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The impact of post-trade transparency on price efficiency and price discovery: Evidence from the Taiwan Stock Exchange

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Abstract

Purpose

The purpose of this paper is to examine the impact of post-trade transparency on price efficiency and price discovery.

Design/methodology/approach

The authors use an exogenous change in market transparency in the Taiwan Stock Exchange that mandates the disclosure of unexecuted orders of the five best bid and ask prices after each trade, and conduct an event study analysis.

Findings

After the change, price efficiency enhances for both large and small firms, although the impact on stock prices is greater when the firm is larger. The authors also find that post-change trading reveals more private information for large firms but more public information for small firms. The findings support the view that transparency has a positive impact on market quality.

Originality/value

The paper adds to a large body of literature investigating the relationship between transparency and market behavior, especially the ongoing debate about whether trading transparency positively affects price dynamics. The findings also have important policy implications for the regulators.

Keywords

Price discovery, Market microstructure, Opening of limit-order books, Post-trade transparency, Price efficiency

1. Introduction

It is broadly accepted that transparency in equity markets matters for market efficiency and price discovery. However, the impact of transparency on market quality is complicated (e.g. Paul, 1993; De Frutos and Manzano, 2014; Tang, 2014). One important reason behind the complexity is that transparency has many dimensions such as corporate disclosure and trading information disclosure. Academic scholars have paid a lot of attention to issues of transparency concerning disclosure in the trading process. Nevertheless, the findings in the literature are mixed and far from conclusive. On the positive side, Admati and Pfleiderer (1991) theoretically demonstrate that sunshine trading can increase the information contained in prices. De Frutos and Manzano (2005) show that trade disclosure increases the informational efficiency of transaction prices and reduces volatility. On the negative side, Biais (1993) and De Frutos and Manzano (2002) argue that in more transparent markets, quote dissemination may have detrimental effects on price efficiency and the welfare of market participants. Madhavan *et al.* (2005) find that the disclosure of information on the limit order book to the public is negatively related to market quality. The third strand of literature suggests that post-trade transparency has no significant effect on price efficiency and discovery. For example, Bloomfield and O'Hara (1999) find that quote disclosure has little effect on market performance. In this study, motivated by the mixed evidence documented in the literature, we aim to gain a richer understanding of this important issue by investigating the impact of post-trade order disclosure on informational efficiency and discovery in the Taiwan Stock Exchange (TSEC).

The TSEC mandated that beginning January 1, 2003, disclosure of unexecuted orders of the five best bid and ask prices must be made to the public after each trade. This rule change applies to all stocks traded on the TSEC. Prior to the rule change, the TSEC disclosed only the best bid/ask along with the transaction price, volume and orders from the limit-order books. The goal of this change was to enhance the level of market transparency. Given that this rule change is exogenous, we use it as a natural experiment to examine the impact of post-trade transparency on price discovery (how information is impounded into prices) and price efficiency (the informativeness of prices). To measure price discovery, we follow the framework in Hasbrouck (1991a, b) which introduce a model based on a vector auto-regression (VAR) in which the nature of information and trading is inferred from the observed sequence of quotes and trades. In this framework, the variance of price changes is

decomposed into two components: trade-related price movements and trade-unrelated price movements. The former captures the flow of private information, whereas the latter reflects the incorporation of public information (e.g. Hendershott *et al.*, 2011). Madhavan (1996) points out that different-sized firms would react differently to varying transparency conditions. Hence, we divide the sample firms into three groups based on their market capitalization. Our results indicate that there is an increase in trade-related price movements for large firms and an increase in trade-unrelated price movements for small firms. In other words, the post-trade disclosure of unexecuted orders of the five best bid and ask prices in the TSEC leads to greater price discovery: more private information incorporation for large firms and more public information incorporation for small firms.

We then follow Amihud *et al.* (1997) to construct three measures of pricing errors: the relative return dispersion (RRD), the lagged response, and the firm-specific noise. We then test whether the change in these measures from the pre-event period to the post-event period are significantly different from zero. Consistent with our hypothesis that post-trade transparency enhances the informativeness of prices, we find a significant decrease in all three measures of pricing errors after the TSEC rule change. Taken together, our findings are consistent with the argument that transparency promotes price efficiency and accelerates stock prices toward their true value. The post-trade disclosure of unexecuted orders of the five best bid and ask prices after each trade allows investors to learn more information about trade patterns[1].

Our paper makes several important contributions to the literature. First, our paper adds to a large body of literature investigating the relationship between transparency and market behavior. Prior studies have examined how pre-trade visibility of market orders, price setters' quotes and post-trade speed of reporting affect price volatility, market liquidity and the welfare of market participants (e.g. Biais, 1993; Pagano and Roell, 1996; De Frutos and Manzano, 2002; Boehmer *et al.*, 2005; Porter and Weaver, 1998). We extend this strand of literature by documenting that enhanced market transparency because of post-trade disclosure of unexecuted orders leads to great price discovery and efficiency. Second, our paper contributes to the ongoing debate about whether trading transparency positively affects price dynamics. Our paper provides some evidence in support of the positive relation between post-trade transparency and price efficiency and discovery.

Our findings also have some policy implications. Finally, our findings have important policy implications. Regulatory agencies in different countries have different opinions on the relation between transparency and market condition. For example, in a speech given in 2014, the SEC chairman reemphasized that "Transparency has long been a hallmark of the US security markets, and I am concerned by the lack of it in these dark venues. We must continue to examine whether dark trading volume is approaching a level that risks seriously undermining the quality of price discovery provided by lit venues." In contrast, the Securities and Investment Board in UK believes that to assure adequate market liquidity, trading transparency should be restricted when it comes to prompt publication of large trades. It is important to point out that although the rule change in TSEC was 15 years ago, it is still valuable to evaluate the event today for the following reasons. First, the TSEC is a purely electronic and automated trading system, and its experience of increased post-trade transparency offers a blueprint for other markets with similar structure around the world which consider the adoption of similar rules in the future. Second, exogenous regulatory change in transparency is very rare, thus the empirical evidence on market quality is sparse. Examination of increased post-trade transparency in the TSEC is thus valuable and would enrich the existing literature. Third, the discussion of increased transparency has accelerated since the financial crisis, but it has not yet been determined whether increased transparency necessarily improves market outcomes. The remainder of the paper is organized as follows: Section 2 gives an institutional background of the TSEC; Section 3 discusses related literature and hypothesis development; Section 4 discusses data sources and the sample; Section 5 discusses the research methodology. The empirical results are provided in Section 6. The conclusion is in the final section.

2. Institutional background of the TSEC

The TSEC is a pure order-driven market with no designated market makers, specialists or dealers. Essentially, it is a fully computerized trading system. The TSEC trades from 9:00 a.m. to 1:30 p.m. five weekdays days a week, except on national holidays. Although investors can submit their orders to the system starting at 8:30 a.m., they are not executed until 9:00 a.m. The TSEC sets the stocks' opening prices by matching the largest amount of bid and ask orders in the limit-order books. After the market opens, the trading rules are as follows: first, the investors' orders are matched by bid-ask price first and then by order submission time; second, the setting price in each call is where the largest number of shares can be traded; third, all bid orders above the setting price and all ask orders below the setting price are executed, with the unexecuted orders kept for the next call; fourth, orders in limit-order books are batched over various time intervals, which depend on the trading situation, but average 45 s for each trading cycle; fifth, in the last 5 min (1:25–1:30), only one call is issued, and the setting price is the closing price for that day; and sixth, a price limit of ± 10 percent from the previous trading day's close price is imposed. The price limit rule is applied to the open price, the closing price and the transaction price during the middle of the trading session (9:00–13:25).

The January 1, 2003, event leading to the increase in transparency is a key institutional characteristic of the TSEC. Before this date, the TSEC disclosed only the best bid/ask after each trade along with the transaction prices, volume and orders from the limit-order books. Since that date, the TSEC now discloses unexecuted orders of the five best bid/ask prices. TSEC officials argued that this change would promote transparency[2].

Individuals are the major investors on the TSEC. According to the TSEC's annual reports, the percentage of trading volume by individuals to total market volume was 70–80 percent for the years 2002 and 2003, respectively. However, because the market was opened to foreign institutional investors, this percentage has gradually decreased. By 2014, the percentage fell to 58.80 percent, with the majority still being retail investors.

3. Related literature and hypothesis development

Our paper is closely related to a body of research that examines how trading transparency affects price dynamics. On the positive side, Admati and Pfleiderer (1991) theoretically demonstrate that sunshine trading can increase the information contained in prices. Baruch (2005) shows that more information is revealed by price in an open limit-order book situation. Boehmer *et al.* (2005) find that the introduction of the NYSE's OpenBook service, which provides limit-order book information to traders off the exchange floor, affects investors' trading strategies and improves the price efficiency. De Frutos and Manzano (2005) show that trade disclosure increases the informational efficiency of transaction prices and reduces volatility. De Frutos and Manzano (2014) further show that in competitive markets, pre-trade information disclosure on the composition of the order flow enhances market quality. One closely related paper is Ke *et al.* (2013) who find that the post-trade disclosure of unexecuted orders of the five best bid and ask prices in TSEC increases market liquidity. In contrast, our paper focuses on the impact of post-trade transparency on the informativeness of prices (price efficiency) and how information is incorporated into prices (price discovery).

On the negative side, Madhavan (1996) shows that disclosing information about the composition of order flows can reduce price efficiency. Biais (1993) and De Frutos and Manzano (2002) argue that in more transparent markets, quote dissemination may have detrimental effects on price efficiency and the welfare of market participants. They also found that less information is impounded into a price in an opaque market, reducing transaction price efficiency. Madhavan, Porter and Weaver (2005) find that the disclosure of information on the limit order book to the public is negatively related to market quality. Naik *et al.* (1999) conduct an experimental study and find that the full and prompt disclosure of first-stage trade details may reduce the welfare of market participants.

In addition, there could be no relation between market transparency and stock price dynamics. For example, in an experimental study, Bloomfield and O'Hara (1999) find that quote disclosure has little effect on market performance. Given the inconsistency of predictions derived from the literature, the following hypotheses are tested:

H1. Disclosure of post-trade unexecuted orders has no effect on efficiency.

H2. Disclosure of post-trade unexecuted orders has no effect on price discovery.

4. Data and sample

In this study, real-time transaction data and daily data from the TSEC for the period from September 1, 2002 to April 30, 2003, are used. All data are retrieved from the Taiwan Economic Journal (TEJ) database. We place several filters to obtain the final sample: first, firms in the sample must be listed over the sample period. Observations with nonpositive bid/ask price or nonpositive bid-ask spread are deleted. Second, we delete stocks with missing trading data. Third, trades and quotes that have been time-stamped outside the regular TSEC trading time are also excluded. Fourth, foreign firms are not included in the sample. Last, if the average stock price of a stock during the sample period is less than \$10 NTD, then the stock is deleted. Low priced stocks have the issue of non-synchronicity because these stocks are usually very thin. Our final sample includes 315 firms and 6,312,788 intraday observations. Each observation includes the firm code, date, time, transaction price, transaction volume, and best bid and ask prices.

Firms listed on the TSEC are sorted into three groups based on their 2001 year-end capitalization. The top tercile includes firms with the largest capitalization stocks, while the bottom tercile is comprised of firms with the smallest capitalization stocks. To well examine the impact of transparency on market quality and make a sharp comparison, we only keep stocks in top and bottom terciles. There are 105 large firms and 105 small firms in our sample. The capitalizations are 8,244–1,472,848 and 203–2,837m NTD for large and small stocks, respectively. Our sample firms are distributed across various industries and are representative of the stock market.

The event day – when the TSEC began to disclose the best five bids/asks with orders in its limit-order books – is naturally January 1, 2003. The period, from September 1, 2002 to December 31, 2002, is called the estimation period (before the event); the period, from January 1, 2003 to April 30, 2003, is called the event period (after the event). During our sample period, no other major events in the TSEC has occurred, allowing us to compare the market quality for the same stocks traded in the same market but at different transparency levels.

Table I contains descriptive statistics for the sample of all, large and small firms, respectively. The characteristics of the average daily closing price, average daily volatility, average daily trading shares and average daily market value are reported. When examining the stocks in each portfolio, we find that large firms have bigger values than small firms in all fields. For example, the average trading share for large firms is 12,502, while it is 849 for small firms. According to TSEC statistics, institutional investors prefer large-firm stocks over small-firm stocks and as a result, the trading of large firms is more intensive than the trading of small firms[3].

5. Methodology

In this section, we discuss the measures of price efficiency and price discovery.

5.1 Efficiency

Following Amihud *et al.* (1997), we use the dispersion of individual stock around market return to measure pricing errors. For day t , the RRD is calculated by:

$$\text{RRD}_t = \frac{1}{n} \sum_{i=1}^n \varepsilon_{it}^2,$$

where ε_{it} is the market model residual of stock i on day t , and n is the number of stocks. The differences between pre-event RRD and post-event RRD indicate the change in efficiency driven by the change in transparency. In the lag market model, there are two factors that may be used to measure inefficiency: lag response and firm-specific noise. The lag market model is formulated as follows:

$$R_{it} = \alpha_i + \beta_i \text{RM}_t + \gamma_i \text{RM}_{t-1} + \varepsilon_{it},$$

where R_{it} is the return for stock i at day t ; RM_t and RM_{t-1} indicate the market returns for day t and $t-1$, respectively; the coefficient γ_i is the lag response; and ε_{it} is the residual whose variance denoted by $\text{var}(\varepsilon)$, which is a proxy for firm-specific noise. The model is estimated separately over the periods before and after the event[4]. The higher the values of RRD, the lag response, and firm-specific noise, the less price efficiency.

5.2 Price discovery

We follow the model in Hasbrouck (1991b) to infer the components of price discovery surrounding the event of January 1, 2003. Following this model, all stock price movements are assigned to one of two categories: one is associated with trade (trade-related), and the other is unassociated with trade (quote-related). Following Hendershott *et al.* (2011), the price movements are considered to release private information if they are associated with trades; otherwise they are considered to reflect public information if they are orthogonal to trades. The full model is as follows[5]:

$$r_t = \sum_{i=1}^{\infty} \alpha_i r_{t-i} + \sum_{i=0}^{\infty} \beta_i x_{t-i} + \varepsilon_{rt},$$

$$x_t = \sum_{i=1}^{\infty} \delta_i r_{t-i} + \sum_{i=1}^{\infty} \eta_i x_{t-i} + \varepsilon_{xt}$$

In model (3), the first equation formulates the trade-by-trade evolution of the bid-ask midpoint; the second one indicates the persistence of the order flow. The x_{jt} is an indicator variable for stock j in trade t (+1 for buying; -1 for selling), and r_{jt} is the log return based on the bid-ask midpoint for stock j in trade t , while $\text{var}(\varepsilon_{rt}) = \sigma_r^2$, $\text{var}(\varepsilon_{xt}) = \sigma_x^2$ are assumed to be held[6],[7]. Using tick-by-tick data, we estimate these two equations by taking ordinary least squares (OLS) for each day and each stock. Under some assumptions, the vector auto-regression (VAR) form of Equation (3) can be inverted into a vector moving average (VMA) representation:

$$y_t = [r_t x_t] = [a(L)b(L)d(L)e(L)][\varepsilon_{rt} \varepsilon_{xt}].$$

Following Hasbrouck (1991b), $a(L)$, $b(L)$, $d(L)$ and $e(L)$ are the lag polynomial operators. The sum of $a(L)\varepsilon_{rt} + b(L)\varepsilon_{xt}$ is the permanent impact of an innovation on the price. Assuming $\text{cov}(\varepsilon_{rt}, \varepsilon_{xt}) = 0$, the variance of the random-walk component can be written as follows:

$$\sigma_{\omega}^2 = \left(\sum_{i=0}^{\infty} a_i \right)^2 \sigma_r^2 + \left(\sum_{i=0}^{\infty} b_i \right)^2 \sigma_x^2.$$

As in Hasbrouck (1991b), the first term of Equation (5) measures the component of the price discovery that is unrelated to trading, and the second term captures the part of the price discovery that is related to the recent trade. The sum of the first term and the second term is called the price discovery or the efficient price change.

To better understand the differences in the price discovery around the rule change in the TSEC, we follow the methodology in Hendershott *et al.* (2011) and Riordan and Storkenmaier (2012) and run a panel regression with control variables. The control variables include: stock price, which is the natural log of the average trading price for stock i on day t ; shares, which is the natural log of the trading shares for stock i on day t ; and market value, which is the natural log of market value for stock i on day t . The regression model is:

$$L_{i,t} = \alpha_i + \beta_i \text{Dummy}_{i,t} + \sum_{K=1}^3 \Psi_K \text{Controls}_{i,t,K} + \varepsilon_{i,t},$$

where $L_{i,t}$ is the cumulative impulse response, trade-related standard deviation, quote-related standard deviation, and price discovery for stock i on day t ; $\text{Dummy}_{i,t}$ is a dummy variable, with a value of 0 if before the event and 1 otherwise; $\varepsilon_{i,t}$ is an error term, assuming it follows classical rules; and $\text{Controls}_{i,t,K}$ are the control factors. The firm fixed effects are also included.

6. Empirical findings

6.1 Improvements in price efficiency

We examine whether the price efficiency exhibits significant changes around the event of the TSEC rule change. The pattern of RRD_s is shown in Figures 1–3. We find that the market becomes more efficient after the rule change for both large and small firms. For example, for total (large, small) firms, the average RRD_s is 3.71 (3.65, 3.77) during the pre-event period, while the value decreases to 2.92 (2.72, 3.13) in the post-event period – a difference of -0.79 (-0.93 , -0.64); the corresponding T -value is -6.82 (-5.43 , -4.23). At the same time, RRD_s begins to decrease, and becomes more concentrated about 30 days after the event day. This phenomenon suggests that investors adjust their behaviors gradually, not immediately, to changes in market conditions.

We next examine two other factors: the lag response and the firm-specific noise. The results are shown in Table II. There is a significant decrease in both the lag response and firm-specific noise after the transparency event. For example, the lag response of large (small) firms decreased from 0.046 (0.095) to -0.015 (0.035), and the firm-specific noise decreased from 5.456 (5.765) to 4.325 (5.013). The decrease in lag response means that investors are adjusting their behaviors to market information faster than before, inducing stock prices to promptly react to new information. The decrease of firm-specific noise after the event implies either a reduction in price error or that more firm-specific information is incorporated into the stock price more precisely. Overall, $H1$ is rejected as the market becomes more efficient following the opening of limit-order books.

6.2 Improvements in price discovery

Table III shows the cumulative impulse response, which is viewed as the permanent price impact of a trade and is usually interpreted as indicating the private information content of a trade. Although the cumulative impulse response is shown to decrease post-event for firms overall, it increases for large firms and decreases for small firms. There are two components to price discovery: trade-related price movements and quote-related price movements. The former relates to private information while the latter connects to public information. Table III shows that the trade-related standard deviation increases after the rule change, while the quote-related standard deviation decreases for firms overall, but the impact varies across firms with different sizes. Price discovery itself increases for firms overall, decreases for large firms, and increases for small firms after the event.

We also use the panel regression method to test the differences in the cumulative impulse response, trade-related standard deviation, quote-related standard deviation, and price discovery around the event. The regression results are shown in Table IV. First, for firms overall, the differences in all four measures are not significant. Further, large firms and small firms are separately examined. There is a significant increase in the cumulative impulse response and the trade-related standard deviation for large firms after the event, while the quote-related standard deviation decreases. In Table IV Panel B, after controlling for the impact of confounding factors such as stock turnover and momentum, we continue to find similar results. It is noteworthy that for the whole sample, the price discovery increases after the rule change. For small firms, there is a significant increase in the quote-related standard deviation and price discovery, while the other measures do not change significantly. The increase in the quote-related standard deviation indicates that more public information is incorporated into stock prices in a timely manner after the rule change[8]. The possible reason for the insignificance of increase in small stocks could be due to adverse selection, individual investors in small firms are less likely to be exploited by institutional investors whose trading likely carries private information.

The increase in price discovery measures indicates that the impact of transparency is beneficial to price discovery for small firms. While for large firms, the change in price discovery is not significant, the rule change lead to more private information incorporation into stock prices. The overall results suggest that post-trade transparency in the TSEC affects the components of price discovery and price discovery itself, but the impacts are different for differently sized firms. In an untabulated analysis, to provide more direct evidence on how post-trade transparency affects price dynamics, we also examine the institutional trading frequency around the rule change in TSEC. Literature has provided ample evidence that institutional investors are at an advantageous position in collecting and trading private information. For example, Piotroski and Roulstone (2004) find that institutional trading is positively associated with stock price informativeness. Hartzell and Starks (2003) find that institutional investors contribute to private information collection and trading. Therefore, more frequent institutional trading indicates more private information incorporation. We find that after the rule change in 2003, institutional investors trade more often in large stocks, but not small stocks. This can explain why the post-trade transparency affects stocks of different sizes in a varying manner.

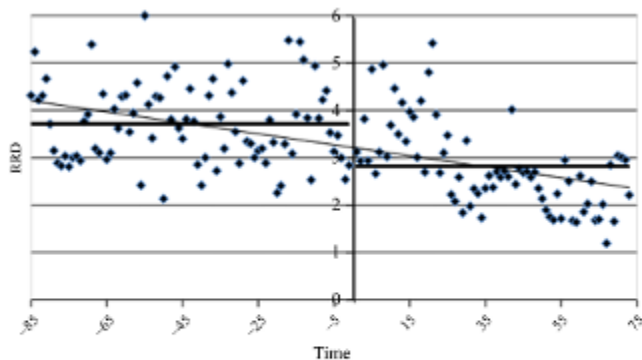
7. Conclusion

Transparency is important to all participants in the stock market. Most previous research has primarily focused on the impact of pre-trade transparency on market quality, whereas this study empirically investigates the impact of enhanced post-trade transparency due to the exogenous rule change in the TWSE that mandates the disclosure of unexecuted orders of the five best bid and ask prices after each trade.

Several findings emerge from this analysis. Consistent with the assumption of regulators and policy makers, greater transparency upgrades market efficiency for both large and small firms and implies that investors impound information into stock prices faster than before. For price discovery, transparency impacts the stock prices of large firms more than that of small firms. Additionally, trade reveals more private information for the large firms, whereas it generally conveys public information in a more timely manner for small firms.

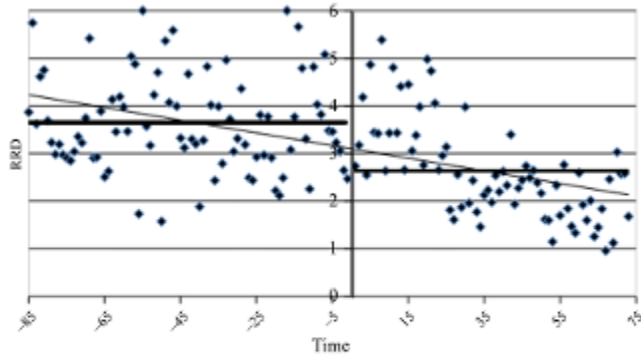
Our findings are consistent with the theoretical argument that traders adjust their trading behavior depending on the level of transparency. The evidence in this paper supports the view that greater transparency has a positive impact on market quality.

Figures



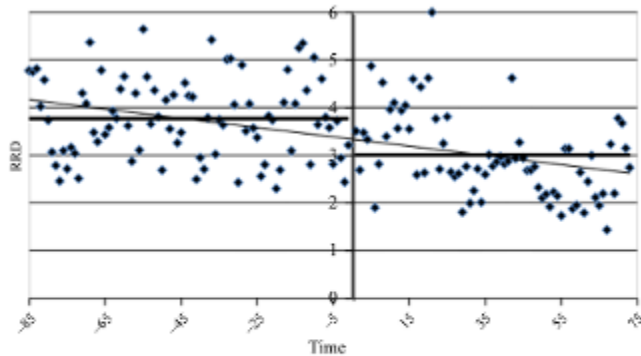
Notes: This figure reports the relative return dispersion (RRD) before and after the event. The period before the event ranges from September 1, 2001 to December 31, 2002; the period after the event ranges from January 2, 2003 to April 30, 2003. There are 100 large firms and 100 small firms in our sample. The RRD for day t is defined by $RRD_t = \frac{1}{N} \sum_{i=1}^N e_{it}^2$. Here e_{it} is the market model residual of stock i on day t . The market model is estimated separately for the pre-event period ($t=-85$ to $t=-1$) and post-event period ($t=0$ through $t=75$) and N is the number of stocks. The two horizon lines are the means for RRD before and after the event.

Figure 1 Relative return dispersion (All firms)



Notes: This figure reports the relative return dispersion (RRD) before and after the event. The period before the event ranges from September 1, 2001 to December 31, 2002; the period after the event ranges from January 2, 2003 to April 30, 2003. There are 100 large firms and 100 small firms in our sample. The RRD for day t is defined by $RRD_t = \frac{1}{N} \sum_{i=1}^N e_{it}^2$. Here e_{it} is the market model residual of stock i on day t . The market model is estimated separately for the pre-event period ($t=-85$ to $t=-1$) and post-event period ($t=0$ through $t=75$) and N is the number of stocks. The two horizon lines are the means for RRD before and after the event

Figure 2 Relative return dispersion (Large firms)



Notes: This figure reports the relative return dispersion (RRD) before and after the event. The period before the event ranges from September 1, 2001 to December 31, 2002; the period after the event ranges from January 2, 2003 to April 30, 2003. There are 100 large firms and 100 small firms in our sample. The RRD for day t is defined by $RRD_t = \frac{1}{N} \sum_{i=1}^N e_{it}^2$. Here e_{it} is the market model residual of stock i on day t . The market model is estimated separately for the pre-event period ($t=-85$ to $t=-1$) and post-event period ($t=0$ through $t=75$) and N is the number of stocks. The two horizon lines are the means for RRD before and after the event

Figure 3 Relative return dispersion (Small firms)

Table I Descriptive statistics from the Taiwan Stock Exchange

| | All firms | Large firms | Small firms |
|-------------------------------|-----------|-------------|-------------|
| Price | 28.54 | 37.08 | 20.00 |
| Volatility | 1.01 | 1.32 | 0.70 |
| Trading shares (in thousands) | 6,676 | 12,502 | 849 |
| Market value (in millions) | 31,033 | 60,242 | 1,824 |
| Number of stocks | 210 | 105 | 105 |

Notes: This table reports the mean values of daily closing price, volatility (the highest price minus the lowest price each day), daily traded shares (in thousands), and daily market value (in millions) for all stocks and for two sub-sample stocks. We sorted the firms listed on the TSEC based on their 2001 year-end capitalization and divided them equally into three groups. The top tercile (large firms) includes stocks with the largest capitalization, and the bottom tercile (small firms) is comprised of stocks with the smallest capitalization. Numbers reported are during the period September 1, 2002 to April 30, 2003

Table II Efficiency change around the event

| Measures of efficiency | Lag response (γ) | Firm-specific noise ($\text{var}(\epsilon)$) |
|------------------------|---------------------------|--|
| <i>Large firms</i> | | |
| Mean-before event | 0.046 | 5.456 |
| Mean-after event | -0.015 | 4.325 |
| Diff. | -0.061 | -1.131 |
| (t-value) | (-3.05***) | (-4.82***) |
| <i>Small firms</i> | | |
| Mean-before event | 0.095 | 5.765 |
| Mean-after event | 0.035 | 5.013 |
| Diff. | -0.060 | -0.752 |
| (t-value) | (-2.96***) | (-2.68***) |

Notes: The market model $R_{it} = \alpha_i + \beta_i \cdot RM_t + \gamma_i \cdot RM_{t-1} + \epsilon_{it}$ is estimated using the OLS firm by firm before and after the transparency event. Here, R_{it} is the daily return on stock i on day t ; RM_t is the market return on day t ; ϵ_{it} is the residual term; and α_i is the intercept term. The β_i and γ_i are the coefficients of current market return and lag market return, respectively. The pre-event period is from September 1, 2001 to December 31, 2002. The post-event period is from January 2, 2003 to April 30, 2003. There are 105 large firms and 105 small firms in our sample. The means of the estimated coefficient γ and the variance of residual term are calculated across all firms. Differences that are significantly different from 0 are denoted by *, **, *** Significant at the 10, 5 and 1 percent significance levels, respectively

Table III Descriptive statistics for price discovery

| Variables | Cumulative impulse response (1) | Trade-related standard deviation (2) | Quote-related standard deviation (3) | Price discovery (4) |
|-----------------------------|---------------------------------|--------------------------------------|--------------------------------------|---------------------|
| <i>Panel A: overall</i> | | | | |
| Before event | 16.09 | 7.79 | 60.89 | 68.68 |
| After event | 15.71 | 12.45 | 59.25 | 71.70 |
| Diff. | -0.48 | 4.66 | -1.46 | 3.02 |
| | 0.02 | 3.58*** | 1.06 | 1.67 |
| <i>Panel B: large firms</i> | | | | |
| Before event | 3.86 | 3.30 | 77.28 | 80.58 |
| After event | 5.73 | 4.97 | 64.99 | 69.96 |
| Diff. | 1.87 | 1.67 | -12.29 | -10.62 |
| | (2.74***) | (3.03***) | (-3.15***) | (-3.02***) |
| <i>Panel C: small firms</i> | | | | |
| Before event | 32.51 | 13.82 | 38.89 | 52.71 |
| After event | 31.20 | 24.07 | 50.34 | 74.40 |
| Diff. | -1.31 | 10.25 | 11.45 | 21.69 |
| | (0.07) | (1.38) | (1.92*) | (2.85***) |

Notes: This table reports the trade-related standard deviation, quote-related standard deviation, and the sum of the both for the pre-event and post-event period. The period before the event ranges from September 1, 2001 to December 31, 2002. The post-event period ranges from January 2, 2003 to April 30, 2003. The numbers in the table are the means before and after the event, respectively. The unit is

the basis point. There are 105 large firms and 105 small firms in our sample. In parentheses are t -values, and symbols **,***Mean significant at 5 and 1 percent significance levels, respectively

Table IV Panel regressions for price discovery

| Dependent variable | Cumulative impulse response (1) | Trade-related standard deviation (2) | Quote-related standard deviation (3) | Price discovery (4) |
|-----------------------------------|---------------------------------|--------------------------------------|--------------------------------------|---------------------|
| <i>Panel A: fixed effects</i> | | | | |
| Panel A: overall | | | | |
| Dummy estimate | -4.70 | 3.99 | 2.68 | 6.67 |
| t -value | (-0.59) | (1.33) | (1.01) | (1.54) |
| <i>Panel B: large firms</i> | | | | |
| Dummy estimate | 2.17 | 1.99 | -4.70 | -2.70 |
| t -value | (2.99***) | (3.32***) | (-1.88) | (-1.00) |
| <i>Panel C: small firms</i> | | | | |
| Dummy estimate | -10.50 | 8.65 | 15.05 | 23.70 |
| t -value | (-0.54) | (1.20) | (2.80***) | (2.45**) |
| <i>Panel B: control variables</i> | | | | |
| Panel A: overall | | | | |
| Dummy estimate | -4.70 | 4.12 | 2.84 | 6.96 |
| t -value | (-0.59) | (1.33) | (1.34) | (1.89*) |
| <i>Panel B: large firms</i> | | | | |
| Dummy estimate | 3.30 | 3.01 | -6.60 | -3.59 |
| t -value | (4.89***) | (5.40***) | (-1.88) | (-1.12) |
| <i>Panel C: small firms</i> | | | | |
| Dummy estimate | 2.46 | 10.70 | 17.30 | 28.00 |
| t -value | (0.13) | (1.48) | (3.24***) | (2.67**) |

Notes: This table reports the panel regression results for the trade-related standard deviation, quote-related standard deviation, and the sum of the both. The panel regressions are performed on daily measures for each stock. The period before the event ranges from September 1, 2001 to December 31, 2002. The post-event period ranges from January 2, 2003 to April 30, 2003. The Panel A model is: $\Sigma_{it} = \alpha_i + \beta VO_t + \gamma D_t + \varepsilon_{i,t}$. The Σ is trade-related standard deviation, quote-related standard deviation, or the sum of them. VO is market-wide volatility, which is measured as the highest price minus the lowest price each day. D is a dummy variable whose value is 1 if after the event, otherwise 0. The Panel B model is:

$$\sum_{it} = \alpha + \beta VO_t + \gamma D_t + \sum_{k=1}^4 \varphi_k \text{Contrls}_{i,k,t} + \varepsilon_{i,t}.$$

The Contrls are control variables, including the logarithm of daily price, logarithm of daily turnover rate, daily volatility (the highest price minus the lowest price for each day), logarithm of market capitalization, book-to-market ratio and momentum. In panel A model, the fixed effects are considered. In Panel B, the control variables are included. The unit is the basis point. There are 105 large firms and 105 small firms in our sample. *, **, *** Significant at 10, 5 and 1 percent levels, respectively

Notes

1. Eom *et al.* (2007) find that traders will adjust their investment behaviors in response to changes in transparency and then the adjustment of investment behaviors impacts the quality of markets.
2. See TSEC's 2003 Fact Book.
3. Literature has shown institutional investors prefer large stocks. For example, using the US stock market data, Gompers and Metrick (2001) find institutional investors increase demand for the stock of large companies and decrease demand for the stock of small companies. Ferreira and Matos (2008) examine the role of institutional investors around the world (27 countries) and find that all institutional investors, whatever their geographic origin, share a preference for the stock of large and widely held firms.
4. In an alternative specification, in Equation (2) we also control other variables such as market capitalization, book-to-market ratio, the cumulative returns in the last three month and stock turnover.
5. Following Hasbrouck (1991b), the lagging three periods are employed.
6. The stock subscript j is omitted from now on.
7. We follow Lee and Ready's (1991) procedure to compare traded price with quotes. If the traded price is larger than the midpoint of the bid and ask quotes, then it is assumed that the transaction is initiated by the buyer and the value of x_{jt} is 1. If the traded price is smaller than the midpoint of the bid and ask quotes, then it is thought that the transaction is initiated by the seller and the value of x_{jt} is -1.
8. Public information is not always reflected into stock prices immediately. For example, using the US stock market data, Hirshleifer and Teoh (2003) and Drake *et al.* (2012) argue that new information in public disclosures is not impounded into stock prices instantaneously but rather is disseminated to investors gradually due to investors' limited attention and the significant information processing costs. While institutions may have better resources for obtaining private information, they are still constrained by limited financial resources and attention span. Thus, institutions must optimize their information acquisition activities because of the costs of information acquisition as predicted by Grossman and Stiglitz (1980).

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