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Tick-Size Change and Spread Components on the Taiwanese Stock Market

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Abstract

This paper investigates the effect of the decrease in tick size that occurred in the Taiwanese stock market in 2005 on spread components. Employing a methodology proposed by Lin, Sanger and Booth (1995) and using rigorous investigation techniques, this study provides a better understanding of emerging order-driven markets. The empirical results show that information asymmetry costs and order processing costs have indeed decreased after the tick-size reduction. We further find that stocks with greater binding-constraint probability experience larger declines in information asymmetry. Besides, stocks traded frequently experience large declines in information asymmetry and order processing costs.

Keywords: Binding-constraint probability; Information asymmetry cost; Order processing cost; Tick-size reduction
JEL Classification Codes: G14; G15

1. Introduction

In recent years, many stock exchanges have reduced the tick size to enhance market competitiveness[1]. Many empirical studies have examined the effect of tick-size reduction on trading costs, with the results indicating that the spread decreases after the tick-size reduction. Generally, spread is a proxy for evaluating market liquidity, with market liquidity increasing when the spread decreases, and market liquidity seems as an important factor in determining the cost of capital (Brockman and Chung, 1999).

[1] For example, the Tokyo Stock Exchange in July, 2000, the New York Stock Exchange (NYSE) in January, 2001, and the NASDAQ in April, 2001.

Hence, it is important for investors and managers to further understand the effect of tick-size reduction on spread components.

In recent years, some scholars have attempted to explain the effect of tick-size reduction on the changes of spread components (Bacidore, 1997 and 2001; Bessembinder and Kaufman, 1997; Gibson et al., 2003; Chakravarty et al., 2005). Most studies focus on the effects of information asymmetry components. Bacidore (1997), for example, claims that spread is reduced after a tick-size reduction and that declines in adverse selection costs made up larger parts of declines of spreads, which is consistent with the findings presented by Bessembinder and Kaufman (1997). Bacidore (2001) further defines adverse selection costs as the difference between the effective spread and the realized spread, showing that after a tick-size reduction, investors spend less time gathering precise information because transactions become less informative. It follows that most declines in spreads can be attributed to declines in information asymmetry costs. By examining the changes of adverse selection costs around NYSE decimalization, Chakravarty et al. (2005) also find similar results, suggesting that adverse selection costs are reduced, while adverse selection components increase. They ascribe the different results to significant changes in spreads. However, by conducting the impact of decimalization during the study periods, 2001-2002, on the information asymmetry using the S&P 500 stock, Gibson et al. (2003) show that, due to increased competition caused by a reduced tick size, almost all the decreased portions in the spreads are a result of a decrease in order processing costs. They also find that inventory holding costs and information asymmetry costs still account for a significantly large proportion of the spreads after the tick-size reduction. They describe this result as evidence that stock prices are constrained by tick size; therefore, they do not reflect the true price. Summarising the above discussions, they all focus on developed quote- (hybrid-) driven markets, but not emerging order-driven markets.

To bring the Taiwanese stock market into conformity with international practices and to compete more effectively with other markets, the Taiwan Stock Exchange Corporation (TSEC) also adjusted tick sizes on March 1st, 2005. This study investigates the impact of tick-size reduction on spread components in the TSEC.

Our empirical results show that both information asymmetry costs and order processing costs decrease after the tick-size reduction, as reported by Bacidore (2001) and Gibson et al. (2003). This may be due to relaxations on the binding constraints. Next, the reasons for the declines in information asymmetry costs and order processing costs are also investigated. The declines in information asymmetry costs are larger for those stocks that are low risk or have a low price but are actively traded. On the other hand, only stock price positively correlates to changes in order processing costs. Consequently, after the concurrent changes in stock characteristics are controlled, stocks with more pre-period binding constraints experience larger declines in information asymmetry costs and order processing costs. This may be due to relaxations of the binding constraints.

The remainder of this paper will be structured as follows. The next section introduces background information on the TSEC and its implementation of tick-size reduction on March 1st, 2005. Section 3 reviews related literature and develops hypotheses. Section 4 presents the data and research methodology, while Section 5 provides and discusses the empirical results. The final section concludes the paper.

2. Institutional Background

The TSEC is an electronic order-driven market where individual investors account for 70% of the trading values. The quotes in the TSEC are only completed through public limit orders. The prices quoted by investors are input into, displayed and matched with a fully automated computerized trading system. The minimum trading unit is 1,000 shares. There are five trading days (Monday to Friday) in a week on the TSEC. The orders are fed into the computerized trading system at 8:30 a.m. but are not executed until trading begins at 9:00 a.m. The opening price is the price that maximizes the trading volume. Concerning the closing price, all orders are accumulated in an order book during the pre-closing period from 1:25 to 1:30 p.m., with the closing price determined by means of a call auction at 1:30 p.m. During this trading process, order and trading information are revealed to the public on real-time integrated terminals.

TSEC is an order-driven market, with the public limit order being the only type of order on the market, which is conducted based on the price-time rule. Further, the TSEC adopts a multiple tick-size system, with different tick sizes for different price ranges, as shown in Table 1. Shares with higher prices have larger tick sizes. There are, in total, six tick-size regimes. The relative tick size (tick size divided by stock price) of the pre-reduction period is between 0.20%~1.00%, while the relative tick size for the post-reduction period is between 0.1%~0.5%.

Table 1: Tick-Size Rule before and after Tick-size reduction

Regime		**1**	**2**	**3**	**4**	**5**	**6**
Tick size (NT$)		0.01	0.05	0.1	0.5	1	5
Price range	Pre-period	[0,5)	[5,15)	[15,50)	[50,150)	[150,1000)	[1000, ∞)
(NT$)	Post-period	[0,10)	[10,50)	[50,100)	[100,500)	[500,1000)	[1000, ∞)

* The pre-period runs from September 1, 2004 to February 28, 2005, while the post- period runs from March 7 to August 31, 2005.

3. Literature Review and Hypothesis Development

3.1. Spread Components

As a smaller tick size will reduce the costs of orders jumped in front to a smaller tick size increases stepping ahead risk, giving informed investors less incentive to gather additional information and further improve the quality of the information. Besides, tick-size reduction leads to a decrease in the number of binding constraints (Bourghelle and Declerck, 2004; Ap Gwilym, McManus and Thomas, 2005), and, as a result, trading information will be disseminated more efficiently due to relaxation of the binding constraints. Hence, the extent of information asymmetry among investors is expected to decrease after the tick-size reduction. Besides, according to definitions proposed by Copeland and Stoll (1990), order processing costs include the following items: (1) the clerical costs of carrying out a transaction; (2) the costs of the dealer’s time; (3) the costs of physical communications; and (4) office equipment necessary to carry out the transaction. In the short run, most parts of the order processing costs are fixed, with the exception of the order processing time. Just as price discreteness was reduced after the 2005 tick-size reduction, time in order matching also decreased, leading to a decrease in order processing costs. Besides, the magnitudes of declines in the information asymmetry costs are expected to be larger than those for order processing costs. With this in mind, we suggest the following hypotheses:

H1: Both information asymmetry and order processing costs decrease after the tick-size reduction.

H2: Declines in information asymmetry costs are larger than those in order processing costs

3.2. Probability of Binding Constraints

If the tick size is larger than the equilibrium spread, the spread will be constrained by the tick size, causing inefficiency in information dissemination. Hence, trading information will be distorted by a larger tick size. So the magnitude of information asymmetry is expected to positively correlate with the binding constraints. Furthermore, after the relaxation of the binding constraints, trading information can be relayed more effectively. Apart from this, due to a decrease in the relative profits per share, informed traders will not precisely evaluate the spread, reducing the degree of information asymmetry. Hence, stocks with more pre-period binding constraints are expected to have experienced larger declines in information asymmetry. Bacidore (2001) also finds similar empirical results in the NYSE. Therefore, our third hypothesis is:

H3: Stocks with more pre-period binding constraints experience larger declines in information asymmetry.

4. Data, Variable Measures and Descriptive Statistics

4.1. Data

As stated previously, the adjustment of the tick size was implemented on March 1st, 2005. Our data covers September 1st, 2004 to August 31st, 2005, yielding a total of 244 trading days. To control any unusual trading behaviour associated with the reduction, data from March 1st, 2005 to March 6th, 2005 is excluded. The pre-reduction period (hereinafter referred to as pre-period) is from September 1st, 2004 to February 28th, 2005, including 120 trading days, while the post-reduction period (hereinafter referred to as post-period) is from March 7th, 2005 to August 31st, 2005, including 124 trading days. Intraday transaction and quote data are used to examine the effects that the tick-size reduction had on the spread components. These data are drawn from the Taiwan Economic Journal (*TEJ*) database and only includes common stocks.

In the TSEC, stocks in different price regimes apply to different tick sizes. After the adjustment of price regimes and tick sizes in March 2005, the tick size of around 260 stocks decreased. This was based on the following exclusion criteria, (1) The firm was delisted, experienced stock splits, or temporary trading halts over the sample periods; (2) The highest or lowest prices underwent a price group shifted from one tick size regime to another during the pre- or post-period; (3) The daily number of transactions was fewer than 10 (Van Ness, Van Ness and Warr, 2001); and (4) The best quotes had missing values. Moreover, because the opening and closing prices are determined through batch trading, the trading mechanism during the opening and closing periods is different from that during the rest of the trading day (Biais, Hillion and Spatt, 1995). Therefore, the opening and closing prices during each trading day are excluded. After satisfying the above criteria, the final "event group" sample experiencing a tick-size reduction consisted of 192 stocks.

The sample is split into Group 1, whose tick size was changed from 0.05 to 0.01, and Group 2 from 0.1 to 0.05. The numbers of stocks for Groups 1 and 2 are 45 and 147, respectively. To avoid possible effects resulting from other contemporaneous market forces on the results, stocks whose tick size remained unchanged (tick size is 0.05) are used as the control group. Based on the selection criteria described above, the total number of stocks in our control sample is 25.

4.2. Measurement of the Variables

4.2.1. Spread Components and Binding Constraints

Many empirical studies use different models to decompose the spread components. By comparing their performance in the NYSE, Van Ness et al. (2001) argue that the spread decomposition model proposed by Lin et al. (1995) performs better than other models. Therefore, this model (Lin et al., 1995) will be employed to decompose the spread components.[2] The spread components are obtained using the following ordinary least square model:

$$Q_{t+1} - Q_t = \lambda Z_t + e_{t+1} \tag{1}$$

$$Z_{t+1} = \theta Z_t + \eta_{t+1} \tag{2}$$

and

$$P_{t+1} - P_t = -\gamma Z_t + u_{t+1} \tag{3}$$

2 Lin et al. (1995) estimate spread components and order persistence in the NYSE, while ignoring inventory holding costs, with the empirical results showing that order processing components are larger than information asymmetry components. Applying the same model to a sample taken from the Stock Exchange of Hong Kong (SEHK), Brockman and Chung (1999) also found the same results reported by Lin et al. (1995).

where Q_t denotes the bid-ask spread midpoint (in logarithms) at time t; Z_t is the logarithm-transformed difference between the trade price and the bid-ask spread midpoint; P_t denotes the logarithm-transformed transaction price; λ is the information asymmetry measure; θ reflects the order persistence (the pattern of order arrivals) which denotes that the order's trading direction is serially correlated, i.e., buy (sell) orders follow buy (sell) orders; the order processing component is defined as $\gamma = 1 - \lambda - \theta$; and e_t, η_t and u_t are normally distributed error terms and uncorrelated to each other. Only those estimates (λ, θ, and γ) that lie between 0 and 1 are included, because the estimates outside this range are not economically meaningful.

However, if the spreads change significantly, the information asymmetry components may give rise to misleading conclusions about the adverse selection components (Chakravarty et al., 2005). Therefore, in order to avoid this, the spread costs can be calculated as the spread components multiplied by the mean daily quoted spreads (e.g., the order processing costs can be defined as γ times the mean quoted spreads). Furthermore, binding constraints are measured as the proportion of quoted spreads, the differences between ask and bid quotes, that are equal to one tick size (Chung et al., 2004).

The spread components (costs) for each stock are calculated on the basis of the following stages. First, the daily estimates can be obtained by using the above regression equations. Next, the pre- and post-period estimates for each stock are obtained by averaging the estimates across individual trading days. Finally, the pre- and post-means are obtained by averaging the estimates of each stock across all stocks. Also, concerning the binding constraints, the values are averaged by using trade-by-trade data to obtain the daily averages. The pre- (post-) period estimates for each stock and the pre- (post-) means are obtained using similar methods as the spread components.

4.2.2. Other Explanatory Variables

Prior studies (e.g., Van Ness et al., 2001; Huang, 2004) argue that the following variables are important in explaining the variations in spread components, including stock price (*P*); market capitalisation (*MV*); trading volume (*VOL*); number of trades (*N*); trade size in dollars (*TD*); trade size in shares (*TS*); and stock return volatility (σ).The values are averaged across the pre-period (post-period) trading days to obtain the pre-period (post-period) mean of each stock. Furthermore, the pre- (post-) means are obtained by averaging the estimates of each stock across all individual stocks.

(a) Stock Price

As low-priced stocks are more constrained by tick size (Chung et al, 2004), they are usually expected to have larger information asymmetry. After a tick-size reduction, the severity of the binding constraints was reduced, especially for low-priced stocks (Chung et al., 2004), thereby enhancing information disseminations. We expect that low-priced stocks in TSEC have experienced larger declines in information asymmetry since March 1st, 2005. Gibson et al. (2003) also found similar results in the NYSE.

(b) Market Capitalisation

Firms with larger market capitalisation are much more well-known and attract significant attention from investors and analysts (Merton, 1987; Harris, 1994; Van Ness et al., 2001). These firms have to disclose their trading information to investors more frequently, thereby enabling investors to obtain frequently updated trading information (Bhushan, 1989). As a result, the degree of information asymmetry should be relatively lower for these larger firms, and due to the relaxation on binding constraints, declines in information asymmetry for firms with larger market capitalisation are expected to be even larger than those with smaller market capitalisation after a tick-size reduction, as reported by Bacidore (2001).

(c) Trading Volume

Stocks with a low trading volume lack market liquidity. Due to a lack of market liquidity order matching needs more time, leading to larger order processing costs. Hence, Hasbrouck (1988) indicates that order processing costs decrease when there is an increase in trading volume. Along similar lines, Huang (2004) investigates spread components in the Taiwan Futures Exchanges and claims that order processing costs are negative with the trading volumes because of economies of scale. Furthermore, stocks with low trading volume are more easily constrained by tick size (Hasbrouck, 1988), and therefore, trading information cannot be revealed through the market. This means that information asymmetry is expected to be negative with increasing trading volume (Lin et al., 1995; Brockman and Chung, 1999; Van Ness et al., 2001). As the magnitudes of binding constraints reduce after tick-size reduction, the extent of information asymmetry decreases (Gibson et al., 2003). Accordingly, the magnitudes of the declines in information asymmetry and order processing costs are expected to positively correlate with trading volume.

(d) Trading Activity

In general, three variables, including number of trades, trade size in dollars and trade size in shares, are usually used as the proxies of trading activity. In the short run, order processing costs are fixed, and thus, the average order processing costs decline as trade size increases (Lin et al., 1995). In this regard, Huang (2004) also adds that an increase in the number of transactions can lead to economies of scale, resulting in lower order processing costs. This paper expects that stocks that are traded frequently in Taiwan must have experienced larger declines in order processing costs. Additionally, because stocks that are traded frequently are usually more constrained by tick size (Harris, 1994), information asymmetry among investors is high. Therefore, after the relaxation of binding constraints, declines in information asymmetry are expected to positively correlate to trading activity. On the other hand, Bacidore (2001) defines trade size in shares as the proxy of trading activity and also finds the same results. Therefore, stocks that are traded frequently are expected to experience larger declines in information asymmetry after the tick-size reduction in the TSEC.

(e) Stock Return Volatility

Stocks with a high risk mean that the stock price is easily affected by additional information, and hence, information about these stocks exhibits high uncertainty. Van Ness et al. (2001) indicate that stocks with high information uncertainty usually experience larger information asymmetry. For this reason, the relations between information asymmetry and risk are expected to be positive. Furthermore, as a smaller tick size can reduce the bid-ask bounce, the degree of uncertainty about trading information decreases (Harris, 1994). Hence, it is expected that high-risk stocks experience larger declines in information asymmetry after the tick-size reduction.

4.3. Cross-sectional Analysis

The ratio for the post-event measure to the pre-event measure is used as the measurement of change, with the logarithm transformation used to reduce the influence of outliers (Smith, Turnbull and White, 2006). The *LTR* (Liquidity Trading Ratio) is defined as follows:

$$LTR_i = \ln(\overline{X}_{i,post} / \overline{X}_{i,pre}) , \tag{4}$$

where $\overline{X}_{i,pre}$ denotes the average measure of stock i during the post-period.

This study uses the t-test to investigate the alternative hypothesis that *LTR* is smaller than zero.[3] If one of the following conditions is satisfied, the spread costs indeed decrease after the tick-size reduction in the TSEC: (1) The *LTR* in the event group is significantly less than zero while the *LTR* in

[3] This study confirms that changes in these variables, including spread components, stock characteristics and binding constraints, follow the normal distribution using the Shapiro-Wilk test or Kolomogorov-Simirnov test. Therefore, the t-test is used in this study.

the control group is not significantly less than zero, or (2) The declines of *LTR* in the event group are significantly larger than the declines of *LTR* in the control group, while both the *LTR* values in the event and control groups decrease.

4.4. Descriptive Statistics for Stock Attributes

Table 2 provides descriptive statistics for changes in spreads, binding constraints and stock attributes for stocks in the event (Groups 1 and 2) and control (Group 3) samples. The results indicate that after the tick-size reduction all the stock characteristics in the event groups decline, especially in Group 1, but increase in the control group. For example, the declines in daily trading volume in Group 1 are larger than those in Group 2. Moreover, stock return volatility in the event group also decreases after the tick-size reduction. Therefore, the degree of information uncertainty after the tick-size reduction is expected to be lower than that before the reduction periods - especially in the case of low-priced stocks. At the same time, because the spread and the trading volume decrease after the tick-size reduction, adverse selection costs may be in effect (Chakravarty et al., 2005). Furthermore, declines in the binding constraints are large in the case of low-priced stocks, suggesting that trading information can be quickly disseminated more efficiently in the case of low-priced stocks. Therefore, declines in information asymmetry are expected to have been large for low-priced stocks.

5. Empirical Results

5.1. Summary Statistics of Spread Costs

The spread components may be misleading in situations where the spread changes significantly (Chakravarty et al., 2005). The results in Table 2 show that the spread changes significantly, with the magnitudes of the declines in the spreads being about 69% and 47% respectively. Therefore, the order processing components and the information asymmetry components are only shown but not reported here. In accordance with Panels A and B in Table 3, the relative declines in information asymmetry costs (order processing costs) in Group 1 are 75.32% (70.92%), which are larger than those in Group 2, where the declines are approximately 44.7% (45%). The analytical results show that after the tick-size reduction, both information asymmetry costs and order processing costs have decreased and declines in information asymmetry costs are larger than those in order processing costs.[4] Thus, Hypotheses 1 and 2 are fully supported. Furthermore, the declines in information asymmetry costs in Group 1 are larger than those in Group 2, which is consistent with our previous expectation that the low-priced stocks experience large declines in information asymmetry costs. Besides, no matter if it is in the pre- or post-period, information asymmetry costs are larger than order processing costs.

Table 2: Descriptive Statistics of Changes in Spread, Binding Constraints and Stock Characteristics
This table shows the descriptive statistics of the changes in the event and control sample. The difference is calculated as *ln* (post-period mean/ pre-period mean). Group 1 refers to the stocks whose tick size changed from 0.05 to 0.01, while Group 2 indicates the stocks whose tick size changed from 0.1 to 0.05. Group 3 consists of the stocks whose tick size remains the same (0.05) in both the pre- or post-periods.

	Group 1	Group 2	Group 3
Panel A. Spread and binding- constraint probability (%)			
Quoted spread	-69.01**	-46.89**	-7.33*
Binding-constraint probability (*Bind*)	-89.82**	-27.77**	19.39
Panel B. Stock characteristics (%)			

[4] Although the magnitudes of the changes in spread costs in the control group also decline significantly, the values are small. Using a two sample t-test, the results show that the declines in Group 1 are significantly larger than those in the control group (Group 3). The difference is statistically significant different from zero. The results are omitted for the sake of brevity but are available upon request.

Daily share volume (*VOL*)	-56.77**	-12.79*	28.08
Market capitalization (*MV*)	-16.11**	-1.70	8.42
Daily number of trades (*N*)	-23.40**	-5.53**	8.59
Trade size in dollars (*TD*)	-6.56**	-1.07	0.94
Trade size in shares (*TS*)	-74.3**	-17.65**	37.30
Return volatility (σ)	-13.81**	-6.68**	9.01
Sample size	45	147	25

* and ** indicate significance at the 0.05 and 0.01 levels , respectively.

5.2. Regression Results

In order to avoid problems of multi-collinearity, only the following five variables are included: stock price (*P*); number of trades (*N*); trade size in shares (*TS*); return volatility (σ); and binding constraints (*Bind*). Because the stock price in Group 1 is lower than that in Group 2, stock price is correlated with the group. Therefore, the dummy variables are omitted and the variable "*P*" is used instead. Coefficients in the following regression analysis have been adjusted by applying White's correction.

Table 3: Descriptive statistics for the spread components (costs)
This table shows the descriptive statistics of the spread components (costs) in the event and control groups. The spread component decomposition is measured using the model proposed by Lin et al. (1995). The difference is calculated as ln (post-period mean/ pre-period mean). The pre-period is from September 1, 2004 to February 28, 2005, and the post-period is from March 7, 2005 to August 31, 2005. The t-test is used to examine the alternative hypothesis that the mean difference is less than 0. Group 1 indicates the stocks where tick size changed from 0.05 to 0.01. Group 2 indicates the stocks where tick size changed from 0.1 to 0.05. Finally, group 3 indicates the stocks where the tick size was the same (0.05) no matter if it is in the pre- or post-period.

		Group 1	Group 2	Group 3
Panel A. Order processing				
Components (%)	Pre-period	18.5101	16.9875	18.6669
	Post-period	18.4013	16.9459	18.1284
	Difference	0.9121	1.7356	-2.3844
Components*spread (NTD)	Pre-period	0.0106	0.0215	0.0130
	Post-period	0.0056	0.0140	0.0116
	Difference (%)	-70.9245**	-45.0456**	-9.5202**
Panel B. Information asymmetry				
Components (%)	Pre-period	55.6815	56.8361	53.4391
	Post-period	52.9601	58.5035	53.9113
	Difference	-5.3687**	2.7442**	0.0935
Components*spread (NTD)	Pre-period	0.0316	0.0720	0.0365
	Post-period	0.0154	0.0459	0.0340
	Difference (%)	-75.3211**	-44.7047**	-6.5203**

* and ** indicate significance at the 0.05 and 0.01 levels, respectively.

5.2.1. Changes in Spread Costs on Pre-period Stock Characteristics and Binding Constraints

While the previous results in Section 5.1 indicate that spread costs (*Y*) decrease after a tick-size reduction, a relevant concern is that the reduction may not be directly attributable to the tick-size reduction. That is, confounding effects may have driven the level changes and led to mixed results. Therefore, in order to avoid confounding effects, the multiple regression analysis in Model (5) is used to investigate the relation again. The model is expressed as:[5]

$$\Delta Y = \alpha_0 + \alpha_1 \ln(P_{pre}) + \alpha_2 \ln(N_{pre}) + \alpha_3 \ln(TS_{pre}) + \alpha_4 \ln(\sigma_{pre}) + \alpha_5 Y_{pre} + \varepsilon \ , \quad (5)$$

5 Based on the indication of Chung et al. (2004), the pre-period variables are used in order to avoid the endogenous problems.

where Δ is defined as the relative mean difference between the pre- and post-period values (ln (post-period mean/ pre-period mean)). Y_{pre} represents the pre-period spread costs, including order processing cost and information asymmetry cost.

As shown in Table 4, after including more explanatory variables, the signs for the variables are all consistent with our expectations, although some coefficients are insignificant. For example, the magnitudes of the declines in the information asymmetry costs and order processing costs positively correlate with stock prices, indicating that the magnitudes of the changes in the order processing and information asymmetry costs are larger for low-priced stocks due to relaxations caused by the binding constraints. The negative coefficient for the number of trades indicates that frequently traded stocks experience larger declines in information asymmetry costs, possibly because related information may be revealed via trading. Additionally, high-risk stocks also experience a low reduction in information asymmetry costs. After controlling the pre-period stock characteristics, we find that stocks with greater pre-period information asymmetry experience large declines in information asymmetry. Similar results are also obtained for order processing costs.

Table 4: Regression analysis for the magnitudes of changes in spread costs
This table provides the regression analyses for the changes in spread costs on pre-period stock characteristics and spread costs. The dependent variables are the changes in spread costs. The independent variables are the pre-period variables, including the average daily stock price (*P*); average daily number of trades (*N*); average trade size in shares (*TS*); and standard deviation of stock return (σ).

	intercept	*Ln (P_{pre})*	*Ln (N_{pre})*	*Ln (TS_{pre})*	*Ln (σ_{pre})*	X_{pre}	*Adj R^2 (%)*
Panel A: Dependent variable - Order processing costs							
(1)	-0.9408**	0.2250**	-0.0268	-0.0057	-0.0646		19.16
(2)	-0.7108**	0.3507**	-0.0875	-0.0367	0.0005	-10.6736**	22.46
Panel B: Dependent variable - Information asymmetry costs							
(1)	-0.7162**	0.2799**	-0.0987**	-0.0661	0.1779**		42.30
(2)	-0.9005**	0.4943**	-0.1149**	-0.0917	0.2505**	-5.4838**	62.97

* and ** indicate significance at the 0.05 and 0.01 levels, respectively.

5.2.2. Changes in spread costs with pre-period binding constraints and spread costs

To obtain robust results, the effects of the magnitudes of spread costs on pre-period binding constraints and spread costs are examined after controlling for concurrent changes in the stock characteristics. The regression model is formulated as follows:

$$\Delta Y = \beta_0 + \beta_1 D_1 + \beta_2 \ln(\frac{P_{post}}{P_{pre}}) + \beta_3 \ln(\frac{N_{post}}{N_{pre}}) + \beta_4 \ln(\frac{TS_{post}}{TS_{pre}}) + \beta_5 \ln(\frac{\sigma_{post}}{\sigma_{pre}}) + \beta_6 Bind_{pre} + \beta_7 Y_{pre} + \varepsilon \quad (6)$$

where D_1 equals 1 if the tick size changes from 0.1 to 0.05; otherwise D_1 equals 0.

As shown in Table 5, the relations between the declines in spread costs with the concurrent changes in stock characteristics are investigated. The results show that changes in stock price and trade size in shares are significant positively correlated to the changes in spread costs, no matter whether it is order processing costs or information asymmetry costs. Additionally, the coefficient "D_1" is significantly positive, indicating that low-priced stocks are more easily constrained by tick size, reconfirming the larger declines in information asymmetry in low-priced stocks. Finally, even if the concurrent changes of stock characteristics are investigated, the results where the coefficients of the intercept are still negative support that the order processing costs and information asymmetry costs indeed decrease after the tick-size reduction in the TSEC.

Besides, after the concurrent changes in stock characteristics are investigated, the declines in information asymmetry costs are still significantly affected by the pre-period binding constraints and the extent of information asymmetry, which supports Hypothesis 3.

Table 5: Changes in spread costs with pre-period binding constraints and spread costs
This table provides the regression analyses for the changes in spread costs on pre-period binding constraints and spread costs after the concurrent changes in stock characteristics are controlled for. The independent variables are the changes in average daily stock price (*P*); average daily number of trades (*N*); average trade size in shares (*TS*); standard deviation of stock return (σ); pre-period binding-constraints ($Bind_{pre}$), and pre-period spread costs (X_{pre}). D_1 equals 1 for group 2, and 0 for group 1. X_{pre} is the pre-period dependent variables, e.g., X_{pre} in Panel A is the pre-period order processing costs.

	intercept	D_1	Δ *Ln (P)*	Δ *Ln (N)*	Δ *Ln (TS)*	Δ *Ln* (σ)	$Bind_{pre}$	X_{pre}	*Adj* R^2 *(%)*
Panel A: Dependent variable - Δ order processing costs									
(1)	-0.6838**	0.2389**	0.4595**	-0.2108**	0.3291	0.2129*			26.52
(2)	-0.3978*	0.2270**	0.5407**	-0.2510**	0.3098	0.2513**	-0.3294		29.63
(3)	-0.7221**	0.2097**	0.4815**	-0.2320**	0.3088	0.2318**		-3.1037	26.92
(4)	-0.0509	0.2834**	0.5636**	-0.2385**	0.3389	0.2427**	-0.6275	-7.1414	30.59
Panel B: Dependent variable - Δ information asymmetry costs									
(1)	-0.6850**	0.2494**	0.4505**	-0.0897*	0.3466*	0.1074			29.60
(2)	-0.4618	0.2400**	0.5140**	-0.1211*	0.3315*	0.1374	-0.2571		31.41
(3)	-0.5984**	0.3900**	0.3457*	-0.0722	0.2968**	0.0915		-3.1816**	37.65
(4)	0.9131**	0.6561**	0.4797**	-0.2168**	0.0946	0.2321**	-1.5137**	-10.4460**	69.70

* and ** indicate significance at the 0.05 and 0.01 levels , respectively.

6. Conclusions

Unlike previous research focusing on quote-driven stock markets in developed countries, this study seeks to further provide insights regarding the potential effects of tick-size reduction on spread components in the specific context of an emerging order-driven stock market. Our sample offers unique opportunities to examine the effects following a tick-size reduction in Taiwan.

Consistent with our prior expectation, both the information asymmetry costs and order processing costs have decreased after the tick-size reduction, indicating that a tick-size reduction can reduce the value of precise information concerning appropriate spreads and order processing time. Consequently, stocks with more pre-period binding constraints experience large declines in information asymmetry costs after a tick-size reduction.

Next, we examined the sources of the declines in the information asymmetry costs and order processing costs. The declines in the information asymmetry costs are large for those stocks that are low risk or have a low price but are actively traded. For example, low-priced stocks experience large declines in information asymmetry costs and order processing costs due to relaxations caused by the binding constraints. In addition, trading information can be disseminated more efficiently after the relaxation of the binding constraints, with the stocks that are traded frequently experiencing large declines in information asymmetry. Similarly, order processing costs decrease with the number of trades because of scale economies.

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