Int. J. Financial Stud. **2014**, *2*, 203–219; doi:10.3390/ijfs2020203

OPEN ACCESS
International Journal of
Financial Studies
ISSN 2227-7072
www.mdpi.com/journal/ijfs

Article

Does Trading by Small Investors Improve or Deteriorate Price Efficiency? Evidence from the Minimum Trade Unit Changes on the Korea Exchange

Hee-Joon Ahn

Business School, Sungkyunkwan (SKK) University, 3-53, Myungryun-dong, Jongno-gu, Seoul 110-745, Korea; E-Mail: heejoon@skku.edu; Tel.: +82-2760-0445; Fax: +82-2760-0440

Received: 4 April 2014; in revised form: 28 April 2014 / Accepted: 28 April 2014 / Published: 12 May 2014

Abstract: In this study, we investigate the effect of minimum trade unit (MTU) reductions on the Korea Exchange (KRX) on price efficiency. The KRX switched its MTU from 10 shares to one share for high-price stocks twice, once in December 2004 and once in July 2006. The MTU changes were intended to attract small individual investors to the markets for high-price stocks. The MTU reductions on the KRX are different from previous cases of MTU reductions in other markets in that the KRX MTU reductions are not chosen by firms but are mandated by the exchange. Using these rare events, we examine whether the reductions in MTU and ensuing small investor participation enhance or deteriorate price efficiency. We examine three variables as indicators of price efficiency: return volatility, residual volatility, and the half-life of return volatility shock estimated from a generalized autoregressive conditional heteroskedasticity (GARCH) model. We find evidence of improved price efficiency from the 2004 event. For the 2004 sample, both return variance and residual return variance declined significantly after the MTU reduction. We also find evidence of reduction, albeit weak, in the half-life of volatility shock for the same sample. Meanwhile, for the 2006 sample, we do not find any changes in return variance or residual variance, nor do we find any evidence of change in the half-life of volatility shock. The difference in the patterns of changes in variables between the 2004 and 2006 events appears to be attributable to differences in the price levels of the stocks that were affected by the MTU changes and, consequently, a difference in reactions by small investors.

Keywords: minimum trade unit; small investor participation; price efficiency; Korea Exchange

JEL Classification: G10, G28

1. Introduction

Security prices are discrete, bound by minimum price variation or tick size. Likewise, trading volume is also discrete in most exchanges, usually dictated by minimum trade unit (MTU) or lot size. [1] For example, stocks listed on the New York Stock Exchange (NYSE) are traded in multiples of 100 shares (round lot). Empirical studies of events that trigger MTU changes report that MTU changes have impacts on liquidity and valuation that are as substantial as or sometimes even greater than those of tick size changes. [2] Since the MTU defines the minimum value of an order, a large MTU effectively bars investors with small capital from entering the market for a given stock. What happens if an exchanged mandated MTU is relaxed, causing a sudden influx of small investors to the market? Will the increased participation by small investors help improve market efficiency or deteriorate it? This is the question we ask in this paper.

Small investors may be individuals with small capital who occasionally trade, or they could be day traders who actively participate in trading almost every day. Whoever small traders might be, they usually comprise a substantial portion of the trading public and affect security trading significantly. Thus, it is important to understand the trading behavior of small investors and the roles they play in financial markets. This is particularly important in equity markets in East Asia, where turnover is usually high and individual investors have traditionally been the major part of the trading public.

Small investors play several important roles in financial markets. Trading by small investors is an important source of liquidity. It is also understood that small investors engage in uninformed trading. Black (1985) calls small investors whose trading is not based on information "noise traders". Noise traders may trade for several reasons. They may simply trade for liquidity. They may have access to information but misinterpret it, or even, if they make correct interpretations, they may not be able to make appropriate trading decisions. It is also possible that noise traders trade on what they believe as correct information, when it is actually incorrect. Whatever the reason is, since trading by noise traders is not based on information, their trading can add noise to prices, increasing temporary swings in price and inflating short-term return volatility (Black [4]). An important implication is that noise trading makes prices less efficient.

However, an opposite inference is also possible. Admadti and Fleiderer [5] posit that informed trading is a positive function of liquidity trading. Since informed traders profit at the expense of uninformed traders, increased uninformed trading can motivate informed investors to engage in informed trading more aggressively. Thus, increased trading by small investors will attract more informed trading. With increased informed trading, price efficiency will improve.

Which of the above two mechanisms regarding the role of small investors on price efficiency is at work is an open empirical question. In this study, we address this question by exploring two unique

---

[1] Some exchanges adopt a uniform MTU while others employ multiple units. An example of the former is the U.S. stock markets. For all stocks listed on the New York Stock Exchange with the exception of Berkshire Hathaway and all stocks on Nasdaq, stocks trade in an MTU of 100 shares. On the Tokyo Stock Exchange, on the other hand, seven different MTUs of 1, 10, 50, 100, 500, 1000, and 3000 shares are used.

[2] Amihud *et al.* [1], Ahn *et al.* [2], and Hauser and Lauterbach [3] all report substantial impacts of lot size changes on liquidity and stock price.

events in Korea that were supposed to significantly increase trading activity by small investors. The events are the MTU reductions of December 2004 and July 2006 that were initiated by the KRX.

Until December 2004, the KRX employed a uniform MTU of 10 shares for all of its listed stocks. On 20 December 2004, the exchange switched its MTU for stocks priced above 100,000 Korean Won (KRW hereafter) from 10 shares to 1 share. Then, on 5 June, 2006, it reduced the MTU of stocks priced between KRW 50,000 and KRW 100,000 from 10 shares to 1 share. A total of 13 stocks in 2004 and 41 stocks in 2006 were affected by the rule change. The MTU changes were intended to attract more individual investors to the market for high-price stocks. Asked about the rationale behind the KRX's rule change towards a smaller MTU, an official at the exchange was quoted as saying "the decision was intended to make it easier for small investors to purchase blue chip stocks" [6]. The MTU changes were related to the unique composition of the investing population on the KRX. Institutional investors play a major role in trading in most major stock markets. Individual investors, meanwhile, contribute to a relatively minor percentage of trading volume. In contrast, individuals dominate trading scenes on the KRX. For example, individual investors were responsible for 89% of the total trading volume on the exchange in 2004. [3] Most of these individuals are small traders, trading with a small amount of investment capital. For high-price stocks, however, individual trading activities are limited mainly because high price itself serves as a barrier to hinder the entry of small investors. The ten-fold reduction in the MTU for high-price stocks was expected to attract a large pool of small investors to the market.

We choose return volatility as well as the half-life of volatility shock calculated by generalized autoregressive conditional heteroskedasticity (GARCH) estimation as proxies for price efficiency. Decreases in both return volatility and the half-life of volatility would indicate that market efficiency has improved after MTU reductions while increases suggest the opposite. Our empirical results generally support the former prediction. Even if we do not find strong evidence from both of the 2004 and 2006 events, at least we find evidence of improvement in price efficiency from the 2004 event. For firms affected by the 2004 MTU reduction, both the mean and median of return variances and residual variances decreased significantly. Since both of our measures of return variance are adjusted for overall variance in the market, our results are not driven by any market trends. Meanwhile, the mean and median of the half-life of volatility shock decreased by 40% and 47%, respectively. Even if these reductions are not statistically significant due to a small sample size, they were seen in about two-thirds of the sample firms.

While we do find evidence of improved price efficiency from the 2004 event, we do not find any evidence of a significant change in any of the efficiency measures with the 2006 sample. We interpret this discrepancy as caused by the difference in magnitudes of trading value reductions by the two events. The 2004 event reduced the binding minimum trade size from KRW 1,000,000 to KRW 100,000, while the 2006 event reduced it from KRW 500,000 to KRW 50,000. While both of the events reduced MTU by 10 to 1, the smaller change in monetary scale of the 2006 event and ensuing lukewarm reaction in the market appear to explain why the 2006 MTU reduction left a much smaller or almost no impact on price efficiency.

---

[3] Source: 2004 Annual Securities Statistics, KRX.

The remaining parts of the paper are organized as follows. The next section describes the details of the 2004 and 2006 MTU rule changes on the KRX. Section 3 explains the sample and the methodology. Empirical results are presented in Section 4. The final section concludes the paper.

2. MTU Changes on the KRX

Until the rule change in 2004, the KRX uniformly employed an MTU of 10 shares across its entire population of listed stocks. On 19 September 2004, the exchange announced a new plan to introduce the MTU of a single share for stocks priced above KRW 100,000, effective from 20 December 2004. The reduction affected 13 stocks, most of which were traded well above KRW 100,000. Then, on 2 June 2006, the KRX made another announcement to introduce another MTU change for stocks priced between KRW 50,000 and KRW 100,000, effective from 5 June 2006. Again, the new unit was a single share, reduced by tenfold from the old unit of 10 shares. A total of 41 stocks were affected.

The series of MTU rule changes by the KRX were intended to bring significant effects to the composition of trading public, especially individual investors. As mentioned previously, one distinct characteristic of the Korean stock market is dominance by individual investors. Many of these individuals trade through a PC-based trading system called the home trading system (HTS) or mobile-phone based trading systems (Lee and Kim [7]). Many of them are also known to actively engage in day-trading practices, trading in small volumes (Choe *et al*. [8]). Considering the unique investor composition and the popularity of day-trading, the new MTU rule was anticipated to bring a significant impact on the market.

The effects of MTU reductions have not been studied extensively because such events are rare. Amihud *et al*. [1] and Ahn *et al*. [2] examine the case of MUT reductions on the Tokyo Stock Exchange (TSE) and report significant liquidity and valuation effects. Hauser and Lauterbach [3] examine a similar event in the Tel Aviv Stock Exchange (TASE). However, the MTU change on the KRX has some characteristics that make the event distinct, compared with the TSE or the TASE. In the TSE, a firm makes the decision to choose the MTU of its own stock. When firms can choose their own MTU, they will change their MTU only when doing so is beneficial to them. The new MTU rule on the KRX was imposed by the exchange and, thus, was a purely exogenous event to the stocks involved. This lets us examine the pure effects of a sudden change in trading unit, free from possible endogenous effects related to firms' intentions. Meanwhile, the case of the TASE involves a change in the minimum monetary trading value and not a trade unit or round lot. Furthermore, the magnitude of the minimum trading value changes on the TASE are moderate with either a 33% increase or 62% to 81% decreases. The MTU changes on the KRX are much greater in magnitude, involving a 90% decrease from 10 shares to 1 share. Ahn *et al*. [2] report that the liquidity and valuation effects of MTU changes are positively related with the magnitude of the changes. Hence, a clearer and sharper impact is expected from the KRX event.

Like MTU changes, stock splits also reduce the minimum trading value for a given stock. However, stock splits can bring fundamentally different impacts on the market for several reasons. First and most important, a stock split is a firm event. The decision to undergo a stock split is made by the management of a firm. This possibly brings effects to the markets that are independent of cosmetic changes in the minimum trading value. For example, stock splits are often used as a signaling tool by

managers (Brennan and Copeland [9]). On the contrary, the MTU changes on the KRX were dictated by the exchange, creating purely exogenous effects on stock trading and pricing. In addition, a stock split can involve a price change and thus affect bid-ask spreads as well as volatility (Angel [10], Shultz [11], and Kamara and Koski [12]). MTU changes do not affect price levels *per se*. Hence, volatility should remain the same before and after an MTU change unless there is a change in the trading pattern of investors or a change in the information environment. This latter point is important, since volatility is a key variable used in our study to detect changes in price efficiency.

3. The Samples and Methodology

Event dates are obtained from newspaper and Internet searches. Price and volume data are obtained from the KIS-Value and FN-Guide datasets. We use two test samples. When the new MTU rule debuted on 20 December, 2004, 13 stocks were traded above KRW 100,000. Our first sample consists of these stocks that were directly affected by the 2004 rule change. The second test sample consists of the 41 stocks that were affected by the rule change on 5 July, 2006. For both samples, we examine two event windows including a pre-event window of 100 trading days from days 120 to 21 prior to the rule change, and the post-event window of the same length from days 21 to 120 following the event day. We impose a condition that during these "pre-" and "post-" event periods the stock stays within a valid price range for at least 80 trading days. A valid price range is defined as the price range of above KRW 100,000 for the 2004 event sample and between KRW 50,000 and KRW 100,000 for the 2006 sample. This filtering process results in 12 stocks in the 2004 event sample and 21 stocks in the 2006 sample. A list of firms in the two samples is presented in Table 1. Understandably, the sample firms, particularly of the 2004 event sample, are large firms that are household names in Korea.

We use short-term volatility and the half-life of volatility shock as measures of price efficiency. The rationale for using volatility measures as the metric for price efficiency is as follows. If small investors add noise to prices, then volatility will increase. This noise must be temporary because it does not contain factors pertinent to fundamentals about firm value. Hence, noise will inflate short-term return variance. The noise-inflated volatility may not be captured if return variances are measured in weekly or monthly intervals. They are more likely to be captured by variances measured over short intervals, such as daily intervals. The extant literature uses temporary volatility as a measure of price efficiency. Included in the literature are classical studies, such as Amihud and Mendelson [13], LeRoy and Porter [14], LeRoy and Parke [15], and Shiller [16]. Merton [17] also regards firm-specific volatility as an important factor to determine the shadow cost of incomplete information.

We measure the variance of daily returns and the variance of daily residual returns from the market model as measures of temporary volatility. Estimations are made separately for pre- and post-event periods. Then, to guard against the possibility that a rise or fall in volatility is triggered by rising or falling trends in the market, we divide each of the return variances obtained in the previous step by the average of the return variances (or residual variances) of the entire population of KRX-listed stocks that are not included in the event sample. For example, the variance ratio (VR) of firm i in an event sample is defined as:

$$\mathrm{VR}_i = \frac{\text{Return Variance}_i}{\text{Average Return Varaince of non-event KRX stocks}} \quad (1)$$

The variance ratio for residual variances is calculated in a similar fashion. As a secondary metric to measure price efficiency, we employ the half-life of volatility shock derived from the following GARCH(1,1) model.

Table 1. List of Firms with minimum trade unit (MTU) Change.

A. Event 1 (22 December 2004)		
	KRX Code	**Company Name**
Price > ₩100,000 (MTU Change from 10 Shares to 1 Share)	A002790	Amore G, Seoul, Korea
	A002380	KCC Corp., Seoul, Korea
	A005300	Lotte Chilsung Beverage, Seoul, Korea
	A004990	Lotte Confectionery, Seoul, Korea
	A003920	Namyang Dairy Products, Seoul, Korea
	A004370	Nongshim, Seoul, Korea
	A005490	POSCO, Pohang, Korea
	A006400	Samsung SDI Co.,Ltd., Yongin, Korea
	A005930	Samsung Electronics, Suwon, Korea
	A004170	Shinsegae Co., Ltd., Seoul, Korea
	A017670	SK Telecom, Seoul, Korea
	A003240	Taekwang Industrial, Seoul, Korea
B. Event 2 (6 July 2006)		
	KRX Code	**Company Name**
₩50,000 < Price ≤ ₩100,000 (MTU Change from 10 Shares to 1 Share)	A000120	CJ Korea Express Corp., Seoul, Korea
	A000210	Daelim Industrial, Seoul, Korea
	A049770	Dongwon F&B Co., Ltd., Seoul, Korea
	A006360	GS Engineering & Const. Corp., Seoul, Korea
	A039130	Hana Tour Service, Seoul, Korea
	A003300	Hanil Cement, Seoul, Korea
	A002960	Hankook Shell Oil, Seoul, Korea
	A017800	Hyundai Elevator, Icheon, Korea
	A012330	Hyundai Mobis, Seoul, Korea
	A005380	Hyundai Motor, Seoul, Korea
	A033780	KT&G Corp., Daejeon, Korea
	A066570	LG Electronics, Seoul, Korea
	A051900	LG Household & Healthcare, Ltd., Seoul, Korea
	A006400	Samsung SDI Co., Ltd., Yongin, Korea
	A003940	Samyang Genex, Seoul, Korea
	A058650	Se Ah Holdings, Seoul, Korea
	A017390	Seoul City Gas, Seoul, Korea
	A035510	Shinsegae Inform. & Comm. Co., Seoul, Korea
	A005800	Shinyoung Wacoal, Seoul, Korea
	A003600	SK, Seoul, Korea
	A010950	S-Oil Corp, Seoul, Korea.

This table presents the list of KRX firms that were affected by the KRX rule changes for minimum trade unit from 10 shares to one share. Event 1 sample (Panel A) consists of the firms whose price exceeded KRW 100,000 on 22 December 2004. Event 2 sample (Panel B) consists of those with prices higher than KRW 50,000 but lower than KRW 100,000 on 5 July 2006.

$$\begin{cases} r_t=\beta_0+\beta_1 \text{Monday}_t+\beta_2 \text{Market}_t+\varepsilon_t \\ \text{where } \varepsilon_t \sim N(0,\sigma_t^2) \\ \sigma_t^2=\alpha_0+\alpha_1 \varepsilon_{t-1}^2+\gamma_1 \sigma_{t-1}^2 \end{cases} \quad (2)$$

where t indicates a trading day. *Monday* in the return equation is a dummy variable that takes the value of one if the day is Monday and zero otherwise. This variable is inserted into the model to control for any possible intraweek effects that might be present in daily returns (French [18], and Jaffe and Westerfield [19]). The last variable in the return equation, *Market*, is the KOSPI index return on day t and is used to control for market movements. The volatility equation contains the usual ARCH and GARCH terms. The half-life of volatility is calculated as:

$$\text{Half Life}_i = \frac{-\ln(2)}{\ln(\alpha_1+\gamma_1)} \quad (3)$$

If market efficiency improves after an MTU reduction, we observe reductions in the two variance measures as well as in the half-life of volatility shock. If market efficiency deteriorates, we observe the opposite.

4. Empirical Results

This section reports the results of the empirical analysis. Our empirical analysis is carried out in four steps. First, we inspect if MTU reductions cause changes in investor composition. The KRX made it clear that the new policy implementation was intended to make high-price stocks more affordable for small investors. Hence, if the KRX was successful in achieving its intended goal, we should witness an increase in number of small shareholders after the rule change. Next, we examine trading volume around the MTU reductions. Trading volume may increase or decrease after an MTU reduction. An influx of small investors triggered by the MTU reduction may intensify overall trading activity and boost trading volume. Then, we should observe increased trading volume subsequent to MTU reductions. Alternatively, smaller orders submitted by small investors after an MTU reduction may front-run large orders submitted by institutions or individuals who trade in large amounts of capital. This would intensify overall price competition and reduce the depth. Market quotes might improve but market depths may decline. An improvement in liquidity in the price dimension does not necessarily translate to an improvement in liquidity in the quantity dimension. The reduced market depth and increased price competition might worsen the trading environment for institutions who usually trade in large quantities. This opens the possibility that MTU reductions lower trading volume. Which of the two situations will emerge is an open empirical question.

The information on shareholder composition around the two cases of MTU reduction is presented in Table 2. While the KIS-Value and FN-Guide both provide information on shareholders, they only offer the information about number of shareholders and percentage holding for three investor groups—small shareholders, large institutional shareholders, and others. Since an MTU reduction is likely to have a direct impact on the trading behavior of small investors, our analysis focuses on small shareholders. However, we also look into the effects on large institutional shareholders because any change in the trading pattern of small investors would have an impact on the trading pattern of institutional investors. We focus on the number of shareholders rather than shareholding because the magnitude of an influx

of new investors to the market can be measured more accurately by number of shareholders than the number of shares they own. For the 2004 event, we compare the number of shareholders recorded at the end of 2003 ("Pre") with the number of shareholders at the end of 2005 ("Post"). The reason why we use the fiscal year of 2005 instead of 2004 as the post-event window is that the event took place near the end of year 2004 (22 December), and it would, thus, be safe to use the accounting data at the end of 2005 instead of 2004 to capture the full effect of the MTU reduction on shareholder composition. For the 2006 event, we compare 2005 ("Pre") with 2006 ("Post"). Both raw and market adjusted numbers are analyzed where the market adjustment is made by dividing the number of shareholders in a specific group of shareholders for an event firm by the average number of shareholders in the entire market for the same group of shareholders. [4] Since the values of number of shareholders are severely skewed, statistical tests for the changes around the MTU reduction are carried out based on the natural logs of the variables.

Table 2. Number of Shareholders.

Panel A. 2004 Sample							
		Raw				**Market Adjusted**	
		Pre	**Post**	**Log(Post/Pre)**	***p*-value**	**Post – Pre**	***p*-value**
No. of Small	Mean	23,714	26,626	0.25	0.006	1.06	0.025
Shareholders	Median	4687	5830	0.18	0.002	0.31	0.001
No. of Large Institutional	Mean	8.58	9.50	−0.17	0.509	0.42	0.329
Shareholders	Median	8.00	7.00	−0.08	0.695	0.05	0.519
Panel B. 2006 Sample							
		Raw				**Market Adjusted**	
		Pre	**Post**	**Log(Post/Pre)**	***p*-value**	**Post – Pre**	***p*-value**
No. of Small	Mean	21,485	24,968	0.12	0.106	0.66	0.247
Shareholders	Median	8062	8896	0.10	0.225	0.06	0.261
No. of Large Institutional	Mean	4.95	5.30	0.07	0.068	0.04	0.522
Shareholders	Median	3.00	3.50	0.00	0.063	−0.01	0.488

This table presents the numbers of small individual shareholders and large institutional shareholders before ("Pre") and after ("Post") MTU changes. For the 2004 event sample, the "Pre" and "Post" periods are 2003 and 2005, respectively. For the 2006 event sample, the "Pre" and "Post" periods are 2005 and 2006, respectively. The market adjusted changes are calculated as the post-minus-pre difference of the ratios of the number of specific group of shareholders for a specific stock divided by the number of the same group of shareholders for an average firm in the entire market excluding the event sample firms.

Table 2 reports the number of shareholders before and after the MTU reduction. The number of large institutional shareholders does not display any changes. Both the raw and market-adjusted figures are insignificantly different between the pre and post periods for both events regardless of whether the mean or median is used.[5] Small shareholders display a different pattern. For the 2004 sample, the number of small shareholders increases significantly after the MTU reduction from 23,714 to 26,626

[4] For the sake of conserving space we only report pre-post changes for the market adjusted number of shareholders.

[5] Even though the log change in number of large shareholders is significant at the 10% level, the significance disappears in market adjusted value.

(from 4687 to 5830) in mean (median) values. Both the mean and median changes in log values are positive and highly significant. It is obvious from this result that the MTU reduction in 2004 effectually reduced price barriers for small investors and triggered their entry to the market. Meanwhile, the MTU reduction of 2006 did not bring any material change to number of small shareholders. For both raw and market adjusted figures, there is no discernible difference between the pre and post periods. This is in contrast with the pattern of the number of small shareholders around the 2004 event. Even if the ratio of reduction is 10 to 1 for both events, small investors were less enthusiastic about the 2006 reduction. This is probably because the 2006 event involved stocks in a much lower price range than the 2004 event. Apparently, the lower prices did not hinder entry by small investors as much as the high prices of the stocks involved in the 2004 MTU reduction. We will have more discussion on this issue later in this section when we interpret the empirical results on return volatility.

Table 3. Share Volume around MTU Change.

Panel A. 2004 Sample						
			Pre	**Post**	**Log(Post/Pre)**	***p*-value**
Share Volume	Mean	Buy	36,582	30,680	0.064	0.563
		Sell	35,937	31,675	0.023	0.777
	Median	Buy	7172	5679	−0.015	0.569
		Sell	7537	6152	0.025	0.850
			Pre	Post	Post–Pre	*p*-value
Market Adjusted Share Volume	Mean	Buy	0.117	0.058	−0.059	0.134
		Sell	0.114	0.060	−0.054	0.096
	Median	Buy	0.023	0.010	−0.006	0.001
		Sell	0.024	0.012	−0.008	0.001
Panel B. 2006 Sample						
			Pre	Post	Log(Post/Pre)	*p*-value
Share Volume	Mean	Buy	85,016	59,097	−0.177	0.186
		Sell	86,035	54,108	−0.330	0.018
	Median	Buy	12,544	14,648	−0.178	0.061
		Sell	13,200	10,382	−0.354	0.002
			Pre	Post	Post–Pre	*p*-value
Market Adjusted Share Volume	Mean	Buy	0.244	0.261	0.016	0.804
		Sell	0.246	0.239	−0.007	0.902
	Median	Buy	0.035	0.064	0.007	0.026
		Sell	0.037	0.046	0.010	0.023

This table presents average and median daily trading volume in number of shares and the market adjusted daily share volume ratios before ("Pre") and after ("Post") MTU changes. The "Pre" period is from 120 to 21 trading days prior to the announcement and the "Post" period is the 21 to 120 trading days subsequent to the MTU change. The market adjusted volume for a specific stock on a specific day is calculated as the daily volume of the stock divided by the average daily volume of the non-event stocks on the day where non-event stocks are the entire set of the KRX listed stocks excluding the event sample stocks.

The results for trading volume are reported in Tables 3 and 4. Table 3 presents trading volume expressed in number of shares. The share volume on the 2004 event sample is shown in Panel A while

the volume on the 2006 sample is displayed in Panel B. Table 3 also shows the market adjusted volume, where the adjustment is made by dividing the share volume of a sample firm by the average share volume of the entire non-event KRX firms during the same pre- or post-event windows. Again, adjustment is needed to shield against any market trends affecting the volume pattern around the event. The *p*-values are from *t*-tests for mean values and sign tests for median values of log differences before and after the MTU changes. [6]

Table 4. KRW volume around MTU Change.

Panel A. 2004 Sample						
			Pre	**Post**	**Log(Post/Pre)**	***p*-value**
KRW Volume	Mean	Buy	8885	7345	0.269	0.039
		Sell	8818	8014	0.227	0.012
	Median	Buy	1375	1285	0.409	0.043
		Sell	1292	1455	0.324	0.016
			Pre	Post	Post – Pre	*p*-value
Market Adjusted KRW Volume	Mean	Buy	5.742	3.307	−2.435	0.243
		Sell	5.555	3.528	−2.037	0.210
	Median	Buy	0.913	0.580	−0.045	0.339
		Sell	0.820	0.663	−0.131	0.186
Panel B. 2006 Sample						
			Pre	**Post**	**Log(Post/Pre)**	***p*-value**
KRW Volume	Mean	Buy	6026	3959	−0.176	0.188
		Sell	6070	3676	−0.328	0.021
	Median	Buy	1026	1013	−0.173	0.066
		Sell	1077	873	−0.333	0.005
			Pre	Post	Post – Pre	*p*-value
Market Adjusted KRW Volume	Mean	Buy	1.798	2.102	0.305	0.442
		Sell	1.810	1.928	0.118	0.724
	Median	Buy	0.361	0.535	0.125	0.000
		Sell	0.355	0.468	0.027	0.015

This table presents average and median daily trading volume in Korean Won (KRW) and the market adjusted daily KRW volume ratios before ("Pre") and after ("Post") MTU changes. The "Pre" period is from 120 to 21 trading days prior to the announcement and the "Post" period is the 21 to 120 trading days subsequent to the MTU change. The market adjusted KRW volume for a specific stock on a specific day is calculated as the daily KRW volume of the stock divided by the average daily KRW volume of the non-event stocks on the day where non-event stocks are the entire set of the KRX listed stocks excluding the event sample stocks.

The share volume reported in Panel A of Table 3 (2004 event sample) does not exhibit any significant changes. The average daily buy (sell) volume is 36,582 (35,937) shares before the event. It is 30,680 (31,675) afterwards. The changes are statistically insignificant for both buys and sells. The median results are not significantly different, either. The market adjusted share volume, however, tells a different story. The volume ratio decreases significantly after the event. Both mean and median share volume decrease after the event. While the mean change in buy volume is not statistically significant,

[6] Log transformation is necessary due to a severe skewness in the distribution of share volume.

the median change is significant at the 10% level. For sell volume, both mean and median changes are highly significant at the 1% level. The 2006 event sample, on the other hand, shows an opposite result (Panel B of Table 3). The unadjusted share volume of the 2006 event sample exhibits reductions in share volume (the upper part of Panel B). However, when the market trend is controlled for, an increase in share volume is observed. While the mean changes are not significant, the median changes are significant at the conventional 5% level.

Table 4 presents trading volume measured in KRW. Again, Panel A shows the results for the 2004 sample while Panel B shows the results for the 2006 sample. The pattern of KRW volume shown in Panel A of Table 4 (*i.e.*, the 2004 event) is different from the pattern of share volume reported in Panel A of Table 3. While the share volume does not show any change around the 2004 MTU reduction, KRW volume displays significant increases. The increases are statistically significant for both buys and sells and for both means and medians. However, when adjusted for market trends, the changes in KRW volume are no longer significant. This is in contrast with the significant reductions shown in adjusted share volume (Panel A, Table 3). Taken together, we cannot draw any definitive conclusions about the 2004 sample regarding whether volume increased or decreased after the MTU reduction, since share volume marginally increased while KRW volume did not change at all. For the 2006 sample, the KRW volume exhibits a similar pattern to that displayed for share volume—with decreases in row volume and increases in adjusted volume. To sum up the volume results reported in Tables 3 and 4, we have evidence that market adjusted volume in both number of shares and in KRW increase significantly after the 2006 MTU reduction, but we do not find any conclusive evidence for either a volume increase or a volume decrease for the 2004 sample.

We now turn to the discussion of return volatility, our key indicator for market efficiency. Table 5 reports the results. The table shows return variances before and after MTU reductions for event sample stocks, non-event sample stocks, and the variance ratios for both the 2004 sample (Panel A) and the 2006 sample (Panel B). Again, the non-event sample firms are the entire universe of the KRX-listed firms that were not affected by the MTU changes. The variance figures given in Table 5 are all expressed in terms of percent square ($\%^2$). In terms of raw variance figures, the 2004 sample firms do not exhibit any significant changes. The non-event firms, however, experienced significant increases in variance. As a result, the adjusted variances of the sample firms or the variance ratios decrease significantly after the MTU reduction. The average change in variance ratio is −0.259 from 0.531 to 0.272, a substantial change of 49% from its pre-event level. The *p*-value is 0.019. The median change is −0.197 from 0.423 to 0.214, a 46% drop, which is not only substantial in magnitude but also highly significant at the 1% level. While the 2004 sample exhibits significant reductions in volatility, the 2006 sample displays few significant changes. While the raw variance itself shows a significant average reduction, it is offset by even larger average reduction in the market. As a result, the variance ratio remains virtually the same before and after the event.

Table 5. Return Variance.

Panel A. 2004 Sample					
		Pre	**Post**	**Post – Pre**	***p*-value (*t*-test)**
Mean	Event Sample (%^{2})	6.43	4.46	−1.96	0.157
	Non-Event Sample (%^{2})	12.10	16.44	4.33	0.092
	Variance Ratio	0.531	0.272	−0.259	0.019
		Pre	Post	Post – Pre	*p*-value (*t*-test)
Median	Event Sample (%^{2})	5.22	3.52	−1.00	0.151
	Non-Event Sample (%^{2})	6.53	8.56	1.38	0.000
	Variance Ratio	0.432	0.214	−0.197	0.003
Panel B. 2006 Sample					
		Pre	**Post**	**Post – Pre**	***p*-value (*t*-test)**
Mean	Event Sample (%^{2})	5.14	3.46	−1.68	0.009
	Non-Event Sample (%^{2})	13.99	9.69	−4.29	0.071
	Variance Ratio	0.374	0.364	−0.010	0.826
		Pre	Post	Post – Pre	*p*-value (*t*-test)
Median	Event Sample (%^{2})	4.26	2.85	−1.53	0.005
	Non-Event Sample (%^{2})	8.64	5.16	−3.03	0.000
	Variance Ratio	0.310	0.299	0.016	0.828

This table presents the cross-sectional means and medians of daily return variances and variance ratios before ("Pre") and after ("Post") MTU changes. The "Pre" period is from 120 to 21 trading days prior to the announcement and the "Post" period is the 21 to 120 trading days subsequent to the MTU change. The non-event stocks are the entire set of the KRX listed stocks other than the event sample. The variance ratio is defined as the ratio of the return variance of the event sample firm to the cross-sectional average return variance of the non-event sample firms.

Table 6 presents residual variance around MTU reductions. Panel A represents the 2004 sample and Panel B represents the 2006 sample. Merton [17] maintains that firm-specific volatility is an important factor to determine the shadow cost of incomplete information. The patterns of residual variances reported in Table 6 are similar to those of return variances shown in Table 5. The variance ratios of the 2004 sample are significantly smaller after the MTU reduction. The mean reduction is −0.178 from 0.418 to 0.240, a 43% reduction. The *p*-value from the *t*-test is 0.04. The statistical significance of the median reduction is even greater with a *p*-value of 0.003. The magnitude of the median reduction is −0.115 from 0.278 to 0.184, a 41% decline. The residual variances of the 2006 sample, like in return variances reported in Table 5, do not show any significant changes. The raw residual variances decreased significantly. However, these decreases are offset by even greater reductions in the market (by non-event stocks), which leads to no change in the variance ratios.

When the results for return variance and residual variance are taken together, there are clear signs that volatility decreased significantly after the 2004 MTU reduction. Both return variance and residual variance declined significantly after the event. This strongly suggests that price discovery improved after the MTU was reduced in 2004. However, for the 2006 event, no signs of improved price efficiency are observed in either return variance or residual variance. The different results for the 2004 and 2006 samples may be interpreted in relation to the magnitudes of the impacts triggered by the events. The magnitude of the effect to attract small investors to the market triggered by an MTU

reduction will be a function of price levels. The higher the price at which a stock trades, the greater will the barrier be that binds small investors. As such, a 10-to-1 reduction in MTU will be much more effective when it is applied to stocks priced above KRW 100,000 than those priced above KRW 50,000. Even if the threshold of KRW 100,000 is twice as high as the threshold of KRW 50,000, the actual difference is much greater, since many of the stocks affected by the 2004 event were priced well above KRW 100,000. For instance, the average price of the 12 stocks from the 2004 sample during the pre-event period is KRW 368,179 compared with the average price of the 21 stocks from the 2006 sample of KRW 68,582. The 2004 sample stocks are on average five times as expensive as the 2006 sample stocks. Hence, the magnitude of binding is far greater with the 2004 sample. This explanation is corroborated by the difference in reactions by small investors between the 2004 and 2006 cases (Table 2). The 2004 event triggered a substantial increase in small investor participation. However, the 2006 event failed to attract any extra trading activity from small investors. The different patterns in return volatility for the two samples could also be explained in terms of timing difference between the two events. Investors might have learned from the earlier 2004 MTU reductions and, thus, they did not take the 2006 reductions as a surprise. It was an expected event and resulted in smaller/insignificant changes in investor reactions. [7]

Table 6. Residual Variance.

Panel A. 2004 Sample					
		Pre	**Post**	**Post – Pre**	***p*-value (*t*-test)**
Mean	Event Sample (%^{2})	4.79	3.64	−1.15	0.254
	Non-Event Sample (%^{2})	11.46	15.15	3.69	0.132
	Variance Ratio	0.418	0.240	−0.178	0.040
		Pre	Post	Post – Pre	*p*-value (*t*-test)
Median	Event Sample (%^{2})	3.19	2.78	−0.56	0.151
	Non-Event Sample (%^{2})	5.65	7.26	1.17	0.000
	Variance Ratio	0.278	0.184	−0.115	0.003
Panel B. 2006 Sample					
		Pre	**Post**	**Post – Pre**	***p*-value (*t*-test)**
Mean	Event Sample (%^{2})	4.35	3.06	−1.29	0.020
	Non-Event Sample (%^{2})	12.15	8.96	−3.19	0.176
	Variance Ratio	0.365	0.348	−0.017	0.719
		Pre	Post	Post – Pre	*p*-value (*t*-test)
Median	Event Sample (%^{2})	3.74	2.55	−1.42	0.013
	Non-Event Sample (%^{2})	6.59	4.41	−1.93	0.000
	Variance Ratio	0.314	0.290	−0.012	0.725

This table presents the cross-sectional means and medians of daily residual return variances and variance ratios before ("Pre") and after ("Post") MTU changes. The "Pre" period is from 120 to 21 trading days prior to the announcement and the "Post" period is the 21 to 120 trading days subsequent to the MTU change. The market model is used to calculate the residual variances where the market index returns used are the KOSPI index returns. The non-event stocks are the entire set of the KRX listed stocks other than the event sample. The variance ratio is defined as the ratio of the residual variance of the event sample firm to the cross-sectional average residual variance of the non-event sample firms.

[7] We thank an anonymous referee for suggesting this interpretation.

We now turn to Table 7, which presents the estimation results for the GARCH model. Due to a convergence problem, the model produces coefficients for 11 stocks for the 2004 sample and 16 stocks for the 2006 sample. A longer window might guarantee better convergence, but it might also invite unwarranted confounding effects that are unrelated to MTU reductions. We will first discuss the estimation results for the 2004 sample (Panel A). There are no significant changes in the estimated coefficients for either the return equation or the volatility equation. Intraweek return seasonality is not a factor affecting returns during the sample period. The coefficient of the market index is close to one, which is understandable considering that the sample firms are large and represent the market well. Even though there is a slight increase in the average beta, the change is not significant by any means. In the volatility equation, the ARCH term coefficient displays a slight increase in both mean and median, but the increase is not significant. Similarly, even if there are slight reductions in both mean and median for the GARCH coefficient, the magnitudes are insignificant. However, there is a sign, albeit weak, that the half-life of volatility shock decreases after the MTU reduction. The average half-life decreases from 5.99 to 3.60 (a change of −2.39) while the median is reduced from 3.72 to 3.07 (a change of −1.75). However, neither of the changes is statistically significant. This weak statistical test result may be due to the small sample problem. Even so, out of the total of 11 stocks in the sample, seven experienced reductions in half-life, indicating that almost 2/3 of the sample firms had shortened half-lives. Therefore, even if the evidence presented in Panel A of Table 6 is at best marginal, together with the stronger evidence shown in return variance and residual variance, we conclude that for the 2004 sample the MTU reduction led to improved price efficiency.

The results presented in Panel B of Table 7 on the 2006 sample do not materially differ from those given by the previous two tables. There is no sign of reduction in the half-life of volatility shock for the 2006 event stocks. If anything, the actual changes are positive and not negative. Again, the difference in the patterns of reactions between the 2004 and 2006 samples appears to be related to the differences in price levels and the ensuing differences in degrees of market impacts brought by MTU reductions.

Table 7. Conditional Variance around MTU Change.

Panel A. 2004 Sample						
	β_1			**β_2**		
Coefficients	Pre	Post	$\Delta\beta_1$ (*p*-value)	Pre	Post	$\Delta\beta_2$ (*p*-value)
Mean	−0.0005	−0.0012	−0.0007 (0.849)	0.8768	0.9002	0.0232 (0.867)
Median	−0.0001	−0.0005	0.0019 (0.577)	0.8177	0.9447	0.1270 (0.999)
	α_1			γ_1		
Coefficients	Pre	Post	$\Delta\alpha_1$ (*p*-value)	Pre	Post	$\Delta\gamma_1$ (*p*-value)
Mean	0.0541	0.1226	0.0686 (0.106)	0.8391	0.7316	−0.1075 (0.199)
Median	0.0883	0.1178	0.0521 (0.206)	0.8942	0.7775	−0.0368 (0.206)
	Half Life of Volatility					
	Pre	Post	Post – Pre(*p*-value)	% Positive		
Mean	5.9927	3.6021	−2.3906 (0.813)			
Median	3.7231	3.0697	−1.7528 (0.519)	36.36%		

Table 7. *Cont.*

Panel B. 2006 Sample						
	β_1			**β_2**		
Coefficients	Pre	Post	$\Delta\beta_1$ (*p*-value)	Pre	Post	$\Delta\beta_2$ (*p*-value)
Mean	−0.0017	0.0023	0.0040 (0.019)	0.6080	0.6808	0.0728 (0.522)
Median	−0.0021	0.0026	0.0039 (0.018)	0.5295	0.7573	0.0193 (0.528)
	α_1			γ_1		
Coefficients	Pre	Post	$\Delta\alpha_1$ (*p*-value)	Pre	Post	$\Delta\gamma_1$ (*p*-value)
Mean	0.2365	0.2065	−0.0300 (0.783)	0.5158	0.6283	0.1125 (0.413)
Median	0.1672	−0.0089	−0.0673 (0.669)	0.5090	0.6846	0.1190 (0.464)
	Half Life of Volatility					
	Pre	Post	Post – Pre(*p*-value)	% Positive		
Mean	1.4691	3.7789	2.3098 (0.808)			
Median	2.9892	2.7019	0.7640 (0.562)	56.25%		

The cross-sectional means and medians of the coefficient estimates of a GARCH(1,1) model based on daily returns before announcement and after MTU change are presented. The model is defined by

$$\begin{cases} r_t = \beta_0 + \beta_1 weekend_t + \beta_2 market_t + \varepsilon_t \\ \text{where } \varepsilon_t \sim N(0, \sigma_t^2) \\ \sigma_t^2 = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \gamma_1 \sigma_{t-1}^2 \end{cases}$$

In the model, r_t is the return based on the midpoint of closing quotes on date *t*. *weekend* is a dummy variable equal to 1 if the day is Monday and 0 otherwise, and *market* is the return on the KOSPI on the day. σ^2 is the conditional return variance and ε is the return innovation. The estimation windows are from 120 to 21 trading days prior to the announcement ("Pre") and from 21 to 120 trading days subsequent to the MTU change ("Post"). The estimation results are based on 11 stocks (2004 sample) and 16 stocks (2006 sample) for which the estimation algorithm converges. The half-life of volatility is calculated as $-\ln(2)/\ln(\alpha_1+\gamma_1)$.

5. Summary and Conclusions

In this study, we investigate the effects of KRX MTU reductions on price efficiency. The KRX switched its MTU twice, both times from 10 shares to one share, for stocks priced above KRW 100,000 on 20 December, 2004, and for stocks priced between KRW 50,000 and KRW 100,000 on 5 June, 2006. The MTU changes were intended to attract small individuals to the stock markets for high-price stocks. On the KRX, individuals are dominant traders, often taking more than 90% of transactions on a day. Given this heavy trading by individuals, the two cases of the exchange-initiated MTU reductions may cause a substantial influx of small investors to the market. On the one hand, this increased trading by individual investors could deteriorate price efficiency, since individuals are usually known as uninformed liquidity traders, adding noise to prices. On the other hand, they may create profit-making opportunities for informed investors according to the framework of Admadti and Fleiderer [5]. That is, increased uninformed liquidity trading can motivate informed investors to more aggressively engage in informed trading. The increased informed trading triggered by an influx of small investors after an MTU reduction may improve price efficiency.

We examine three variables as indicators of price efficiency—return volatility, residual volatility, and the half-life of return volatility shock estimated from a GARCH model. We find evidence of improved price efficiency from the 2004 sample. For this sample, both market-adjusted return variance and residual variance declined significantly after the MTU reduction. The mean (median) return variance declined by 49% (46%) and the residual variance by 43% (41%). We also find weak evidence of reduction in the half-life of volatility shock for the 2004 sample. For the 2006 sample, however, we do not find any sign of changes in return variance or residual variance, nor do we find any evidence of change in the half-life of volatility shock. The differences in the reactions to MTU changes between the two events may be related to the different price levels of the firms that were affected by the MTU changes and ensuing difference in small investor reaction. The 2004 event involved much more expensive firms, with prices that were on average five times higher than those affected by the 2006 event. As a consequence, only in the case of the 2004 event, there was a substantial increase in small investor participation, which lead to an improvement in price efficiency.

Acknowledgments

This work was supported by the National Research Foundation of Korea Grant by the Korean Government (NRF-2010-327-B00260). The author is thankful to Woo-baik Lee and three anonymous reviewers for their helpful comments.

Conflicts of Interest

The author declares no conflict of interest.

References

1. Amihud, Y.; Mendelson, H.; Uno, J. Number of shareholders and stock prices: Evidence from Japan. *J. Financ.* **1999**, *54*, 1169–1184.
2. Ahn, H.; Cai, J.; Hamao, Y.; Melvin, M. *Little Guys, Liquidity, and the Informational Efficiency of Price: Evidence from the Tokyo Stock Exchange on the Effect of Small Investor Participation*; Working Paper; University of Southern California: Los Angeles, CA, USA, 2010.
3. Hauser, S.; Lauterbach, B. The impact of minimum trading units on stock value and price volatility. *J. Financ. Quant. Anal.* **2003**, *38*, 575–589.
4. Black, F. Noise. *J. Financ.* **1986**, *41*, 529–543.
5. Admati, A.; Pfleiderer, P. A theory of intraday patterns: Volume and price variability. *Rev. Financ. Stud.* **1988**, *1*, 3–40.
6. High price stocks can now be bought and sold by the single-share basis. *Kyunghyang Daily*, 19 October 2004.
7. Lee, W.; Kim, J. Price discovery of online and offline trading on Korea Exchange. *J. Insur. Stud.* **2011**, *11*, 109–141. (In Korean)
8. Choe, H.; Chung, J.; Kho, B. The impacts of day-trading on volatility and liquidity. *Asia-Pac. J. Financ. Stud.* **2009**, *38*, 237–275.

9. Brennana, M.; Copeland, T. Stock splits, stock prices and transaction costs. *J. Financ. Econ.* **1988**, *22*, 83–101.
10. Angel, J. Tick size, share price, and stock splits. *J. Financ.* **1997**, *52*, 655–681.
11. Schultz, P. Stock splits, tick size, and sponsorship. *J. Financ.* **2000**, *55*, 429–450.
12. Kamara, A.; Koski, J. Volatility, autcorrelations, and trading activities after stock splits. *J. Financ. Mark.* **2001**, *4*, 163–184.
13. Amihud, Y.; Mendelson, H. Volatility, Efficiency, and Trading: Evidence from the Japanese Stock Market. *J. Financ.* **1991**, *46*, 1756–1789.
14. LeRoy, S.F.; Porter, R.D. The present-value relation: Tests based on implied variance bounds. *Econometrica* **1981**, *49*, 555–577.
15. LeRoy, S.F.; Parke, W.R. Stock price volatility: Tests based on the geometric random walk. *Am. Econ. Rev.* **1992**, *82*, 981–992.
16. Shiller, R.J. Do stock prices move too much to be justified by subsequent changes in dividends? *Am. Econ. Rev.* **1981**, *71*, 421–436.
17. Merton, R. A simple model of capital market equilibrium with incomplete information. *J. Financ.* **1987**, *42*, 483–511.
18. French, K. Stock returns and the weekend effect. *J. Financ. Econ.* **1980**, *8*, 55–69.
19. Jaffe, J.; Westerfield, R. The week-end effect in common stock returns: The international evidence. *J. Financ.* **1985**, *40*, 433–454.