Price Stabilization and Discovery under a Random-end Trading Mechanism

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Abstract

We study the effects of a *random-end (RE) trading mechanism* on price stabilization, discovery, and efficiency. Using the real-time order book, we analyzed all RE occurrences among the 1,567 firms listed on the Korea Exchange (KRX) during the daily opening and closing call auctions in 2009 and 2010. We found that the RE trading mechanism promoted price stabilization. This price stabilization effect came mainly from the cancellation or correction of existing orders. We also found that the RE trading mechanism improves opening price discovery. In contrast, the prices overreacted during the additional pre-closing price discovery process following a closing RE occurrence. Our results, along with analyses of "Option Shock" (the worst price manipulation in KRX history), however, suggest that the current KRX RE trading mechanism is not effective against large manipulations of the spot market connected to the expiration of index options and futures. This suggests that policymakers should tighten the RE trading mechanism to restrain extreme manipulative attempts linked to derivatives trading on the spot market. Additionally, our results suggest that securities markets becoming advanced emerging markets in terms of market capitalization and nominal volume should employ a much more sophisticated RE trading mechanism than the current KRX mechanism.

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1. Introduction

Opening and closing prices in a traditional limit-order book stock exchange are typically determined by call auctions, in which the exchange accumulates orders that are held but not executed until the open or close. The call auctions have evolved to include a *random-end (RE) trading mechanism*. In the RE trading mechanism, the orders are used to project an opening or closing price on a real-time basis over a certain time interval before the normal opening or closing time. The *projected price*[1] may fluctuate, as orders are placed or withdrawn; see Figure 1 for a detailed illustration. The projected price at the scheduled time of opening or closing is called the *potential price*. The *extreme projected price* is the projected price with the largest absolute difference from the potential price; the absolute difference between the extreme projected price and the potential price is called the *extreme distance*. If the extreme distance exceeds a threshold (expressed as a percentage of the potential price), the RE trading mechanism extends the call auction for a brief randomly-chosen span of time (hereafter the "RE session"). The random length of the extension is not announced until the extension ends. The randomization is primarily designed to force traders to withdraw orders that were not intended to be executed, but instead intended solely to manipulate the price. The threshold for invoking the RE trading mechanism is drastically reduced on the expiration dates of derivative contracts whose prices are closely linked to the prices of underlying stocks.

The world's major exchanges[2] including the Korea Exchange (KRX) have adopted the RE trading mechanism in order to prevent rapid price fluctuations (e.g., manipulative orders such as spoofing orders) during periodic call auctions and, in turn, enhance the integrity of the market. The resulting price stabilization is intended to enhance price discovery and efficiency during periodic call auctions, especially the opening and closing call auctions.

In this paper, we examine whether the specific RE trading mechanism adopted by KRX is effective in accomplishing these objectives, and discuss the appropriate design of RE mechanisms more generally. We address the following concrete questions: Is the RE trading mechanism effective for price stabilization? If so, through which channels does it operate? Is the RE trading mechanism effective for price discovery? Does it make a contribution to

[1] The projected price is often called the indicative price.
[2] European exchanges, especially Deutsche Börse (DB), Euronext, and the London Stock Exchange (LSE) have been praised for providing some of the most sophisticated RE trading mechanisms in the world.

price efficiency? Is it effective against price manipulation connected to the expiration of derivative contracts such as index options and futures?

RE trading mechanisms have been little studied. As far as we know, there are only two papers—Medrano and Vives (2001) and Hauser, Karmara, and Shurki (2012).[3] Medrano and Vives (2001) theoretically analyzed the price discovery process during the opening call auction with an RE trading mechanism. Given a typical market-microstructure model including a market maker, noise traders, and informed traders, Medrano and Vives (2001) considered a single strategic informed trader and a sector of competitive informed agents. The behavior of this monopolistic strategic informed trader plays a central role in their results on the RE trading mechanism. They showed that the RE trading mechanism can limit, but not eliminate, stock price manipulation arising from a contrarian strategy by the strategic informed trader.[4] This manipulation only occurs in periods when there is a relatively low probability that the market will open on time. They also showed that the market price does not converge to the fundamental value of the stock, no matter how many tâtonnement rounds are carried out.[5] Meanwhile, Hauser et al. (2012) conducted an event study of the introduction of an RE trading mechanism in the Tel Aviv Stock Exchange (TASE), to examine the effects of opening time randomization and options expiration on pre-opening and opening stock prices. They found that, after the randomization, the informativeness of pre-opening prices improved significantly and pre-opening prices on expiration dates became as accurate as on non-expiration dates. They also reported that the introduction of an RE trading mechanism in TASE did not lead to complete convergence of the opening stock prices to the full-information prices, but it did improve price discovery and reduce excess volatility and price distortion, especially on expiration dates. Based on their empirical results, they argued that the social benefits from the introduction of a suitable RE trading mechanism could be

[3] Even though they did not directly analyze an RE trading mechanism, Kuk, Liu, and Pham (2013) provided meaningful implications on its effectiveness. They developed a theoretical model in which strategic limit orders (i.e., spoofing orders) can move the opening price away from its true value. In their model, the deviation from the true value increases as information becomes more asymmetric. Using the first-day pre-opening periods of Australian IPO firms, they confirmed the predictions of their theoretical model and recommended that the Australia Stock Exchange (ASX) improve its RE trading mechanism to prevent manipulative activities via strategic limit orders.

[4] The contrarian strategy in the model of Medrano and Vives (2001) aims to keep the informativeness of the market prices low.

[5] Using simulations of their model, Medrano and Vives (2001) stated that their outcomes are consistent with the empirical evidence of Biais, Hillion, and Spatt (1999), in which the pre-opening price discovery in Paris Bourse is a learning process, since the information content of projected prices steadily increases as opening time approaches.

substantial.

Even though the above papers analyzed RE trading mechanisms, they did not directly test RE trading mechanisms; one is a theory paper, while the other is an event study designed to determine the overall social benefits of RE trading mechanisms, but not to understand their functioning in detail. Thus, those papers have inherent limitations for understanding the economic functions and effects of RE trading mechanisms. In this paper, we directly investigate a real-world RE trading mechanism. Specifically, we study the economic functions and effects of the RE trading mechanism for the opening and closing prices adopted by KRX, in terms of price stabilization, price discovery, and price efficiency. While KRX is one of the leading advanced stock and derivatives markets in the world,[6] its RE trading mechanism is more primitive than those of major European exchanges. Our study allows us to investigate how to set the parameters of the RE trading mechanism for a specific market with a given level of maturity. In addition, because the market structure has been drastically changed by the increased prevalence of algorithmic and high-frequency trading, practitioners, market operators, and policy makers have become increasingly interested in the RE trading mechanism, particularly for its roles in ensuring price discovery, market stability and integrity, and investor protection. Hence, our research provides meaningful insights on the economic functions and roles of RE trading mechanisms to both academics and practitioners.

In this paper, we examine all the RE occurrences among 1,567 stocks listed on KRX[7] during the daily opening and closing call auctions for two years (504 trading days) from January 2009 to December 2010. We reconstructed the real-time order book and the RE occurrences from the KRX Trade and Quote (TAQ) data.[8]

The following are our empirical results and implications, along with a brief explanation of our analytical methodology.

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[6] As of 2012, market capitalization of KRX ranked 15th and trading volume (using the number of contracts) for KOSPI 200 index futures and options ranked ninth and second, respectively, in the world (World Federation of Exchanges, 2012).

[7] KRX is comprised of two equity markets, KOSPI and KOSDAQ. KOSPI is the main board, while KOSDAQ is the new (or growth) market which provides funding mainly to IT-related, newly incorporated, and/or innovative small- and medium-sized enterprises (SMEs). Among 1,567 stocks, 671 stocks are listed on KOSPI, while 896 stocks are listed on KOSDAQ.

[8] As will be mentioned in Section 3, KRX internal rules prohibit any socially sensitive data from being provided to outsiders for research or other purposes. Thus, it was necessary to construct the real-time order book and RE occurrences from their TAQ data. KRX kindly provided an appropriate sample of the real-time order book and RE occurrences, so that we could match our reconstructed order book against it and validate the reconstruction process.

First, for the price stabilization effect of an RE occurrence, we used a binomial distribution analysis on the reversals of price changes among the extreme projected price, the potential price and the actual opening price (hereafter the *opening price*). Similarly, we analyzed price reversals at the close. We interpret a reversal as an indication of stabilization: the potential price had risen (fallen) as a result of manipulative orders, and it falls (rises) when the manipulative orders are withdrawn during the RE session. We did these analyses for each RE occurrence on KOSPI and KOSDAQ, for each of the calendar years 2009 and 2010. We found that the RE trading mechanism stabilized prices in 7 of 8 cases (two exchanges, two years, opening and close). The exception, the 2010 closing call auctions on KOSPI, occurs in a period which included the worst price manipulation in KOSPI history. The price stabilization effect comes mainly from the cancellation or correction of existing orders, not from the inflow of new orders; we interpret these cancellations or corrections as the withdrawal of manipulative orders. These manipulative orders occur more frequently in the closing call auction than in the opening call auction. Thus, many of the RE events at the opening may reflect the arrival of substantial information overnight instead of manipulation.

Second, for the price discovery effect of the RE trading mechanism, we performed an unbiased regression analysis used by Biais, Hillion, and Spatt (1999). We found that the RE trading mechanism makes a meaningful contribution to price discovery for the opening price, sufficient to support the no-manipulation-hypothesis proposed by Medrano and Vives (2001). In contrast, we found that price discovery for the closing price is delayed from the beginning of the closing call auction at 14:50 to the RE occurrence at 15:00, and that the prices overreact during the RE session. This indicates that it might be desirable for KRX to employ multiple RE sessions at the close, as is the practice in Europe.

Third, for the effect of the RE trading mechanism on price efficiency, we used a volatility analysis on the 30 minute (or 1 hour) returns calculated from the potential opening price at 9:00 and from the opening price (i.e., right after the RE session ends), respectively. We found that, when RE occurs, the volatility of 30 minute (or 1 hour) returns calculated from the opening price is lower than that of 30 minute (or 1 hour) returns calculated from the potential opening price at 9:00, and is statistically significant at the 1 % level. This implies that the RE trading mechanism improves the efficiency of the opening price. Naturally, however, this improvement is not big enough to exceed price efficiency on the days when RE did not occur.

Fourth, for the effect of RE trading mechanism against manipulative attempts linked to derivatives trading during the closing call auction, we performed a comparative analysis and a simple time-series analysis using the numbers of RE occurrences in KOSPI 200 index constituent stocks and non-constituent stocks. Our results suggest that the current KRX RE trading mechanism is not effective against attempted manipulations of spot market prices in connection with the KOSPI 200 options and futures. This suggests that policymakers should tighten the RE trading mechanism to restrain extreme manipulative attempts linked to derivatives trading on the spot market. Additionally, our results suggest that securities markets becoming advanced emerging market in terms of market capitalization and nominal volume should employ a much more sophisticated RE trading mechanism than the current KRX mechanism.

The remainder of the paper is organized as follows. Section 2 briefly describes the RE trading mechanism adopted in KRX. Section 3 discusses the data and the characteristics of the stocks for which RE occurred. Sections 4 presents the empirical analyses, results and their implications. We conclude the paper in section 5.

2. The RE Trading Mechanism on KRX

An RE trading mechanism is an integral part of a call auction mechanism. The ending time of the call auction is not fixed, but extended under certain circumstances for a brief randomly-chosen span of time less than or equal to a "*maximum duration.*"[9] The random-ending time is not announced until it is reached. In practice, the maximum duration is usually set at 5 minutes on most major European exchanges such as DB, Euronext, and LSE, but occasionally is set at a very short interval such as 1 minute as on Nasdaq OMX Nordic.

A variety of RE trading mechanisms have been developed in Europe, and now RE trading

[9] In KRX, the random-ending time is selected as a computer-generated random number in the interval between zero and the maximum duration specified by the exchange. However, the random number evidently does not come from a uniform distribution: the median intervals are 81.5 and 91 seconds on the opening/closing on KOSPI (116 and 124 seconds on KOSDAQ), while the means are 82.5 and 90 on KOSPI and 115.7 and 122 on KOSDAQ). There were 24 (8 on KOSPI, 16 on KOSDAQ, all at the opening) when the interval exceeded 5 minutes. KRX confirmed the validity of our results, but replied that it could not provide the details for investor protection reasons. There is a theoretical advantage to use an exponential distribution rather than a uniform distribution, because the exponential distribution has a constant hazard rate, while the uniform distribution has a low hazard rate at the beginning of the interval, increasing over time.

mechanisms are very broadly used globally. The major European exchanges adopted RE trading mechanisms with a goal of protecting investors and promoting market stabilization when the stock price moves dramatically due to market overreactions. Hence, in Europe, the RE trading mechanism is widely utilized as a tool by which stock exchanges try to maximize positive effects from their "*volatility interruption* (VI)" systems,[10] i.e., single-stock circuit breakers. The European exchanges allow for two or three consecutive RE sessions to achieve the objectives of the VI system.

The purpose of the introduction of the RE trading mechanism in KRX is narrower and more specific than on European exchanges. KRX introduced the RE trading mechanism on January 26, 2004 (March 7, 2005) on KOSPI (KOSDAQ) to "prevent price manipulation utilizing spoofing orders during the call auction, and protect investors." The RE trading mechanism in KRX is as follows.

The threshold for invoking an RE session is an extreme distance of 5% within a 5 minute period immediately prior to the scheduled opening or closing time throughout our data period.[11] The maximum duration of an RE session on KRX is 5 minutes. Figure 1 illustrates an RE trading mechanism at the opening on KRX.

<Figure 1>

3. Data and the Characteristics of Stocks with an RE Occurrence

3.1 Data

In this paper, the sample period is 504 trading days of two years from January 2009 to December 2010. For the sample stocks, we include all the stocks listed on KOSPI and KOSDAQ except foreign stocks (DRs), SPACs, investing companies (including REITs), ETFs, newly-listed or delisted stocks, and stocks that switched their listings from KOSDAQ to

[10] A VI system is a sophisticated microstructure mechanism providing cooling-off periods and effective price discovery in brief periods of abnormal volatility. VI systems are implicit dynamic price-limit systems, compared to the explicit price-limit systems which most Asian exchanges have adopted. For an example of a VI system, see Deutsche Börse Group (2013). A U.S. version of the VI system is Limit Up/Limit Down, which was adopted on April 8, 2013 and consists of single-stock circuit breakers intended to prevent the recurrence of the Flash Crash of May 6, 2010.

[11] Prior to May 30, 2011, the threshold was the same on option expiration days as on other days. Since May 30, 2011, the threshold at the close has been 3% on KOSPI index option expiration days, 5% on the close on all other days, and 5% at the opening of all days.

KOSPI within the data period. Altogether, our sample consists of 1,567 stocks, of which 671 stocks were listed on KOSPI and 896 stocks were listed on KOSDAQ.

For data, we reconstructed the real-time order book and RE occurrences from the KRX TAQ data. The reconstruction of RE occurrences was carried out using the KRX definition of RE as described in Section 2. As mentioned in the introduction, we verified our reconstruction against an appropriate sample of the real-time order book provided by KRX.

3.2 The characteristics of stocks with an RE occurrence

In our sample, there were 17,548 RE events at the opening and 7,093 at the close (see Table 2).[12] It is quite difficult to concisely describe the characteristics of stocks with an RE occurrence. As we can see in Figure 2, which lists firms by market capitalization rank, firm size and the number of times of RE occurrences in the opening price seem to be strongly positively related, but this is misleading, as we shall see.

<Figure 2>

We examine the correlations among major characteristics of stocks and RE occurrences. Those variables are as follows: Number of times of RE occurrence in the opening price (*NT_open*), number of times of RE occurrence in the closing price (*NT_close*), average closing price (*prc*), average daily return (*ret*), average daily turnover ratio (*turnover*), standard deviation of daily returns (*std_dev*), trading volume (*volume_value*) (in Korean won, KRW), trading volume in shares (*volume_share*), and market capitalization (*mrk_cap*).

<Panel A> and <Panel B> in Table 1 show Pearson and Spearman correlations among these variables. The relationship between firm size (measured by market capitalization) and the number of times of RE occurrence in the opening or closing price is strongly negatively correlated (-0.45～-0.62). Hence, the smaller the firm size, the more RE occurrences in the opening or closing price. Additionally, RE events occur more frequently on stocks with low price (*prc*) or high volatility (*std_dev*), and this relation is stronger in the opening price than in the closing price.

<Table 1>

[12] During our sample period, RE occurred in 1,497 stocks (95.5%) of our 1,567 sample stocks. Specifically, RE occurred in 606 stocks (90.3%) of 671 stocks listed on KOSPI and 891 stocks (99.4%) of 896 stocks listed on KOSDAQ.

4. Empirical Methodology, Results and Their Implications

4.1 Price stabilization effect of an RE occurrence

When the gap between the projected price and the potential opening (or closing) price exceeds 5%, the RE mechanism is invoked. We examine the changes between the extreme projected price and the potential price, and between the potential price and the actual opening price. Reversal in these two changes is an indication of stabilization: the potential price had risen (fallen) as a result of manipulative orders, and it falls (rises) when the manipulative orders are withdrawn during the RE session.

To test this, we take three steps. At the first step, we examine how many times the potential opening (or closing) price moves up or down from the extreme projected opening (or closing) price when the RE event is invoked. As shown in Table 2, for the opening price, the number of times that the potential price moves up is 8,519, which is slightly less than the number of times (8,998) that the potential price moves down. However, they look balanced in general. In contrast, for the closing price, the number of upward movements is 4,708, which is almost twice the number of downward movements (2,372). If an RE occurrence is related to manipulative orders, these results suggest that there were significant attempts to manipulatively push up the closing price.

<Table 2>

At the second step, we examine the change between the potential price and the opening (or closing) price terminating the RE session. The third column A in Table 3 reports the number of times in RE events that the potential price and the opening (or closing) price are equal, which implies that the RE mechanism made *no* difference in the opening (closing) price; the total number is 10,674, or 43.3% of the 24,641 RE occurrences (KRX total in column A/KRX total in column D). This surprisingly high proportion indicates either that almost half of the RE occurrences resulted from price movements reflecting real information rather than manipulation, or alternatively that the RE mechanism failed to correct the manipulation. Nonetheless, 56.7% of all RE occurrences had an effect on price. This effect is higher in KOSDAQ (57.3%) than in KOSPI (54.5%), but the difference is not statistically significant.

As the third step, we compare the number of reversals of price changes (column B in Table 3), which indicates price stabilization, with the number of continuations of price changes (column C in Table 3). If the potential price accurately reflected the information available to the market and any change between the projected price and the opening (closing) price reflected the arrival of new information, the probability of a reversal should be exactly one-half and the observed distribution of the number of reversals would be binomial. If the number of reversals significantly exceeds half, it indicates that the RE mechanism is counteracting mispricing in the potential price, and hence stabilizing the price. Table 3 shows that in 7 out of 8 cases (two exchanges, two years, opening and close), the number of reversals was statistically significantly greater than one-half. The exception, the 2010 closing call auctions on KOSPI, were affected by "Option Shock," the worst price manipulation in KOSPI.

Through the above three-step analysis, we have shown that the RE trading mechanism stabilizes prices. We now address the size of the price stabilization effect. The results in Table 3 show that the reversals offset 24.3% and 25.8% of the extreme distances at the opening and the close, respectively. When the two changes go in the same direction, the second change averages 17.1% and 16.4% of the extreme distance. Thus, there are more price reversals than continuations, and the reversals are larger than the continuations.

<Table 3>

4.2 The path of the price stabilization of RE trading mechanism

To understand and appropriately utilize RE trading mechanisms, it is important to understand whether the price stabilization effect shown in Section 4.1 comes from the inflow of new orders and/or the cancellations or corrections of the existing orders. For this, we perform two analyses; one is for both opening and closing call auctions, while the other is only for the opening call auction. In the first analysis, we categorize all order flows during the opening (or closing) RE session by number of orders, order proportion, effective number of orders, and effective order proportion. Then, we categorize the path of the opening (or closing) price stabilization of RE trading mechanism as ordinary, cancellation, or correction order. In the second analysis, we follow the same procedure as in the first analysis for all

order flows during the first 5 minutes in the continuous trading session right after the opening price. Then, we compare the results to those during the RE session done in the first analysis.

4.2.1 Counting number of orders by type

Analysis during the opening (or closing) RE session.—At first, we count the number of orders of each order type (ordinary; cancellation; correction) during the opening (or closing) RE session. RE terminates the opening (or closing) call auction randomly, so that the intervals are of different lengths for different stocks.

<Panel A> and <Panel B> in Figure 3 show that, regardless of order type, more than half of the orders during the RE session were submitted in the first minute and few orders were submitted after 3 minutes, both at the opening and close.[13] This phenomenon was much stronger at the close than at the opening.

Moreover, during the RE session, far more buy than sell orders were submitted, regardless of opening or close. Cancellation and correction orders together were almost half as numerous as ordinary orders at the opening and significantly more numerous than ordinary orders at the close. Cancellations and corrections should be relatively rare, so the large number of these orders suggests they were cancelling or correcting earlier manipulative orders. So, the price stabilization effect comes mainly from the cancellations or corrections of existing orders, not from the inflow of new orders. Our results also imply that these manipulative orders occur more frequently in the closing call auction than in the opening call auction. Thus, many of the RE events at the opening may reflect the arrival of substantial information overnight instead of manipulation.

<Figure 3>

Analysis of the first 5 minutes of the continuous trading session right after the opening price.—Next, we compare the number of orders by type (ordinary; cancellation; correction) during the first 5 minutes of the continuous trading session right after the opening price to that during the RE session for the stocks for which RE occurred. <Panel C> in Figure 3 shows

[13] There were 228,902 ordinary buy orders submitted during the first minute of the RE session, but only 115 orders of all types after 3 minutes in the RE session. For brevity, we do not report this result in Table.

that, after the opening, ordinary orders were overwhelmingly predominant, whereas cancellation or correction orders were rare during the first 5 minutes of the continuous trading session.

4.2.2. Robustness checks: The order proportion and the number or proportion of effective orders by type

The order proportion by type.—Comparing <Panel C> to <Panel A> in Figure 3, it looks like cancellation or correction orders are submitted much more in the RE session than in the first 5 minutes in the continuous trading session. However, this may appear so because <Panel A> in Figure 3 shows the number of orders calculated by simply summing up all the numbers of orders of the stocks for which RE occurred. In this case, it is somewhat difficult to clearly identify the distribution of order submissions at the later stage of the RE session, since most order submissions are overwhelmingly concentrated in the first 1 to 2 minutes during the RE session.[14]

To generalize our results of the number of orders with this difficulty adjusted, we perform a robustness-check analysis using order proportion by type. We define the order proportion by type as follows: first, for each stock for which RE occurred, we normalize the number of orders of each type by total number of ordinary orders submitted during the RE session; so, the order proportion of ordinary order is 1. Next, we average order proportion by type for all stocks for which RE occurred. Since the RE event was invoked more frequently in small stocks if firm size is appropriately considered (see Table 1), order proportion by type may reflect some aspects of the reality which the number of orders by type might miss.

The results from order proportion analyses by type in Figure 1-A of the Appendix maintain most of the characteristics of those from the analyses of the number of orders by type in Figure 2. Specifically, regardless of order type, order proportion is also highly concentrated in the first 1 to 2 minutes, while it diminishes rapidly after 3 minutes. Also, regardless of buy or sell, order proportion of cancellations or corrections is quite significant at the opening even though order proportion of ordinary order is still the highest. In contrast,

[14] Hence, <Panel A> in Figure 3 can be interpreted as showing the distribution of order submissions for the large stocks which have higher number of orders during the RE session.

at the close, order proportion of cancellations is the highest and that of corrections is the significant lowest for both buy and sell.

In spite of the similar characteristics to the results from the analyses of the number of orders by type, the results from order proportion analyses by type reveal an interesting new aspect of RE trading mechanisms—active utilization of cancellation orders by strategic traders (or spoofers). Comparing <Panel A> and <Panel B> in Figure 3 and Figure 1-A, we see from the order proportion that cancellation orders play a much more significant role in pricing than we might have anticipated from the number of orders. Our finding that presumably manipulative orders are more important at the close than at the opening is not affected. Only at the opening for sell is the cancellation order proportion quite lower than the ordinary order proportion, but this finding can be easily explained if spoofing orders are considered. Specifically, spoofing-sell orders are rarely observed in the Korean stock markets due to the technical difficulty of short selling. Accordingly, a spoofing-buy strategy is usually taken by strategic traders, which is a limit-buy order that is followed by a sell order for the same stock and the subsequent cancellation of the initial limit-buy order. So, the submitted spoofing orders before 9:00 are spoofing-buy orders, not spoofing-sell orders. These spoofing-buy orders should be cancelled in the RE session and, in turn, the cancellation order proportion becomes very high for buy during the RE session. Moreover, cancellation orders are much more actively submitted at the close than at the opening because, practically, there is no more trading opportunity after the close. Altogether, these results emphasize the significance of the role of cancellation orders in an RE trading mechanism.

On the one hand, for the stocks for which RE occurred, the order proportion by type during the first 5 minutes in the continuous trading session right after the opening price shows a very similar pattern to that during the 5 minutes of the RE session (see <Panel C> in Figure 1-A and <Panel C> in Figure 3). The only difference is the somewhat relative prominence of cancellation orders in the first minute right after the opening price in order proportion analyses.[15]

The number or proportion of effective orders by type.—A considerable number of the

[15] We conjecture that this comes from strategic traders' ongoing unwinding of spoofing orders which could not be cancelled out during the RE session.

submitted orders do not affect the execution prices. We define an "effective order" as an order which affects the projected or potential or opening (or closing) price over the process of an RE trading mechanism. Hence, for example, the effective order includes an ordinary and a correction buy (sell) order whose price is higher (lower) than the current projected price, and a cancellation buy (sell) order whose price is lower (higher) than the current projected price.

The results from the analysis of the number of effective orders show that their economic implications are not different from those from the analyses of the number of orders or order proportion by type using all order flows.[16] The only different result from using effective orders than all order flows is that, at the close, the number of effective buy-cancellation orders is much lower than the number of effective buy-ordinary orders. However, even in this case, the number of effective cancellations and corrections together is much higher than the number of effective ordinary orders at the close, while the relation is reversed at the opening. This suggests that the submission of manipulative orders is more probable at the close, reconfirming the result from the analysis using all order flows.

The results and their implications from the analyses using effective order proportion by type have also qualitatively similar characteristics to those from using the number of effective orders by type, the number of orders, or order proportion of all order flows. That is, the effective cancellation orders play a significant role in pricing at the opening and particularly at the close, and the effective correction orders play an important role at the close as well.

4.3. Price-discovery and price-efficiency effects of the RE trading mechanism

4.3.1 The price discovery effect of the RE trading mechanism

To identify the price discovery effect of the RE trading mechanism, we compare the price discovery effect of the stocks for which RE had not occurred (hereafter "non-RE stocks") to that of the stocks for which RE occurred (hereafter "RE stocks"). We estimate the price discovery effect utilizing an unbiased regression proposed by Biais et al. (1999),[17] who

[16] For brevity, we do not report figures on the results from the analyses using effective orders by type (number of orders and order proportion). The detailed results are available from the authors on request.

[17] An unbiased regression proposed by Biais et al. (1999) has been being widely used for follow-up studies testing

analyzed all the sample stocks using the seemingly unrelated regressions (SUR). Compared to Biais et al. (1999), however, we have too many sample stocks and days to run SUR. Therefore, instead, we first estimate the coefficients from simple OLS regressions of equation (1) for each stock and then average the coefficients of all stocks.

$$\frac{V_i - E(V_i|I_0)}{E(V_i|I_0)} = \alpha_{i,t} + \beta_{i,t}\left[\frac{P_{i,t} - E(V_i|I_0)}{E(V_i|I_0)}\right] + z_{i,t} \quad (1)$$

For the opening, the following variables in equation (1) appear: V_i is the opening price of stock i, $E(V_i|I_0)$ is the previous day closing price of stock i, $P_{i,t}$ is the projected price of stock i at pre-opening time t, and $z_{i,t}$ is an error term. For testing, we first estimate the coefficient $\beta_{i,t}$ of equation (1) for each stock i listed on KRX. Next, we categorize all the sample stock-day pairs into two groups, RE stocks and non-RE stocks, and then average the coefficients at each minute from 8:00 to the opening time for each group of RE stocks and non-RE stocks. Finally, we perform the *t*-test for mean difference of the two groups for each minute.

Figure 4 displays the mean of coefficients (or slopes) $\beta_{i,t}$ of equation (1) for each group of RE stocks and non-RE stocks at each minute at the opening. The price discovery of RE stocks is a little bit faster than that of non-RE stocks until 8:25, but, after that time, it slows down. During the RE session after 9:00, however, $\beta_{i,t}$ of RE stocks reaches close to 1 and is also larger than that of non-RE stocks, indicating that the KRX RE trading mechanism makes a meaningful contribution to the price discovery at the opening. Our result supports the "no-manipulation-hypothesis" proposed by Medrano and Vives (2001), differing from the result of Hauser et al. (2012) in which $\beta_{i,t}$ did not converge to 1 in all the analyses. Put differently, the KRX RE trading mechanism makes a meaningful contribution to price discovery for the opening price, sufficient to support the no-manipulation-hypothesis proposed by Medrano and Vives (2001).

<Figure 4>

Figure 5 depicts the price discovery effect for each group of RE stocks and non-RE stocks at the close, which is quite different from the price discovery effect at the opening. The price discovery of RE stocks is delayed from the beginning of the closing auction at 14:50 to the RE

the price discovery effect. A recent example is Hauser et al. (2012) who used this methodology to test whether the introduction of an RE trading mechanism in TASE improved the price discovery for the opening price.

occurrence at 15:00. Moreover, $\beta_{i,t}$ goes down briefly right after 15:00 and then moves over 1 during the rest of the RE session, indicating that the prices overreact during the RE session.[18] This seems to be closely related to the fact that trading on KRX is not active after the closing auction which terminates the RE session. With the lack of trading opportunity for the rest of the day, some of traders, possibly high frequency or day traders, want to make their positions as flat as possible. This indicates that it might be desirable for KRX to adopt multiple RE sessions at the close, as is the practice in Europe. Especially when an extreme price manipulation occurs as on witching days, the adoption of the multiple RE sessions at the close might be critically required.

<Figure 5>

4.3.2 The effect of the RE trading mechanism on price efficiency

To see the effect of the RE trading mechanism on price efficiency, we compare the volatility of 30 minute returns calculated from the potential opening price at 9:00 and to that of 30 minute returns calculated from the opening price (i.e., right after the RE session ends) for RE stocks, separately for the days when RE occurred (hereafter "RE days") and for the days when RE did not occur (hereafter "non-RE days").[19] So, we assume that an equilibrium price reaches 30 minutes after the opening. Volatility is measured by standard deviation. To obtain meaningful standard deviations of the returns, we have limited our sample to 715 stocks for which RE occurred more than 10 times.

We use a paired *t*-test twice. The first paired *t*-test is to compare the standard deviations of 30 minute returns calculated from the potential opening price at 9:00 to those of 30 minute returns calculated from the opening price (i.e., right after the RE session ends) for each stock on RE days. Table 4 shows that the volatility of 30 minute returns calculated from the opening price is lower than that of 30 minute returns calculated from the potential opening price, and is statistically significant at the 1% level. Assuming that the price formed about 30 minutes after the normal opening time is a true equilibrium price, this implies that the RE

[18] Unlike at the opening, prices overreact at the close. Even so, this does not support the result of Hauser et al. (2012), but still rather supports the no-manipulation-hypothesis by Medrano and Vives (2001) since $\beta_{i,t}$ moves below and over 1.

[19] Non-RE days mean all the trading days except RE days over our two years sample period.

trading mechanism improves the efficiency of opening price.

The second paired *t*-test is to compare the standard deviations of 30 minute returns calculated from the opening price on RE days to those on non-RE days, for each stock. Table 4 shows that the volatility of 30 minute returns calculated from the opening price on RE days is higher than that on non-RE days, and is statistically significant at the 1% level. This implies that the opening price on RE days is inefficient relative to that on non-RE days, which seems a natural result since the RE event itself is invoked as the opening (or closing) price discovery proceeds abnormally.

Instead of 30 minutes, we also use 1 hour for the interval to calculate the returns. The test results are qualitatively the same as the above.[20]

<Table 4>

4.4. Manipulative attempts linked to derivatives trading at the close and the effectiveness of RE trading mechanism

It is well documented that, on the futures and/or options expiration days, it often occurs that the attempts of price manipulation on the underlying index constituent stocks at the closing call auction to make a profit in the corresponding index futures and/or options positions (for example, see Hsieh, 2009). Korea is not an exception. On November 11, 2010, Korea experienced Option Shock, the worst price manipulation on the KOSPI spot market linked to the KOSPI 200 index options trading on the expiration date. Even though it is not an extreme case as occurred in Option Shock, the market participants in the Korean stock markets widely believe that to some extent, there exist manipulative trading activities on the prices of KOSPI 200 index constituent stocks at the closing call auction.

To evaluate the effectiveness of the KRX RE trading mechanism against manipulative attempts in connection with derivative trading during the closing call auction, we perform the following two analyses in this section. First, we compare the number of RE occurrences between KOSPI 200 index constituent stocks and non-constituent stocks. Second, we perform a simple time-series analysis using the numbers of KOSPI 200 index constituent stocks for which RE occurred and identify whether there are any significant abnormalities on

[20] For brevity, we do not report this result in Table. The detailed results are available from the authors on request.

the day of Option Shock.

4.4.1 A comparative analysis between KOSPI 200 index constituent stocks and non-constituent stocks

Given the aforementioned beliefs that are widely held among the Korean market participants, if the KRX RE trading mechanism works appropriately for the objectives to be adopted, then the RE event should occur at the close more in KOSPI 200 index constituent stocks than in non-constituent stocks. However, <Panel A> in Table 5 shows that RE occurred 1,327 times (828 times in 2009 and 499 times in 2010) in 1,267 non-constituent stocks during our sample period, which is significantly more than 207 times (158 times in 2009 and 49 times in 2010) in 230 constituent stocks. This suggests that the current KRX RE trading mechanism may not have a sufficient effect against manipulative attempts linked to the KOSPI 200 index futures and/or options trading during the closing call auction.[21]

The ineffectiveness of the current KRX RE trading mechanism at the closing call auction can be also confirmed from the results of <Panel B> in Table 5, which reports the price stabilization effect of RE trading mechanism at the close in KOSPI 200 index constituent stocks. The Table shows that the number of reversals of price changes (i.e., the price stabilization effect) at the close in KOSPI 200 index constituent stocks is 21.0%, which is smaller than 22.8% of all stocks (including KOSPI 200 index constituent stocks and non-constituent stocks together; see Table 3).

<Table 5>

4.4.2 "Option Shock" at KRX

As mentioned above, on November 11, 2010, a KOSPI 200 index options expiration date, the KRX experienced Option Shock, the worst price manipulation in its history. Right before

[21] In order to infer this implication, of course, we should analyze data only for expiration days of futures and/or options. However, we cannot perform any meaningful analysis on it since the sample size is too small. Even if the sample size were sufficiently large, the RE trading mechanism would still not have much effect against manipulative attempts on a whole market scale since the manipulation would barely occur to significantly larger firms.

the closing call auction began at 14:50, KOSPI was at 1,963.03. The order book contained about 280 billion KRW of net buy orders by program traders using index arbitrage (i.e. net buying of individual stocks and shorting the index). At 14:57, a foreign securities firm submitted a block programmed sell order for 2.44 trillion KRW (approximately 1.8 billion USD) worth of individual stocks.[22] Earlier that day, the same firm had acquired index options to create a synthetic short position in index futures to hedge the block programmed sell order.[23] Moreover, the firm acquired out-of-the-money index put options. KOSPI dropped by 48.30 from 1963.03 at 14:50 to 1,914.73 at the close, which was 2.46% fall of the index. The foreign securities firm roughly broke even on the block program sale combined with the synthetic futures contract; it earned the whopping 44.8 billion KRW from the out-of-the-money puts only at the closing call auction, which was about 40 times higher than the amount it bought.

To understand the effectiveness of the KRX RE trading mechanism in restricting the severity of Option Shock, we perform a simple time-series analysis using the numbers of RE occurrences at the close in KOSPI 200 index constituent stocks during the sample period.[24]

Figure 6 shows that RE did not occur to most of KOSPI 200 index constituent stocks. In particular, on the day of Option Shock, November 11, 2010, the RE event was invoked in only three KOSPI 200 index constituent stocks: SK Telecom, KT and LG Household and Health Care (see the small circle in Figure 6). On that day, the projected price of SK Telecom at 15:00 was 168,000 KRW and its closing price was 168,500 KRW. The projected prices of KT and LG Household and Health Care were 45,500 KRW and 379,000 KRW, respectively, and their closing prices were as same as their projected prices. Hence, on the day of Option Shock, the RE that was invoked on an individual constituent stock had little effect on the closing price of KOSPI 200 index. This suggests that the KRX RE trading mechanism was not effective against large manipulations of the spot market linked to the expiration of the KOSPI 200 index options and/or futures. This implies that policymakers should set the threshold for

[22] KRX rules required that notice of large block programmed orders be given no later than 14:55. The firm paid a fine of 2 million KRW for the failure to give the required notice.

[23] The firm sold index call options and bought index put options, thereby creating a synthetic futures contract. The expiration date of the synthetic futures contract is the options expiration date, i.e. the same date the contract was established. No actual futures contracts expired that date. However, the firm falsely reported its open interests as "stock-buy and futures-sell" position, not as "stock-buy and synthetic-futures-sell" position, providing the false signal to the market participants.

[24] Up to this section, we used cross-sectional analyses. Thus, we could not separately analyze the effectiveness of the KRX RE trading mechanism during Option Shock, since it was only one-time event.

involving RE trading mechanism up rigidly enough to restrain possibly extreme manipulative attempts on the spot market linked to derivatives trading. Further, our results on Option Shock suggest that the securities markets which have been entering into advanced emerging markets in terms of market capitalization and nominal volume such as KRX should adopt much more sophisticated RE trading mechanism than the one that KRX currently has.

<Figure 6>

5. Concluding Remarks

In this paper, we examined the economic functions and effects of the KRX RE trading mechanism by focusing on price stabilization, discovery, and efficiency. We also analyzed the effectiveness of the KRX RE trading mechanism during Option Shock, the worst price manipulation on the spot market in the KRX history. This is the first attempt in the academic finance literature to directly investigate a real-world RE trading mechanism. Using data on all the RE occurrences among 1,567 firms listed on KRX during the daily opening and closing call auctions for two years in 2009-2010, we obtained the following empirical results and implications.

First, from a binomial distribution analysis, we found that the RE trading mechanism promoted price stabilization. This price stabilization effect came mainly from the cancellation or correction of existing orders. Second, from an unbiased regression analysis, we also found that the RE trading mechanism improved opening price discovery, whereas the prices during the closing RE session overreacted. This seems to be closely related to the fact that trading on KRX was not active after the closing auction which terminates the RE session. So, the lack of trading opportunity for the rest of the day had an influence on the trading behavior of some traders, possibly high frequency or day traders, who wanted to make their positions as flat as possible. Third, from a volatility analysis, we found that the RE trading mechanism improved the efficiency of the opening price, although it remained below that on the days when RE did not occur. Fourth, our results, along with analyses of Option Shock, suggest that the current KRX RE trading mechanism is not effective against large manipulations of the spot market connected to the expiration of index options and/or futures.

Our results also suggest some policy implications. Policymakers should tighten the RE

trading mechanism to restrain extreme manipulative attempts linked to derivatives trading on the spot market. That is, the RE mechanism should be tightened on the expiration dates of index options and/or futures. For example, policymakers could lower the threshold for invoking an RE session, and use repeated RE sessions, on dates on which they expect highly volatile price movements. The European exchanges, which allow for two or three consecutive RE sessions or a much reduced price threshold on options expiration dates, are a good example. Further, the securities markets becoming advanced emerging markets in term of market capitalization and nominal volume should employ a much more sophisticated RE trading mechanism than the current KRX mechanism.

For brevity and the range of the paper, we did not discuss some important issues related to the RE trading mechanism in this paper. For example, the characteristics of stocks for which RE is invoked frequently, the effects of an RE occurrence on price manipulations like spoofing orders, and so forth are worthy of further consideration.

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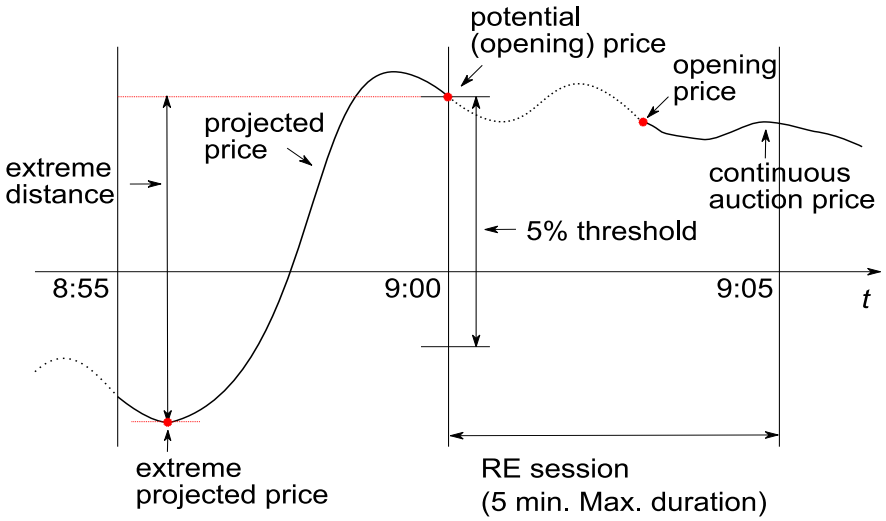


Figure 1. An illustration of an RE trading mechanism at the opening on KRX

KRX starts accepting orders for the opening (closing) call auction at 8:00 (14:50). It announces the *projected price* which is the real-time auction price from 8:30 (14:50) for the opening (close). The projected price may fluctuate, as orders are placed or withdrawn. The projected price at the scheduled time of opening is called the *potential (opening) price*. The *extreme projected price* is the projected price with the largest absolute difference from the potential price; the absolute difference between the extreme projected price and the potential price is called the *extreme distance*. If the extreme distance exceeds the threshold of 5% (expressed as a percentage of the potential price), the RE trading mechanism extends the call auction for a brief randomly-chosen span of time, RE session, with 5 minute maximum duration.

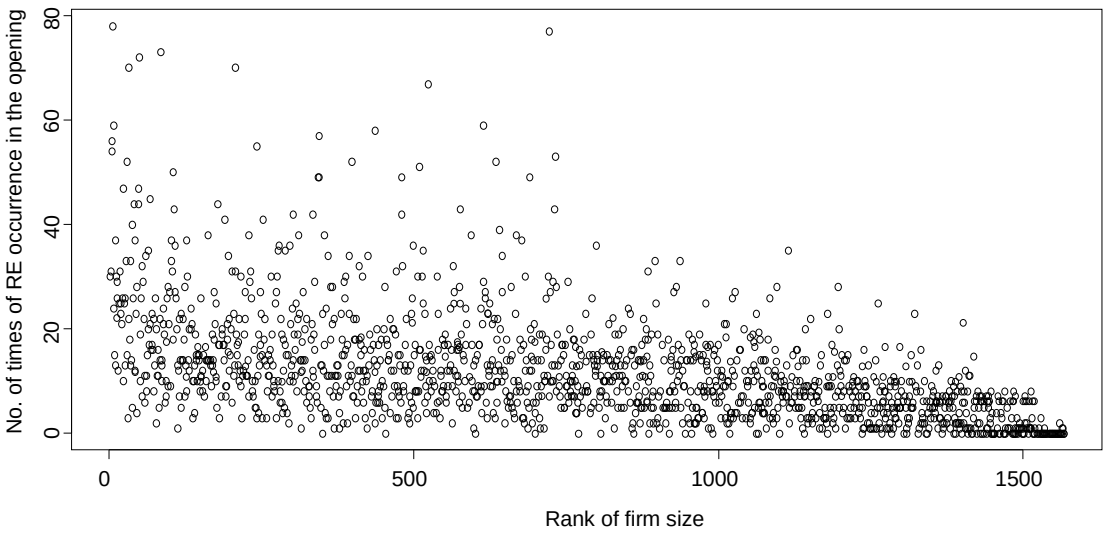
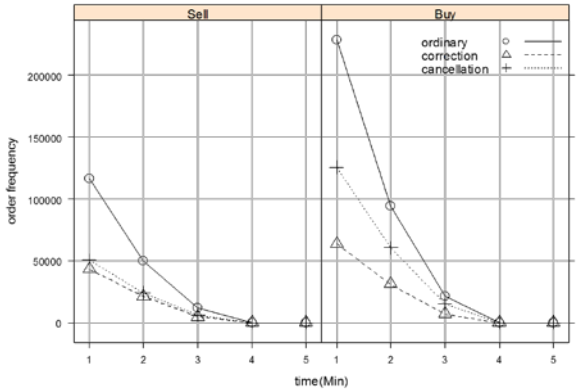
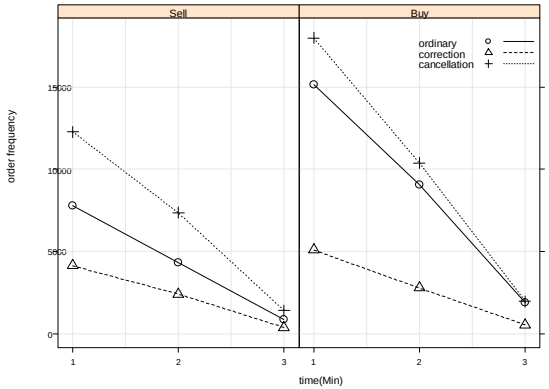


Figure 2. The relationship between firm size and the number of RE occurrences in the opening price

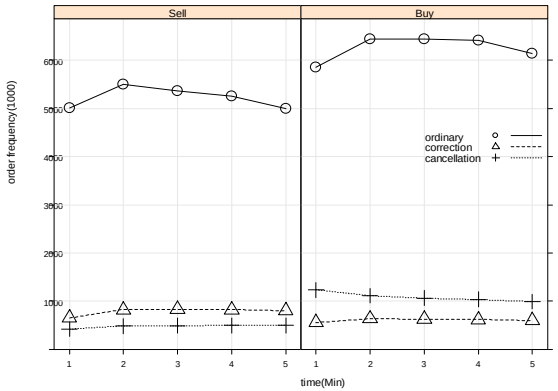
The x-axis gives the firm rank by market capitalization.



<Panel A> Number of oders by type during the opening RE session



<Panel B> Number of orders by type during the closing RE session



<Panel C> Number of orders by type during the first 5 minutes in the continous trading session right after the opening price

Figure 3. The number of orders by type during the opening and closing RE sessions, and the first 5 minutes in the continuous trading session right after the opening price

The orders in all trading sessions of the above panels are categorized as ordinary, cancellation, and correction orders. We count the number of orders by simply summing up all the number of orders of the stocks for which RE occurred. <Panel A> shows the number of orders by type during the opening RE session. Total number of orders are 17,548 of 1,440 stocks. <Panel B> shows the number of orders by type during the closing RE session. Total number of orders are 7,093 of 1,318 stocks. Instead of 5 minutes used for <Panel A> and <Panel C>, we report the number of orders by type for <Panel B> during the first 3 minutes of the closing RE session, since there were few orders submitted after 3 minutes. <Panel C> shows the number of orders by type during the first 5 minutes in the continuous trading session right after the opening price. Total number of orders are 17,548 of 1,440 stocks.

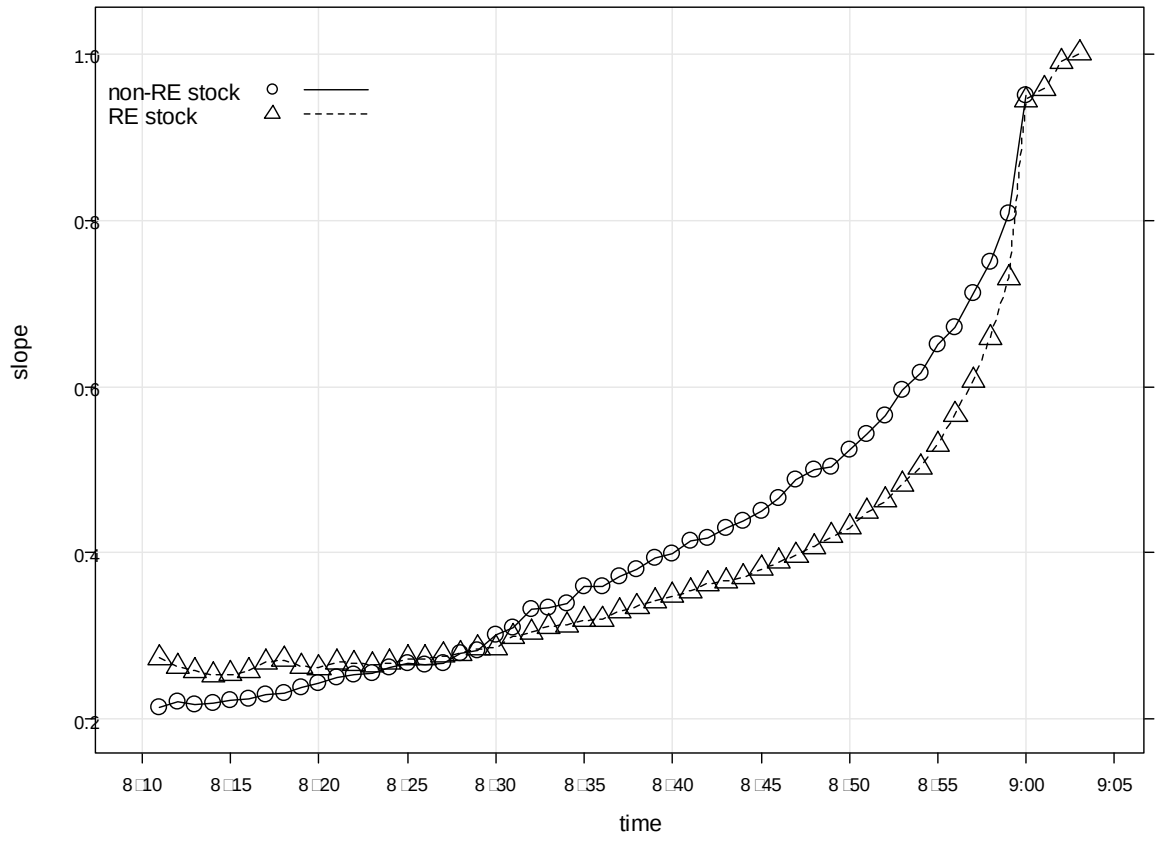


Figure 4. Price discovery effect during the opening call auction with RE invoked

"Non-RE stocks" denote the stocks for which RE did not occur, whereas "RE stocks" denote the stocks for which RE occurred. For testing, we first estimate the coefficient (slope) $\beta_{i,t}$, price discovery effect, of the below equation for each stock *i* listed on KRX.

$$\frac{V_i - E(V_i|I_0)}{E(V_i|I_0)} = \alpha_{i,t} + \beta_{i,t}\left[\frac{P_{i,t} - E(V_i|I_0)}{E(V_i|I_0)}\right] + z_{i,t}$$

For the opening, the following variables in the above equation appear: V_i is the opening price of stock i, $E(V_i|I_0)$ is the previous day closing price of stock i, $P_{i,t}$ is the projected price of stock i at pre-opening time t, and $z_{i,t}$ is an error term. Next, we categorize all the sample stock-day pairs into two groups, RE stocks and non-RE stocks, and then average the coefficients at each minute for each group of RE stocks and non-RE stocks. Finally, we perform the *t*-test for mean difference of the two groups for each minute.

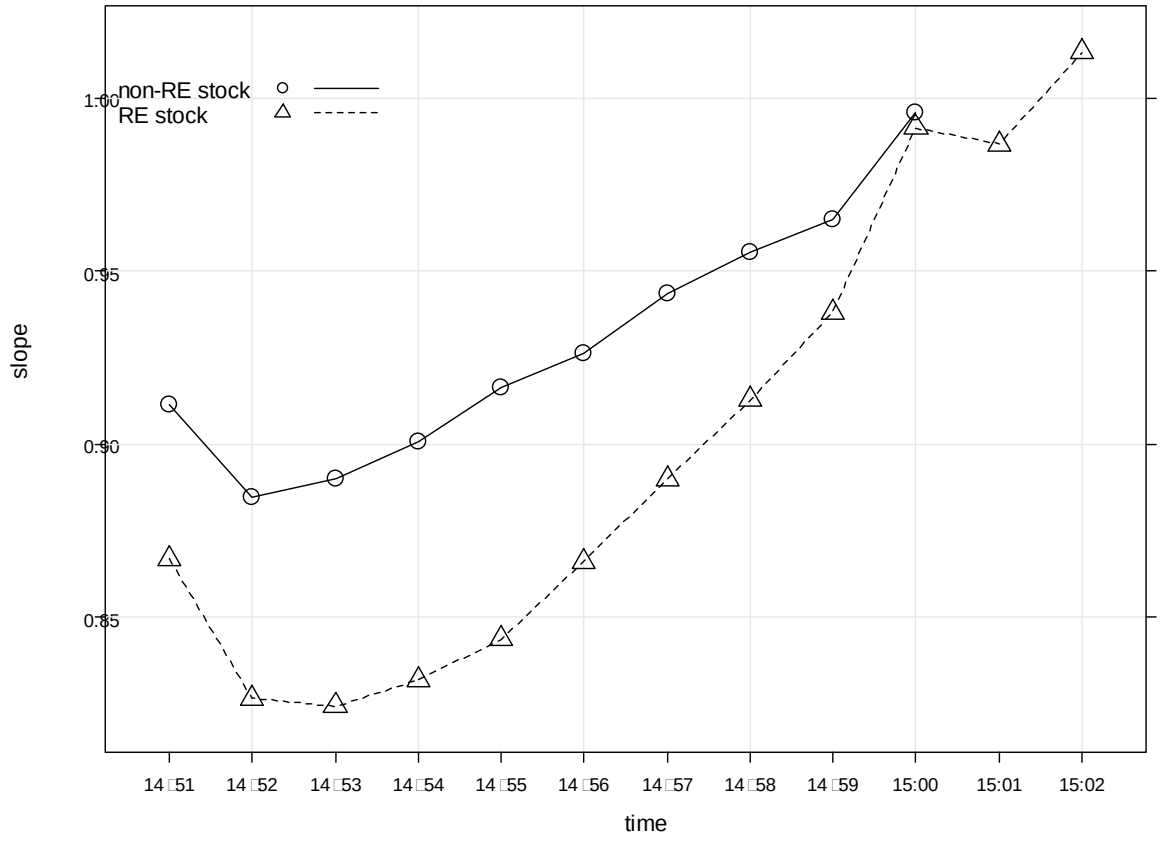


Figure 5. Price discovery effect during the closing call auction with RE invoked

"Non-RE stocks" denote the stocks for which RE did not occur, whereas "RE stocks" denote the stocks for which RE occurred. For testing, we first estimate the coefficient (slope) $\beta_{i,t}$, price discovery effect, of the below equation for each stock i listed on KRX.

$$\frac{V_i - E(V_i|I_0)}{E(V_i|I_0)} = \alpha_{i,t} + \beta_{i,t}\left[\frac{P_{i,t} - E(V_i|I_0)}{E(V_i|I_0)}\right] + z_{i,t}$$

For the close, the following variables in the above equation appear: V_i is the closing price of stock i, $E(V_i|I_0)$ is the previous day closing price of stock i, $P_{i,t}$ is the projected price of stock i at pre-closing time t, and $z_{i,t}$ is an error term. Next, we categorize all the sample stock-day pairs into two groups, RE stocks and non-RE stocks, and then average the coefficients at each minute for each group of RE stocks and non-RE stocks. Finally, we perform the t-test for mean difference of the two groups for each minute.

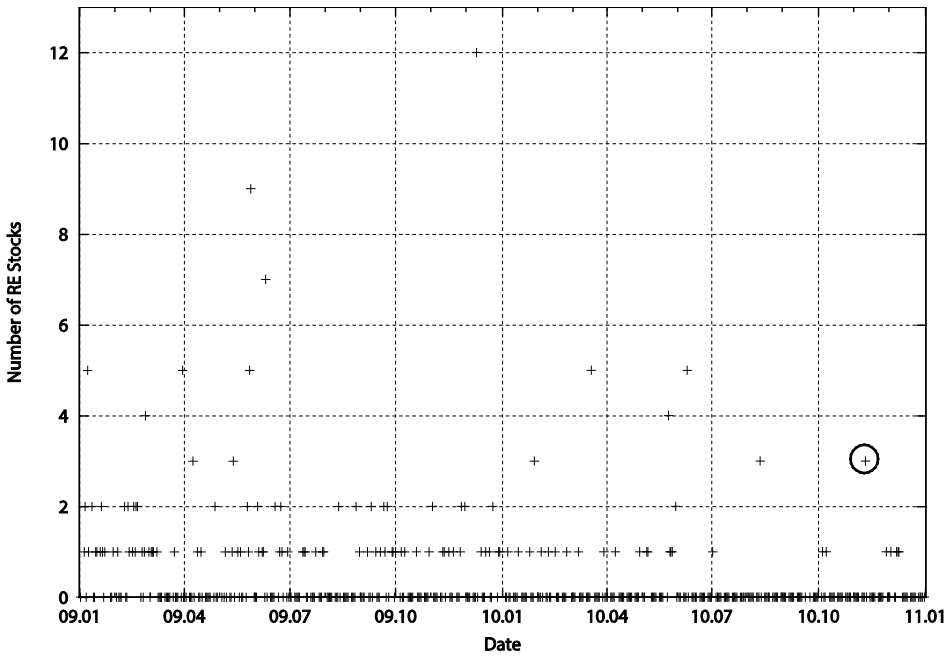


Figure 6. The numbers of RE stocks at the close in KOSPI 200 index constituent stocks

This Figure shows the number of RE occurrences at the close in KOSPI 200 index constituent stocks during the sample period. The maximum number of RE occurrences at the close in KOSPI 200 index constituent stocks was 12, on December 10, 2009. "Option Shock" occurred on November 11, 2010, when the RE event was invoked in only three KOSPI 200 index constituent stocks: SK Telecom, KT and LG Household and Health Care (marked in the small circle).

Table 1. Correlations among major characteristics of stocks and RE occurrences

The variables in this Table are as follows. *nt_open:* number of times of RE occurrence in the opening price, *nt_close:* number of times of RE occurrence in the closing price, *prc:* average closing price, *ret:* average daily return, *turnover:* average daily turnover ratio, *std_dev:* standard deviation of daily returns, *volume_value:* trading volume (in Korean won, KRW), *volume_share:* trading volume in shares, *mkt_cap:* market capitalization.

<Panel A> Pearson correlation coefficients

	nt_ open	*nt_ close*	*Prc*	*ret*	*turn over*	*std_ dev*	*volume_ value*	*volume_ share*	*mrk_ cap*
nt_open	1.000	0.659	-0.194	-0.136	0.302	0.748	-0.188	0.215	-0.515
nt_close		1.000	-0.151	-0.123	0.092	0.483	-0.309	0.011	-0.450
prc			1.000	-0.021	-0.143	-0.242	0.219	-0.205	0.432
ret				1.000	0.031	0.003	0.199	0.044	0.083
turnover					1.000	0.658	0.429	0.643	-0.177
std_dev						1.000	0.175	0.581	-0.415
volume_value							1.000	0.698	0.692
volume_share								1.000	0.126
mrk_cap									1.000

<Panel B> Spearman correlation coefficients

	nt_ open	*nt_ close*	*Prc*	*ret*	*turn over*	*std_ dev*	*volume_ value*	*volume_ share*	*mrk_ cap*
nt_open	1.000	0.657	-0.594	0.036	0.406	0.744	-0.202	0.190	-0.620
nt_close		1.000	-0.414	-0.014	0.097	0.446	-0.364	-0.066	-0.562
prc			1.000	0.101	-0.415	-0.553	0.224	-0.444	0.672
ret				1.000	0.201	0.185	0.228	0.105	0.055
turnover					1.000	0.764	0.603	0.811	-0.186
std_dev						1.000	0.241	0.586	-0.425
volume_value							1.000	0.723	0.600
volume_share								1.000	0.093
mrk_cap									1.000

Table 2. The directional movement of the potential price when the RE trading mechanism was invoked

This table shows the number of times that the potential opening (or closing) price moved up or down from the projected opening (or closing) price when the RE trading mechanism was invoked. * denotes that the potential price moved up or down more than 5% during the 5 minutes before the normal opening (9:00) or the normal closing (15:00) time and, by coincidence, the maximum up and down are of equal magnitude.

	Direction of the changes in the potential price	No. of times of occurrences
Opening	Up	8,519
	Equal up and down*	31
	Down	8,998
Close	Up	4,708
	Equal up and down*	13
	Down	2,372

Table 3. Price stabilization effect of RE trading mechanism

"No. of times of price unchanged" in column A includes 44 of "equal up and down" in "opening" (31) and "close" (13) in Table 2. [a] denotes a percentage measure of reversals of price changes (B), which is calculated as follows: |potential price - opening (or closing) price|×100/(change of projected price). [b] denotes a percentage measure of continuations of price changes (C), which is calculated as follows: |potential price - opening (or closing) price|×100/(change of projected price). *** and ** denote the statistical significance by binomial distribution at the 1% and 5% level, respectively.

Equity Market	Year	No. of times of price unchanged (A)	No. of reversals of price changes (B)	No. of continuations of price changes (C)	Total no. of times of RE occurrences (D)	Stabilization rate (%) (B/(B+C))	Price stabilization effect (%)[a]	Price continuation effect (%)[b]
<Panel A>	Opening price							
KOSPI	2009	856	712	663	2,231	51.8**	20.1	15.3
	2010	544	596	497	1,637	54.5***	23.8	15.0
	Sub-total	1,400	1,308	1,160	3,868	53.0***	21.8	15.2
KOSDAQ	2009	2,960	2,876	2,125	7,961	57.5***	25.0	17.0
	2010	1,854	2,253	1,612	5,719	58.3***	24.9	18.7
	Sub-total	4,814	5,129	3,737	13,680	57.9***	25.0	17.7
Opening total		6,214	6,437	4,897	17,548	56.8***	24.3	17.1
<Panel B>	Closing price							
KOSPI	2009	698	170	118	986	59.0***	22.5	11.2
	2010	358	98	92	548	51.6	23.3	12.1
	Sub-total	1,056	268	210	1,534	56.1***	22.8	11.6
KOSDAQ	2009	2,377	836	508	3,721	62.2***	26.8	13.5
	2010	1,027	487	324	1,838	60.0***	25.8	13.8
	Sub-total	3,404	1,323	832	5,559	61.4***	26.4	13.6
Closing total		4,460	1,591	1,042	7,093	60.4***	25.8	13.2
KRX total		10,674	8,028	5,939	24,641	57.5***	24.6	16.4

Table 4. Price efficiency of the opening call auction on the days when RE occurred

This Table reports the results from two paired *t*-tests. The first paired *t*-test is to compare the standard deviations of 30 minute returns calculated from the potential opening price at 9:00 (A) to those of 30 minute returns calculated from the opening price (i.e., right after the RE session) (B) for each stock on RE days. The second paired *t*-test is to compare the standard deviations of 30 minute returns calculated from the opening price on RE days (B) to those on non-RE days (C) for each stock. To obtain meaningful standard deviations of the returns, we have limited our sample to 715 stocks for which RE occurred more than 10 times.

	The days when RE occurred (RE days)			**The days when RE did not occur (non-RE days)**	
	30 minute returns calculated from the potential opening price at 9:00 (A)	30 minute returns calculated from the opening price (i.e., right after the RE session ends) (B)	A-B	30 minute returns calculated from the opening price (i.e., 9:00) (C)	B-C
Standard deviation	0.03792	0.03279	0.00512***	0.02348	0.00931***
Number of stocks that the standard deviation of column A (or B) is greater [smaller] than that of column B (or C) at the 5% level			52[0]		377[10]
Number of stocks that the standard deviation of column A (or B) is greater [smaller] than that of column B (or C) without consideration of statistical significance			583[132]		610[105]

Table 5. Analyses on manipulative attempts linked to derivatives trading at the close

<Panel A> presents the numbers of RE occurrences in KOSPI 200 index constituent stocks and non-constituent stocks, respectively. <Panel B> reports the price stabilization effect of the RE trading mechanism at the close in KOSPI 200 index constituent stocks. "No. of times of price unchanged" in column A includes 44 of "equal up and down" in "opening" (31) and "close" (13) in Table 2. [a] denotes a percentage measure of reversals of price changes (B), which is calculated as follows: |potential price - opening (or closing) price|×100/(change of projected price). [b] denotes a percentage measure of continuations of price changes (C), which is calculated as follows: |potential price - opening (or closing) price|×100/(change of projected price). [c] denotes total price change in percentage, not absolute value, when the price change occurs (i.e., B and C), which is calculated as follows: -(potential price - opening (or closing) price)×100/(change of projected price). ‡ denotes the statistical *insignificance* by binomial distribution even at the 10%level.

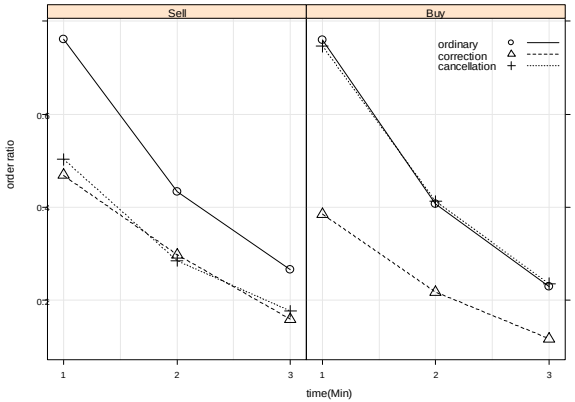
<Panel A> The numbers of RE occurrences in KOSPI 200 index constituent stocks and non-constituent stocks

	No. of RE occurrences		
	Year 2009	**Year 2010**	**Total**
KOSPI 200 index constituent stocks	158	49	207
KOSPI 200 index non-constituent stocks	828	499	1,327

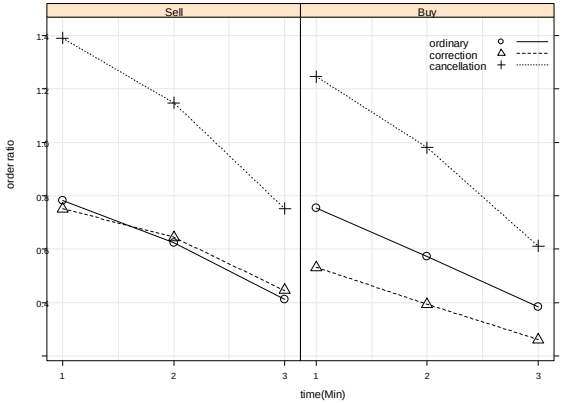
<Panel B> Price stabilization effect of the RE trading mechanism at the close in KOSPI 200 index constituent stocks

Year	**No. of times of price unchanged (A)**	**No. of reversals of price changes (B)**	**No. of continua-tions of price changes (C)**	**Total no. of times of RE occur-ences (D)**	**Stabiliza-tion rate (%) (B/(B+C))‡**	**Price stabiliza-tion effect (%)[a]**	**Price continu-ation effect (%)[b]**
2009	94	33	31	158	51.6	20.1	5.1
2010	34	8	7	49	53.3	24.6	6.2
Total	128	41	38	1,534	51.9	21.0	5.3

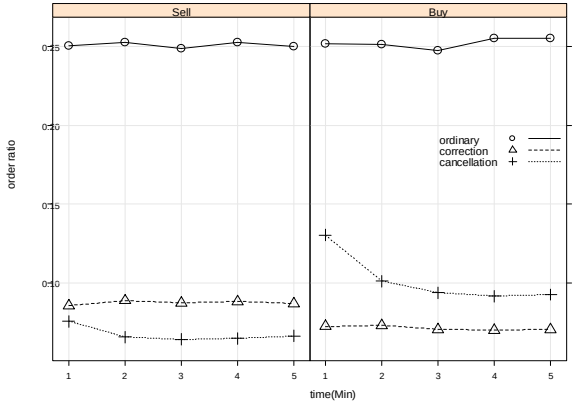
Appendix



<Panel A> Order proportion by type during the opening RE session



<Panel B> Order proportion by type during the closing RE session



<Panel C> Order proportion by type during the first 5 minutes in the continous trading session right after the opening price

Figure 1-A. Order proportion (or order ratio) by type during the opening and closing RE sessions, and the first 5 minutes in the continuous trading session right after the opening price

The orders in all trading sessions of the above panels are categorized as ordinary, cancellation, and correction orders. We define the order proportion (or order ratio) by type as follows: first, for each stock for which RE occurred, we normalize the number of orders of each type by total number of ordinary orders submitted during the RE session; so the order proportion of ordinary order is 1. Next, we average order proportion by type for all stocks for which RE occurred. <Panel A> shows order proportion by type during the opening RE session. Total number of orders are 17,548 of 1,440 stocks. <Panel B> shows order proportion by type during the closing RE session. Total number of orders are 7,093 of 1,318 stocks. For <Panel A> and <Panel B>, we report the order proportion by type in the first 3 minutes during the closing RE session, since there were few orders submitted after 3 minutes. <Panel C> shows order proportion by type during the first 5 minutes in the continuous trading session right after the opening price. Total number of orders are 17,548 of 1,440 stocks. Summing up order proportions of ordinary sell order over 3 minutes, it is over 100% (accurately, 146.2%). This comes from the calculation based on our definition of order proportion.