0.0049	-0.0181	0.0132 (0.77)
Downside ρ	0.0841	0.0543	0.0298 (1.91)*
Downside-minus-upside ρ	0.0891	0.0725	0.0166 (0.71)
Panel B. Skewness			
Raw returns (in %)			
Overall	0.1483	0.2220	-0.0737 (-1.16)
Upside	2.0171	2.0202	-0.0031 (-0.09)
Downside	-1.8808	-1.8421	-0.0387 (-0.76)
Abnormal returns (in %)			
All	0.3700	0.3650	0.0050 (0.06)
Upside	1.9211	2.0328	-0.1117 (-2.44)**
Downside	-1.8151	-1.8536	0.0385 (0.91)
Panel C. Extreme negative returns			
Frequency [(Return<Mean-(2)*(SD)]	0.0253	0.0263	-0.001 (-0.99)
Extreme value return (in %)	-5.4368	-4.3587	-1.0781 (-6.86)***

Note: The asterisks *,**,*** indicate significance at 10%, 5%, and 1%, respectively. The values in parentheses are t-values.

Panel B of Table 3 reports skewness of stock raw returns and stock abnormal returns in the pre- and post-period. Contrary to our hypothesis, the results in general indicate no significant difference in return skewness between the pre- and post-period. For example, the downside skewness of raw returns is -1.88% in the pre-period, which is close to the corresponding -1.84% in the post-period. Similarly, the downside skewness of abnormal returns is -1.82% in the pre-period, which is close to the corresponding -1.85% in the post-period. Finally, Panel C of Table 3 indicates that there is no significant difference in the frequency of extreme negative returns between the pre- and post period. The frequency of returns below two standard deviations from the mean of returns is 2.53% in the pre-period, which is close to the corresponding 2.63% in the post-period. However, the expected value of these extreme returns is more negative in the pre-period than that in the post-period. The expected value of these extreme returns is -5.44% in the pre-period, which is more negative than the corresponding -4.36% in the post-period. Overall, the results in Table 3 do not support the notion that short sales constraints are associated with less negative skewness and less extreme negative returns.

4.2. The overvaluation hypothesis. Table 4 reports abnormal returns following the event of large price declines. Panel A of Table 4 indicates that there is no significant difference in the pre- and post-period abnormal returns. The three-day cumulative abnormal returns, CAR(1,3), of 0.11% in the pre-period is close to the corresponding 0.07% in the post-period. The difference of 0.04% is insignificantly different from zero with a t-value of 0.28. Thus, the result does not support the overvaluation hypothesis that predicts overvalued prices in the pre-period.

Table 4. Abnormal returns following price decline (raw return<0, AR<0, top 20%)

The table reports the abnormal returns in the event window for the top 20% sample ranked by negative abnormal returns in the pre- and post-period, respectively. Abnormal returns are estimated by the market-adjusted model.

Panel A. Cumulative abnormal returns (in %)			
Event window: (1 , t)	Pre-period	Post-period	Difference (t-stat)
CAR(1 , 1)	-0.0476 (-0.84)	-0.0813 (-1.62)	0.0337 (0.45)
CAR(1 , 2)	0.0738 (0.88)	-0.0029 (-0.04)	0.0767 (0.70)
CAR(1 , 3)	0.1118 (1.09)	0.0749 (0.88)	0.0368 (0.28)
Panel B. Breakdown of abnormal returns (in %) on event day 1 through 3			
AR_1	-0.0476 (-0.84)	-0.0813 (-1.62)	0.0337 (0.45)
Overnight	-0.1571*** (-5.02)	0.0564** (-2.2)	-0.1007** (-2.50)
Trading time	0.1095** (2.12)	-0.0249 (-0.57)	0.1344** (2.05)
AR_2	0.1214* (1.96)	0.0784 (1.54)	0.043 (0.54)
Overnight	-0.0583 (-1.43)	0.0246 (0.88)	0.0829* (-1.69)
Trading time	0.1798*** (3.56)	0.0538 (1.19)	0.1259* (1.86)
AR_3	0.0380 (0.66)	0.0778 (1.48)	-0.0399 (-0.51)
Overnight	-0.0191 (-0.58)	-0.0072 (-0.22)	-0.0119 (-0.26)
Trading time	0.0570 (1.17)	0.0850 (1.94)	-0.0280 (-0.43)

Note: The asterisks *,**,*** indicate significance at 10%, 5%, and 1%, respectively. The values in parentheses are t-values.

Panel B of Table 4 reports the breakdown of abnormal returns into overnight and trading-time abnormal returns. The results indicate that the overnight abnormal return is more negative in the pre-period than that in the post-period. In comparison, the subsequent trading-time abnormal return is more positive in the pre-period than that in the post-period. For example, the day 1 overnight abnormal return of -0.157% in the pre-period is significantly lower than the corresponding -0.056% in the post-period. In comparison, the day 1 trading-time abnormal return of 0.109% is significantly higher in the pre-period than the corresponding -0.025% in the post-period. Thus, the results suggest that investors tend to overreact in the overnight period in the pre-period compared to the post-period. The overnight overreaction in the pre-period is followed by a price reversal in the subsequent trading-time period. Thus, although the cumulative abnormal returns indicate no significant difference between the pre- and the post-period, the breakdown of daily abnormal returns indicates an overreaction in the overnight period, followed by a subsequent trading-time price reversal in the pre-period compared to the post-period.

Table 5 reports the cross-sectional regression of day 1 abnormal returns against trading activity, firm size, market return, and the dummy variable, D_UpTick. Consistent with the results in Table 4, the results indicate that there is no significant difference in the pre- and post-period day 1 abnormal returns. In regression (5) where the dependent variable is day 1 abnormal return (AR_1), for example, the coefficient of 0.035% for the dummy variable, D_UpTick, is insignificantly different from zero with a t-value of only 0.46. However, the results indicate that the overnight abnormal return is significantly lower in the pre-period than that in the post-period, and the trading-time abnormal return is significantly higher in the pre-period than that in the post-period. In regression (1) where the dependent variable is the day 1 overnight abnormal return ($AR_{1,\ co}$), the coefficient of -0.093% for the dummy variable, D_UpTick, is significantly negative with a t-value of -2.29. In contrast, in regression (3) where the dependent variable is the day 1 trading-time abnormal return ($AR_{1,\ oc}$), the coefficient of 0.128% for the dummy variable, D_UpTick, is significantly positive with a t-value of 1.95.

Table 5 also examines the impact of dispersion of investor opinion on abnormal returns. The proxy variables for dispersion of investor opinions are $Range(raw)_{t-1}$ and $Range(AR)_{t-1}$. $Range(raw)_{t-1}$ is the daily return range, measured as the difference between the high and low prices on t-1, then divided by the closing price on day t-2. $Range(AR)_{t-1}$ is the difference between $Range(raw)_{t-1}$ and the corresponding market return range on day t-1. D_UpTick is a dummy variable set to one in the pre-period where the short sales constraints are in effect, and 0 in the post-period.

Table 5. Cross-sectional regressions of day 1 abnormal returns (in %) against the short sales dummy variable and control variables

The table reports the cross-sectional regression results of day 1 abnormal returns against dispersion of opinion, firm size, and the dummy variable D_UpTick. The dependent variables are the abnormal returns estimated from the market-adjusted model over 480 days before and after the event date of May 16, 2005, respectively. $Range(raw)_{t-1}$ and $Range(AR)_{t-1}$ are the proxies for dispersion of investor opinions. $Range(raw)_{t-1}$ is the daily return range, measured as the price range between high and low prices on day t-1, then divided by the closing price on day t-2. $Range(AR)_{t-1}$ is the difference between $Range(raw)_{t-1}$ and the corresponding market return range on day t-1. TradingVol is the daily trading volume (in 10 million shares) in the pre- and post-period. FirmSize is the market value of sample firms (in NT$100 billions). D_UpTick is a dummy variable set to one in the pre-period where the short sales constraints are in effect, and zero in the post-period.

	Overnight AR_1		Trading time AR_1		Overall AR_1	
Regression	(1)	(2)	(3)	(4)	(5)	(6)
Intercept	-0.119** (-2.33)	-0.025 (-0.64)	-0.049 (-0.60)	-0.034 (-0.54)	-0.169* (-1.77)	0.059 (-0.812)
$Range(raw)_{t-1}$	-4.111*** (-3.09)		-0.131 (-0.06)		-3.98* (-1.82)	
$Range(AR)_{t-1}$		-2.456** (-2.22)		-2.998 (-1.27)		-5.454** (-2.00)
FirmSize	-0.021** (-2.23)	-0.023** (-2.31)	0.005 (0.34)	0.004 (0.23)	-0.016 (-0.90)	-0.019 (-1.04)
$R_{m,t}$	-0.003 (-0.02)	-0.001 (-0.05)	-1.130*** (-4.318)	-0.131*** (-4.34)	-0.130*** (-3.77)	-0.132*** (-3.80)
$R_{m,t+1}$	0.011 (0.68)	0.012 (0.68)	0.122*** (4.41)	0.122*** (4.41)	0.133*** (4.19)	0.134*** (4.20)
D_UpTick	-0.121*** (-2.99)	-0.166** (-2.811)	0.134** (2.035)	0.143** (2.14)	0.012 (0.165)	0.027 (0.35)
N (obs)	2279	2279	2279	2279	2279	2279
R2	0.01	0.007	0.018	0.018	0.015	0.014
Adj. R2	0.008	0.004	0.015	0.016	0.013	0.012
F-Statistic	4.612***	2.989**	8.129***	8.22***	7.033***	6.512***

Note: The asterisks *,**,*** indicate significance at 10%, 5%, and 1%, respectively. The values in parentheses are t-values.

To examine the impact of dispersion of investor opinion on overvaluation, we use the range of raw returns as well as the range of abnormal returns as the proxy for dispersion of investor opinion. If the overvaluation hypothesis is valid, stock prices would tend to be overvalued under the short-sales constraint than otherwise. However, divergence of opinion can be measured in different ways. For example, forecast dispersion in financial analysts' earnings forecasts is a common way to proxy for divergence of opinion. Since our research examines the impact on price overvaluation, we follow Chang et al. (2007), Harris and Raviv (1993) and Shalen (1993), among others, by using dispersion of investor opinion as a proxy for divergence of opinion.

Columns (1), (2) and (5), (6) in Table 5 indicate that the coefficients for the variables $Range(raw)_{t-1}$ and $Range(AR)_{t-1}$ are all significantly negative (-4.111, -2.456 and -3.98, -5.454). The results are consistent with the notion that the impact of short-sales constraint on overvaluation appears to be larger when investors disagree regarding the true value of securities. With the lift of the short-sales constraints, stock prices revert to their intrinsic value especially for securities with more divergent views among investors.

4.3. Sensitivity analysis. The results reported above are based on the top 20% of observations ranked by negative abnormal returns. To examine the robustness of the empirical results, results based on the top 10% and 30% of observations are estimated respectively. Table 6 reports results for the top 10% and the top 30% samples ranked by negative abnormal returns. The results resemble those in Table 4 in that there is no significant difference in the day 1 pre- and post-period abnormal returns. For the top 10% negative abnormal returns, the day 1 abnormal return in the pre-period is insignificantly different from that in the post-period. However, the overnight abnormal return is significantly lower in the pre-period than that in the post-period, while the subsequent trading-time abnormal return is significantly higher in the pre-period than that in the post-period. The overnight abnormal return is -0.098% lower (with a t-value of -1.69) in the pre-period than that in the post-period. In contrast, the subsequent trading-time abnormal return is 0.22% (with a t-value of 2.23) higher in the pre-period than that in the post-period.

Table 6. Day 1 abnormal returns for the top 10% and the 30% sample ranked by negative abnormal returns

The table reports the day 1 abnormal returns for the top 10% and the top 30% sample ranked by negative abnormal returns in the pre- and post-period. Abnormal returns are estimated by the market-adjusted model.

	Pre-period	Post-period	Difference (t-value)
Panel A. Top 10% of abnormal returns			
AR_1	0.0026 (0.03)	-0.1196 (-1.57)	0.1223 (1.09)

Table 6 (cont.). Day 1 abnormal returns for the top 10% and the 30% sample ranked by negative abnormal returns

	Pre-period	Post-period	Difference (t-value)
Overnight	-0.1924*** (-4.61)	-0.0946** (-2.36)	-0.0978* (-1.69)
Trading time	0.1950** (2.56)	-0.0251 (-0.39)	0.2201** (2.23)
Panel B. Top 30% of abnormal returns			
AR_1	-0.0306 (-0.66)	-0.0395 (-0.98)	0.0089 (0.15)
Overnight	-0.1583*** (-5.88)	-0.0475** (-2.17)	-0.1108*** (-3.21)
Trading time	0.1278*** (3.29)	0.0081 (0.23)	0.1197** (2.32)

Note: The asterisks *,**,*** indicate significance at 10%, 5%, and 1%, respectively. The values in parentheses are t-values.

The empirical results reported above are based on the sample period of 480 trading days in both the pre- and the post-period. While not reported here for brevity, results based on 240 trading days in both the pre- and the post-period are also examined. The results are qualitatively the same as those based on the sample period of 480 days in both the pre- and post-period. The results from the shorter sample period indicate significant higher R^2 and significantly higher cross-autocorrelation in the pre-period as compared to those in the post-period. Moreover, the results from the shorter sample period indicate no significant difference in the 3-day cumulative abnormal returns following the large price decline between the pre- and the post-period. Finally, the day 1 overnight abnormal return is significantly lower in the pre-period than that in the post-period, while the day 1 trading-time abnormal return is significantly lower in the pre-period than that in the post-period.

Finally, we examine the price behavior for sample following large price gains. Since short sales constraints should not affect the price behavior for observations with price gains, we would expect no significant difference between the pre- and the post-period. To verify this, we examine the price behavior for observations with the top 20% positive abnormal returns. Table 7 indicates that there is no significant difference between the pre- and the post-period in day 1 abnormal returns, as well as in the overnight and the trading-time abnormal returns. Panel A of Table 7 indicates that the three-day cumulative abnormal return of -0.23%, in the pre-period is insignificantly different from the -0.25% in the post-period. Similarly, Panel B of Table 7 indicates that the day 1 overnight abnormal return of 0.012% in the pre-period is insignificantly different from the 0.04% in the post-period. And the day 1 trading-time abnormal return of -0.107% in the pre-period is insignificantly different from the -0.146% in the post-period.

Table 7. Abnormal returns following price gains (raw return>0, AR>0, top 20%)

The table reports the abnormal returns in the event window for the top 20% sample ranked by positive abnormal returns in the pre- and post-period respectively. Abnormal returns are estimated by the market-adjusted model.

Panel A. Cumulative abnormal returns (in %)			
Event window: (1, t)	Pre-period	Post-period	Difference (t-value)
CAR(1, 1)	-0.0953 (-1.72)	-0.1060 (-1.93)	0.0106 (0.14)
CAR(1, 2)	-0.2400*** (-3.12)	-0.1763** (-2.30)	-0.0637 (-0.59)
CAR(1, 3)	-0.2378*** (-2.58)	-0.2531*** (-2.83)	0.0153 (0.12)
Panel B. Abnormal returns (in %)			
AR_1	-0.0953 (-1.72)	-0.1060 (-1.94)	0.0106 (0.14)
Overnight	0.0120 (0.38)	0.0402 (1.30)	-0.0282 (-0.64)
Trading time	-0.1073** (-2.35)	-0.1462*** (-3.18)	0.0389 (0.59)
AR_2	-0.1447*** (-2.73)	-0.0704 (-1.31)	-0.0743 (-0.098)
Overnight	-0.0735** (-2.49)	-0.0164 (-0.50)	-0.0571 (-1.30)
Trading time	-0.0712 (-1.58)	-0.0540 (-1.22)	-0.0172 (-0.27)
AR_3	0.0022 (0.04)	-0.0767 (-1.48)	0.0789 (1.09)
Overnight	-0.0480** (-2.00)	0.0038 (0.13)	-0.0518 (-1.39)
Trading time	-0.0502 (-1.10)	-0.0805 (-1.84)	0.0303 (0.51)

Note: The asterisks *,**,*** indicate significance at 10%, 5%, and 1%, respectively. The values in parentheses are t-values.

Conclusion

This paper examines the impact of short sales constraints on stock price behavior using data from the Taiwan Stock Exchange. The data involves 33 constituent stocks of the Taiwan 50 index fund over the 480 days in both the pre- and post-period surrounding the lift of the uptick rule effectively on May 16, 2005. The results indicate that the R^2 estimated from the market model is significantly higher in the pre-period than that in the post-period. Similarly, the cross-autocorrelation between the individual stock returns and the lagged market returns is significantly higher in the pre-period than that in the post-period. The results are consistent with the delayed price discovery hypothesis in that short sales constraints delay the incorporation of information into securities prices.

Moreover, there is no significant difference in the 3-day cumulative abnormal returns between the pre- and the post-period following large price declines. The results do not support the overvaluation hypothesis which predicts a significant overvaluation in the pre-period when the uptick rule is imposed. However, the empirical results indicate a significantly negative overnight abnormal return following the large price decline in the pre-period than that in the post-period, followed by a significantly positive trading-time abnormal return in the pre-period than that in the post-period. The results are consistent with the hypothesis that investors overreact to bad news in the presence of short sales constraints, followed by a price reversal in the subsequent trading-time period.

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