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The Market Impact Of An Electronic Call Method To Close The Market: Empirical Evidence From Taiwan Stock Market.

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I. Introduction

Motivation

Numerous studies have indicated that the trading mechanism of a security market can influence the price formation process. In particular, the difference in their impacts on market quality between continuous and call trading methods has attracted considerable attention in the market microstructure literature. In a continuous trading market, orders are executed upon submission. Under this trading mechanism, an order might be filled at multiple settlement prices. On the other hand, in a call market, orders are batched over time for simultaneous execution to satisfy the most trading volume. All matched orders in a given call are settled at a single price. So how the trading mechanism makes the market quality different is what we are concerned about.

Theoretical work on how a trading system can affect the asset price formation process appears to precede empirical work. It has been demonstrated that relative to a continuous trading system, a periodic call trading mechanism can overcome the problems of information asymmetry and temporal market fragmentation through a batching process. It can reduce the deviation of the transaction price from its equilibrium value. However, the improvement in pricing efficiency is often achieved at the expense of trading volume. Seminal work in that regard is exemplified by studies such as Garbade and Silber (1979), Goldman and Sosin (1979), Domowitz and Wang (1994), Madhavan (1992), Ho et al. (1985), and Cohen and Schwartz (1989).

Unlike the overwhelmingly concordant contention of theoretical studies, empirical investigations of the issue worldwide provide somewhat mixed results. Amihud and Mendelson (1987), among the first to empirically examine the issue rigorously, find that the price volatility in the call session is higher than that of the following continuous session for the New York Stock Exchange. Similar findings are documented in the study by Amihud and Mendelson (1989) for Tokyo Stock Exchange and Amihud, Mendelson and Murgia (1990) for Milan Stock Exchange. Since New York Stock Exchange, Tokyo Stock Exchange, and Milan Stock Exchange all open with a call method and proceed with a continuous trading mechanism until the close, these studies make inferences about the effects of the two trading mechanisms on the stock price behavior from comparing the behavior of open-to-open and close-to-close returns. However, the conclusion is questioned by later studies such as Amihud and Mendelson (1991) and Gerety and Mulherin (1994), which suggest that the more significant volatility of open-to-open returns is more likely to be caused by the overnight non-trading period rather than the call method.

Furthermore, based on laboratory experiments, Friedman (1993) documents that the periodic call trading mechanism results in higher price volatility and trading volume than the continuous call trading mechanism. On the other hand, recent studies appear to predominantly characterize the continuous market as a market with large trading volumes and high price volatility in relation to the call market. These studies include Amihud et al. (1997) for Tel Aviv Stock Exchange, Muscarella and Piwowar (2001) for Paris Bourse Stock Exchange, Comerton-Forde (1999) for Australian Stock Exchange and Jakarta Stock Exchange, and Chang et al. (1999) and Huang and Tsai (2008) for Taiwan Stock Exchange.

Economides and Schwartz (1995) and Cohen and Schwartz (1989) propose that an electronic call be used to open and close the market once during the trading day. Accompanied by superior computer technology, more and more security exchanges adopt call trading mechanisms to open or close the market to improve market quality. Economides and Schwartz (1995) further contend that closing the market with an electronic call improves pricing efficiency at a time of critical importance because the closing prices might be used for various purposes, such as accounting and regulatory reporting, portfolio performance evaluations, and derivative benchmarks. Due to the limited types of prevailing trading systems for exchanges worldwide, the existing literature primarily focuses on the effects of market-open and during-the-trading-day calls on market quality. In the past, the London Stock Exchange (LSE) and Singapore Exchange (SGX) replaced their open and closed trading systems to call market methods. Except for the swift of the Taiwan Stock Exchange (TWSE), the Hong Kong Stock Exchange transformed into a call method to open the market, the American Stock Exchange (ASE) adopted it at market close, and the NASDAQ and Toronto Stock Exchange also followed up. As Schwartz (2000) predicted, the electronic call trading mechanism is widespread nowadays. Especially deserving to be mentioned is that the periodical market-close call is the most popular method worldwide. Nevertheless, up to now, empirical investigations on the impacts of a market-close call are stillrare. This study aims to provide completed data and refined methodology to examine and evidence the published theory and, most importantly, to fill the scantiness for empirical investigation concerning market-close calls.

Purposes and Contributions

In order to promote the representative, equitableness and objectivity of closing price, the closing price formation process was reformed; Taiwan Stock Exchange switched from a virtually continuous auction mechanism to a call method to close the market. Under the new mechanism, the market closing price is determined by the simultaneous execution of the batch of orders cumulated over the 5-minute interval prior to the close of the market. Besides providing us with an unprecedented opportunity to evaluate the proposal of a market-close call by Economides and Schwartz (1995), this micro-structural change allows us to compare the two trading systems more accurately and insightfully via a refined methodological design concerning the existing studies. The reasons are threefold. First, unlike some of the previous studies such as Amihud and

Mendelson (1987), Amihud and Mendelson (1989), Amihud, Mendelson and Murgia (1990), and Amihud and Mendelson (1991), whose findings are essentially more related to the consequence of the sequential order of the two trading systems during the trading day, our study makes a more direct comparison between the two systems. Before and after the micro-structural change, the last 5-minute interval of the trading day is always preceded by a trading period under the continuous auction mechanism since the market's opening. Thus, we can compare the two trading systems by focusing on the difference in market activity for a given set of stocks during the last 5-minute interval before and after the micro-structural change.

Second, in previous event-type studies such as Amihud et al. (1997), Muscarella and Piwowar (2001), Chang et al. (1999), and Lang and Lee (1999), the trading method for a given stock is wholly altered. This system-wide change makes it difficult to separate the effects of the micro-structural change from those of the macro-level change. In our study, a stock experiences only a partial change in the trading system. We thus can develop an event study methodology, which employs the whole part as a benchmark to control for confounding effects due to differences in macro-environments.

Third, the previous studies examine only a subset of the stocks listed on a given stock exchange, primarily selecting those with high trading volume or market capitalization. Huang and Tsai (2008) test the effectiveness of the five-minute new mechanism for the Taiwan Stock Exchange but only include the component stocks of the Taiwan 50 index. Our study looks at all the stocks traded on Taiwan Stock Exchange. This large sample not only holds the consistency of the statistics but also enables us to investigate further if the impacts of the trading system on market quality are related to characteristics of individual stocks, on which empirical results have yet to be documented. Besides, we only keep stocks actively traded across our sample period; if one stock's trading is ever restricted on any day within our sample period, then we exclude it. Thus, we can ensure that there is no missing sample bias.

Our results corroborate the accomplishment of the new market-close revolution; we indicate that relative to the continuous auction method, the periodic call method can reduce price volatility at the expense of trading volume and liquidity, and these changes bear some relations with market characteristics such as stock price, firm size, trading volume, volatility, and trading frequency. It seems that investors are allured to submit their orders beforehand as their trading behavior near market closed can be restricted. However, we find that the periodic call trading mechanism can significantly improve the effectiveness of the market by comparing the results from the penultimate 5-minute trading data and the results of the last 10-minute trading data. Our study examines the theoretical model proposed by Economides and Schwartz (1995). It makes up for the need for well-designed empirical investigations on the impacts of a market-close call.

The rest of the paper proceeds as follows. In section 2, we review the relevant literature concerning the influence of market quality by implementing a new call trading method and constructing testable propositions for this study. Section 3 describes the background of the Taiwan security market when the new call trading mechanism is executed, characterizes sample data and methodology analyzed in this study, and sets up those market quality variables' definitions. Section 4 reports our empirical results concerning those changes in price performances caused by different market structures.Section 5 summarizes the results and announces the contributions of this paper.

II. Testable Propositions and Relevant Literature

Market Quality Patterns

Theoretical studies comparing the two organizations between continuous and call markets gradually attract more and more attention (Garbade and Silber (1979), Mendleson (1985, 1987a)). Madhavan (1992) examines the dissimilarity between continuous quote-driven and order-driven systems. Madhavan demonstrates the procedure of price formation and detects that the periodic auction system, which induces higher information costs and reduces price continuity, also provides greater price efficiency and works better than a continuous system. Economides and Schwartz (1995) propose using an electronic call to open and close the market once during the trading day. They indicate that the call market is a trading mechanism particularly suitable for computerization and contend that closing the market with an electronic call can improve pricing efficiency.

Amihud and Mendelson (1987) first empirically compare the dealership market regime (continuous quotes) and the systematic trading process in the New York Stock Exchange (NYSE). They suggest that pricing behavior is more efficient, less fluctuated, and the price return deviates less from normality under the continuous quote system. Amihud and Mendelson (1991) further analyzed the Tokyo Stock Exchange (TSE) behavior but found that the periodic clearing procedure appears to be the same as the continuous dealership market. Huang and Tsai (2008) tested the effectiveness of the five-minute new mechanism for the Taiwan Stock Exchange. They concluded that the closing call effectively reduced market volatility and trading noise, but market liquidity declined.

Up to the present, the existing empirical studies related to comparison between the call and continuous trading systems can be classified into three fields. The first one is to examine two different trading methods executed in the same market within the same trading day; the non-concurrent trading mechanisms during the same day are such as that call trading mechanism is used to open the New York Stock market, which then operates under continuous trading mechanism till the market close. This kind of result is probably due to not only the change of trading method but also the effect of distinct trading periods within a trading day(Amihud & Mendelson, 1987; Amihud and Mendelson, 1989, Amihud, Mendelson and Murgia, 1990; Amihud & Mendelson, 1991). The second category is to investigate the stock exchange, which concurrently contains two different trading systems. Stock stocks listed on the stock exchange can be transferred from one trading system to another according to some stock characteristic criteria changes. For example, Tel Aviv and Paris Bourse Stock Exchange maintain two trading systems simultaneously. Studies by Amihud et al. (1997), Muscarella and Piwowar (2001), Chang et al. (1999), and Lang and Lee (1999) belong to this category, and the mixed effects of trading method improvement and changes in the characteristics of sample stocks may cause the outcomes of these studies. The third category is those studies that compare the two trading systems across different stock exchanges. For example,Comerton-Forde (1999) compares the call-trading-opened Australian Stock Exchange with the continuous-trading-opened Jakarta Stock Exchange. The findings contain the effect of different trading methods and the inherent changes of different stock exchanges.

According to the restrictions of the sample and the imperfect methodology designs of previous literature, the micro-structural change of the Taiwan Stock Exchange allows us to compare the two trading systems more accurately and insightfully via a refined methodological design with the existing studies. Therefore, we set up the first testable propositions as follows.

【PROPOSITION 1】

Market quality variables, Trading Volume, Price Volatility, and Market Liquidity will be influenced by introducing a new call trading mechanism for the Taiwan Stock Exchange.

Easley et al. (1996) suggest that the probability of information-based trading differs across trading volume levels. In particular, it is lower for high-volume stocks. The finding prompts us to examine whether the effect of the 5-minute market-close call on market quality differs across stocks with various trading volumes. Muscarella and Piwowar (2001) find that liquidity improvements to stocks under different trading mechanisms are related to their trading activities. Notably, continuous markets offer better liquidity for frequently traded stocks. Chang, Rhee, Stone, and Tang (2008) use Open-to-Open, and Close-to-Close returns to capture the price discovery process and market quality for the call market method adopted by the Singapore Exchange (SGX) and find that the call market method improves market quality, especially for the liquid stocks. For the logic that stock characteristics affect the price formation process and return pattern, it is necessary to examine the robustness test for the influence of market quality under different subsample groups. Except for the criteria such as trading volume, transaction frequency, and liquidity mentioned above, we also include factors such as stock price, firm size, return volatility, and MB ratio etc., which are popularly discussed among studies concerning price formation.

【PROPOSITION 2】

The effectiveness of the new call trading mechanism will be affected by characteristics such as stock price, firm size, trading volume, return volatility, transaction frequency, liquidity, and growth potential.

Investors' Reactions to New Call Mechanism

There was rare literature mentioning whether investors adjust their investment decisions and how investors react to the new trading mechanism. The behavior of investors dealing with the new mechanism revolution is a significant and exciting issue, and we try to shed light on the shortage of this field and reexamine the effectiveness of the new call trading mechanism to observe whether investors change their strategy against the new call trading method.

We intend to focus on the investors' reactions to the new rule as the U-shaped pattern for intraday returns and trading volume is regularly evidenced in the Taiwan Stock market (Ho, Cheung, and Cheung, 1993, Lee, Fok, and Liu, 2001, Lee, Liu, Roll, and Subrahmany, 2004, and Chow, Lee, and Liu, 2004). Because there is an abnormally high trading volume near the market close and numerous reasons for investors to submit their orders when the market is almost closed, many orders are submitted and matched when the market is near close, and day traders do not want to hold any position overnight. To ensure that they can clean all of their open positions, day traders are likely to conduct all or part of the orders ahead of time, otherwise occurring during the last 5-minute interval. We further reinvestigate whether the market quality using penultimate trading data also changes.

【PROPOSITION 3】

Despite investors' behavior near market close being limited by the trading regulation, investors will likely proceed to submit their orders before the last 5-minute break-off trading period.

【PROPOSITION 4】

Suppose investors are allured to submit their orders ahead because the trading regulation limits their behavior near market close. In that case, the new last 5-minute call trading mechanism will improve market quality.

III. Data and Methodology

Description of the Trading Mechanism of the Taiwan Stock Exchange

Accompanied by superior computer technology, more and more security exchanges adopt call trading mechanisms to open or close the market to improve market quality. As Schwartz (2000) predicted, the electronic call trading mechanism is widespread nowadays. Especially deserving to be mentioned is that the periodical market-close call is the most popular method worldwide.

[Insert Table 1 here]

Table 1 highlights the market capitalization, daily trading value, market turnover rate, and the number of listed companies on the Taiwan Stock Exchange. As the figures showed, the market capitalization for TWSE was around NT $ 9,904 to 12,869 billion; the average daily trading value was NT $ 88.2 billion, and the market turnover rate reached 205%. Although the Taiwan Stock Exchange is still one part of the emerging stock market, it had a very high market turnover and matured quickly. In order to accommodate the trend of the call trading system and improve the price formation process, the Taiwan Stock Exchange transferred to a periodical call method to settle the closing price. TWSE is an order-driven market with no market makers (i.e., dealers or specialists). The exchange uses a periodic call method to determine transaction prices. Buy and sell orders are batched and processed periodically by a fully automated securities trading system (FASTS). Based on the price-priority principle, the price that maximizes the trading volume for each batch is chosen to be the market clearing price.[1] The clearing price is the settlement price for buy orders with prices higher than the clearing price and sell orders with lower prices.[2] If the unfilled orders are not canceled, they are carried over to the next call until the end of the trading day.

The trading session of TWSE starts at 9:00 a.m. and ends at 1:30 p.m. The market-open call processes orders that are batched over 30 minutes from 8:30 a.m. to 9:00 a.m. Post-opening trades are also made under a

[1]Orders (either to buy or to sell) with the same price are processed according to the time-priority principle except in the market-open batch, where the orders are randomly arranged. Furthermore, the clearing price, except the market-open price, cannot be more than two ticks away from the previous one. All clearing prices must fall within the ±7% limits of the closing price of the previous trading day.

[2]Orders with prices equal to the clearing price might be partially filled.

similar call mechanism. However, in post-opening calls, the queuing time for orders is shortened to within 30 seconds, thanks to the significant advances in computer technology. Therefore, the trading process in the Taiwan stock market can be viewed as a virtually continuous trading market.

TWSE implemented a new market closing method. Under the new rule, no trades are made from 1:25 p.m. to 1:30 p.m. Within this 5-minute interval; market participants may submit, change, or cancel their orders. At the end of the 5-minute interval, the batched orders are matched by a call mechanism to determine the market closing price. The change in the trading mechanism is depicted in Figure 1. A 5-minute call to close the market is to promote the representative, equitableness, efficiency, and objectivity of the market-closing price.

[Insert Figure 1 here]

Sample Descriptions

We use transaction data of common stocks listed on the Taiwan Stock Exchange to capture the micro-structural changes. It is different from the paper studied by Huang and Tsai (2008); they tested the market quality of the Taiwan Stock Exchange only by the component stocks of the TWSE Taiwan 50 index. We include all companies listed in TWSE to reinvestigate further whether different influences exist across distinct characteristics for stocks. These intra-day data are provided by the Taiwan Economic Journal (TEJ) Data Bank, which collects and sells data disseminated by the Taiwan Stock Exchange Corporation. In order to examine the disparity of market quality between old (continuous) and new (periodic call) trading mechanisms, we choose a two-year event window consisting of one year preceding and another one-year period following the event date. Although the choice of a two-year event window appears to be a little arbitrary, it is intended to eliminate possible seasonal factors, if any, within a year. Therefore, the whole sample period of the study is two years.

We filter out those stocks with complete trading records over the two-year event window. Facing the enormous tick-by-tick data, first of all, we take every five minutes as an interval, select the last trading price of the interval to stand for the prevailing price, and use these five minutes corresponding data to calculate those measurements of market quality, including standardized trading volume (TV), market volatility (VOLA), and market liquidity (LIQU). Because there are 4.5 hours a trading session, in other words, there are 54 5-minute intervals across a trading day.

Measuring Changes in the Market Quality

The event-study methodology is used to investigate the effects of the change in trading mechanism on market quality. We measure market quality by using trading volume, price volatility, and liquidity. Therefore, we examine if these measures have significant disparities between the one year before the change in trading mechanism and the one-year period following the change. Although the choice of a two-year event period centering appears to be arbitrary, it is intended to mitigate possible seasonal noises. Since the new and the old trading mechanisms differ only in the frequency of calls within the last 5-minute interval of the trading session, our primary concern is to compare the market quality for the 5-minute interval under the old mechanism with that under the new mechanism.

However, a direct comparison of the market quality for the last 5-minute trading interval in the pre-and post-change periods is only meaningful since, with the change in trading mechanism, the market quality still can vary over time. Therefore, we use the market quality for the trading day, excluding the last 5 minutes, as a benchmark to control the time-varying nature of the market quality. To be more specific, the adjustment, in general, takes the following format:

$$AMQ_{t,13:25-13:30} = \frac{MQ_{t,13:25-13:30}}{MQ_{t,9:00-13:25}} \qquad (1)$$

where $AMQ_{t,13:25-13:30}$ is the adjusted market quality measure for the last 5-minute trading interval on the day t. $MQ_{t,13:25-13:30}$ and $MQ_{t,9:00-13:25}$ denotes the market quality measures for the specified periods, respectively.

Since the numerator and denominator of the adjusted market quality measure are measured on the same day, they are affected by all possible outside factors on the same day. The time-varying effect is eliminated by dividing the benchmark $MQ_{t,9:00-13:25}$. In other words, if there are disparities between $AMQ_{t,13:25-13:30}$ the continuous trading method (old rule) and the periodical call trading method (new rule), the effect of the trading mechanism swift is the only possible cause. Introducing this specific control benchmark variable, we apply it to all the market quality variables, trading volume, price volatility, and liquidity, respectively. The complex variables' definitions are described below.

Trading Volume

The purpose of controlling the time-varying effect, the change in trading volume between the new and old trading mechanism is calculated as follows:

For a given stock i on day t, the standardized variable, trading volume (TV), is measured as:

$$TV_{i,t} = \frac{TV_{i,t,_{13:25-13:30}}}{TV_{i,t,_{9:00-13;25}}} \qquad (2)$$

$$\Delta TV_i = TV_{i,NEW} - TV_{i,OLD} \qquad (3)$$

where

$$TV_{i,NEW} = \frac{1}{T_{NEW}} \sum_{t=1}^{T_{NEW}} TV_{i,t} \qquad (4)$$

$$TV_{i,OLD} = \frac{1}{T_{OLD}} \sum_{t=1}^{T_{OLD}} TV_{i,t} \qquad (5)$$

Furthermore, $TV_{i,t,13:25\sim13:30}$ and $TV_{i,t,09:00\sim13:25}$ are the stock i's trading volume on day t from 13:25 to 13:30 and from 09:00 to 13:25, respectively. The subscripts "New" and "Old" in $TV_{i,NEW}$ and $TV_{i,OLD}$ refer to new and old trading mechanism. T_{Old} and T_{New} are the number of trading days during the pre-and post-event periods.

Price Volatility

Amihud and Mendelson (1987) found that NYSE's stock price under a continuous auction mechanism is more stable. Conversely, Amihud and Mendelson (1991) showed opposite findings in Tokyo Stock Exchange; Domowitz and Wang (1994) indicated that computer modeling makes trading volume and price volatility more serious. We also control the time-varying effect and further calculate the standardized variable, price volatility (VOLA), as below:

$$VOLA_{i,t} = \frac{\left|R_{i,t,13:25\sim13:30}\right|}{\sigma_{\left|R_{i,t,9:00\sim13:25}\right|}} \qquad (6)$$

$$\Delta VOLA_i = VOLA_{i,NEW} - VOLA_{i,OLD} \qquad (7)$$

where

$$VOLA_{i,NEW} = \frac{1}{T_{NEW}} \sum_{t=1}^{T_{NEW}} VOLA_{i,t} \qquad (8)$$

$$VOLA_{i,OLD} = \frac{1}{T_{OLD}} \sum_{t=1}^{T_{OLD}} VOLA_{i,t} \qquad (9)$$

$\left|R_{i,t,13:25\sim13:30}\right|$ is stock i's absolute return on day t from 1:25 p.m. to 1:30 p.m., and $\sigma_{\left|R_{i,t,9:00\sim13:25}\right|}$ is stock i's standard deviation of absolute return on day t from 09:00 a.m. to 1:25 p.m.. The subscripts "New" and "Old" in $VOLA_{i,NEW}$ and $VOLA_{i,OLD}$ refer to new and old trading mechanism. T_{Old} and T_{New} are respectively number of trading days during the pre- and post-event periods.

Liquidity

Finally, we are also concerned about how the liquidity of stocks changes under different trading mechanisms. Following Muscarella and Piwowar (2001), Cooper et al. (1985), and Amihud, Mendelson, and Lauterbach (1997), Khan and Baker (1993) and in order to test whether liquidity of the same group of stocks significantly changes without any macro-level influence after the new regulation is executed, the standardized variable, liquidity (LIQU) is calculated as:

First of all, we define stock $i's$ liquidity measure for a 5-minute interval during the pre-and post-event periods as follows:

$$LIQ_{i,m,Old} = \frac{\sum_{t=1}^{T_{Old}} TV_{t,i,m}}{\sum_{t=1}^{T_{Old}} \left| R_{t,i,m} \right|} \quad (10)$$

$$LIQ_{i,m,New} = \frac{\sum_{t=1}^{T_{New}} TV_{t,i,m}}{\sum_{t=1}^{T_{New}} \left| R_{t,i,m} \right|} \quad (11)$$

$TV_{t,i,m}$ is the stock $i's$ trading volume on t a day during the m^{th} 5-minute interval. $\left| R_{t,i,m} \right|$ is the absolute value of stock $i's$ return on the day t during the m^{th} 5-minute interval. The “ m ” ranges from 1 to 54, indicating the 5-minute intervals of 9:00-9:05, 9:05-9:10 respectively, ..., and 13:25-13:30. The subscripts "New" and "Old" in $LIQ_{i,m,OLD}$ and $LIQ_{i,m,NEW}$ refer to new and old trading mechanism. Moreover, T_{Old} and T_{New} are respectively number of trading days during the pre- and post-event periods.

For each of the pre-and post-event periods, we divide the liquidity measure from 13:25 to 13:30 (i.e., the 54th 5-minute interval) by the average of the liquidity measures for the rest of the 5-minute intervals. The change in liquidity is calculated by subtracting the adjusted pre-event liquidity measure from the adjusted post-event liquidity measure.

$$\Delta LIQU_{i} = LIQU_{i,New} - LIQU_{i,Old} \quad (12)$$

where

$$LIQU_{i,New} = \frac{LIQ_{i,54,New}}{\frac{1}{53}\sum_{m=1}^{53} LIQ_{i,m,New}} \quad (13)$$

$$LIQU_{i,Old} = \frac{LIQ_{i,54,Old}}{\frac{1}{53}\sum_{m=1}^{53} LIQ_{i,m,Old}} \quad (14)$$

See Muscarella and Piwowar (2001) for a history of the variable as a measure of liquidity. Liquidity refers to the ease of converting an asset to cash. An asset is said to have perfect liquidity if it can be immediately converted to cash at no cost. The trading component (i.e., the numerator) of the proposed measure is to capture the time dimension of liquidity. The volatility component (i.e., the denominator) is to account for transaction cost since it indicates the uncertainty of trading at an observed market price.

Sub-Sample Reinvestigations and Regression Models

Following the preview of standardized market quality variables, including TV, VOLA, and LIQU, we will try to reexamine the results under samples grouped by trading volume, stock price, firm size (market value), trading frequency (number of trades per trading day), volatility, liquidity, and MB ratio, respectively. In this section, we average those original measures of each firm throughout the entire sample period. For example, we want to test whether the market quality differs between large and small sub-samples grouped by trading volume, so we first calculate the average trading volume of each stock[3] Throughout the entire sample period, divide the total sample equally into two sub-samples, a large trading volume group and a small one, and then recalculate the TV, LIQU, and VOLA of the Large and small sub-sample respectively and finally retest the statistics of the difference.

Besides, we would further like to reinvestigate what causes the market quality to be different when Taiwan Stock Exchange changes to call trading market structure. We construct the regression models to figure out. The model contains three regressions as follows:

Model 1: Regression of the Difference of Trading Volume

$$DTV_i = \alpha_i + \beta_{i,1} * \log(stock \quad price) + \beta_{i,2} * \log(size) + \beta_{i,3} * trading \quad frequency$$

$$+ \beta_{i,4} * volatility + \beta_{i,5} * liquidity + \beta_{i,6} * MB \qquad (15)$$

where

$$DTV_i = \frac{1}{T_{NEW}} \sum_{t=1}^{T_{NEW}} TV_{i,t} - \frac{1}{T_{OLD}} \sum_{t=1}^{T_{OLD}} TV_{i,t} \qquad (16)$$

Model 2: Regression of the Difference of Price Volatility

$$DVOLA_i = \alpha_i + \beta_{i,1} * trading \quad volume + \beta_{i,2} * \log(stock \quad price) + \beta_{i,3} * \log(size)$$

$$+ \beta_{i,4} * trading \quad frequency + \beta_{i,5} * liquidity + \beta_{i,6} * MB \qquad (17)$$

where

$$DVOLA_i = \frac{1}{T_{NEW}} \sum_{t=1}^{T_{NEW}} VOLA_{i,t} - \frac{1}{T_{OLD}} \sum_{t=1}^{T_{OLD}} VOLA_{i,t} \qquad (18)$$

Model 3: Regression of the Difference of Liquidity

$$DLIQU_i = \alpha_i + \beta_{i,1} * trading \quad volume + \beta_{i,2} * \log(stock \quad price) + \beta_{i,3} * \log(size)$$

$$+ \beta_{i,4} * trading \quad frequency + \beta_{i,5} * volatility + \beta_{i,6} * MB \qquad (19)$$

where

[3]We used all the value of stock characteristics, which include trading volume, volatility, and liquidity, to divide the whole sample as the original value of stocks and is not the value from the market quality variables we designed above.

$$DLIQU_i = \frac{1}{T_{NEW}} \sum_{t=1}^{T_{NEW}} LIQU_{i,t} - \frac{1}{T_{OLD}} \sum_{t=1}^{T_{OLD}} LIQU_{i,t} \quad (20)$$

IV. Empirical Results

Primary Results

Since the periodic call trading method was executed at the last five minutes of the trading session, intuitionally, the trading frequency and the time interval between transactions would change. Table 2 contains the sample size and mean time lapse between the last two trades under continuous and call trading methods. We can see that in the sample period, the time lapse between the last two successes transactions is about 3 minutes and 9 seconds (189 seconds) under continuous trading, on the other side; it is about 7 minutes and 16 seconds (436 seconds) under periodic call trading method. These findings exhibit that the new mechanism effectively breaks off the trading, the lapse between transactions extends, and the trading frequency reduces.

[Insert Table 2 here]

[Insert Table 3 here]

Table 3 presents the sample descriptions and statistical tests for TV, VOLA, and LIQU under continuous trading mechanism (old rule) and call trading (new rule) from three pre- and post-event periods, respectively. Within the sample period,there were 489 trading days and 691 sample firms. In order to avoid the missing sample bias, we only include those "full-trading stocks". "Full-trading stocks" means those firms included in our sample are all actively traded on full 489 trading days; even stock that was absent one trading day would still be excluded, and finally, there is only 390 firms remainder. Panel A of Table 3 shows the outcomes on one-year pre- and post-event periods significant disparities exist between old and new mechanisms. Relative to the old continuous trading mechanism, market quality variable TV significantly decreases by 0.022 under call trading, variable VOLA and LIQU diminish by 0.211 and 0.108 after the trading method is changed, respectively, and their T-statistics are both significant at 1% level. These indicate that the figures for TV, VOLA, and LIQU under the new call rule are all significantly smaller than the ones under the old rule. The standardized variables, TV and LIQU, decline because of the periodic call trading, and we can say that it is evidence that the market has become less liquid. On the other side, the standardized variable, VOLA, under periodic call trading is also smaller, even though the liquidity under call trading has deteriorated. Panel B and Panel C of Table 3, we shorten the pre- and post-event period to three and six months. Here, we only include those "full trading stocks" to avoid the missing sample bias. There are 248 trading days, 643 sample firms, and 486 "full trading stocks" left in the six-months sample period. As to the three-month sample period, there are 128 trading days, 643 sample firms, and 548 "full trading firms" remainder. Similar results are generated in Panel A relative to the continuous auction method; trading volume, price volatility, and market liquidity significantly decrease under the periodic call method. Moreover, compared to the outcomes for the whole sample period in Panel A, the magnitude of the difference for TV and VOLA are both smaller in Panel B and Panel C, but the cost of less liquid is not getting worsen. These all stand that the new trading mechanism is valid, and the effect is more evident as we lengthen our observation period.

As the findings of Madhavan (1992) and Amihud and Mendelson (1991), smaller trading volumes and less market liquidity did not make stock prices fluctuate more seriously. Despite the trading frequency, trading volume, and market liquidity all reducing, the price volatility also significantly decreases. Although this outcome is agreed with our expectations, what caused this? Is it because the information transparency is not getting worse and the investors still know the market situations well or is the reason the periodic break-off mechanism works so successfully, avoiding someone manipulating the price out of control? This answer is needed and worth further investigation.

[Insert Table 4 here]

Concerning whether the results we got above will change under samples grouped by trading volume, stock price, firm size (market value), trading frequency (number of trades per trading day), volatility, liquidity, and MB ratio, respectively. Table 4 helps us to figure out this question, and for the brief of the paper, we only represent the whole sample period, which means one year pre- and post-event period. Panel A indicates results for small and large subsamples divided by trading volume; there are 195 firms in each subsample, and the mean trading volume is 1500.35 lots in small groups and 11216.31 lots in large groups. Although there are considerable gaps in the trading volume of each subgroup, market quality, including variables TV, VOLA, and LIQU, still has significant declines under the periodic call trading mechanism. Panel B to Panel G, respectively, presents the results among each subsample grouped by stock price, market value, number of transactions per trading day, volatility, liquidity, and MB ratio. All of them consistently represent the same outcomes whether the company belongs to hot (high trading volume), expensive (high stock price), big size (high market value), busy (large number of transactions per day), volatile (high standard deviation of daily return), liquid or not. Even for growth stocks (high market-to-book ratio) or value ones (low market-to-book ratio), the outcomes are robust across each subsample. Price volatility is reduced at the expense of trading volume and liquidity.

[Insert Table 5 here]

Furthermore, Lang and Lee (1999) ever exhibited the performance of various transaction frequencies under the call market in TWSE; they found that the market with greater trading frequencies is more volatile for all firms and more liquid for low turnover firms. Now we show our results below. In order to find out the relationship between market quality and stock characteristics, we suppose characteristics such as trading volume, stock price, firm size, trading frequency, volatility, liquidity, and MB ratio etc., may play an important role. Table 5 shows that firm size is the critical regressor for the difference between TV, VOLA, and LIQU. Volatility and trading volume are not affected so strongly for large firms after the call method is executed, but the liquidity difference is enhanced; otherwise, higher price stock also leads to more significant volatility, which is what we expected. Nevertheless, except for firm size, trading volume, volatility, trading frequency, and MB ratio all significantly influence the changes in LIQU. Under the periodical call trading mechanism, stocks with large firm size, higher trading volume, higher volatility, less trading frequency, and larger MB ratio may cause more enormous liquidity. After the mechanism revolution, the market volatility lessens, especially for cheap and large stocks. Furthermore, LIQU is significantly caused by stock characteristics, such as trading volume and volatility; after the mechanism changes to call trading, high trading volume and less volatile stocks can effectively destroy market liquidity. Only firm size significantly affects TV; small firms still have higher TV even when the call trading mechanism comes into operation.

V. Conclusions

Continuous trading mechanism and periodic call trading mechanism, two types of trading systems, make the price performance and market quality different. There is significant and exciting "mechanism-specific performance" between two different trading systems, and it has become a consensus among financial studies. Nevertheless, there are difficulties in executing the empirical investigations for these distinct trading mechanisms because lacking adaptive and relative benchmarks to test the pure disparity. Besides, possibly due to the limited types of prevailing trading systems for exchanges around the world, empirical investigations on the impacts of a market-close call are rare. In order to promote the representative, equitableness and objectivity of closing price, Taiwan Stock Exchange switched from a virtually continuous auction mechanism to a call method to close the market. Under the new mechanism, the market closing price is determined by the simultaneous execution of the batch of orders cumulated over the 5-minute interval before the market close. This partial change in the microstructure allows us to compare the two trading systems more accurately and insightfully via a refined methodological design to the existing studies.

Our study compares the two trading systems by focusing on the difference in market activity for those full-trading stocks during the last 5-minute interval before and after the micro-structural change. Thus, we can make a more direct comparison between the two systems. This study investigates all the stocks listed on Taiwan Stock Exchange. It examines whether these two different trading regulations led to varied market quality and how the new mechanism for the closing price is accomplished.

Our evidence indicates that the periodic call trading method can reduce price volatility at the expense of trading volume and liquidity relative to the continuous auction method. Furthermore, these changes bear some relations with market characteristics such as stock price, firm size, trading volume, volatility, and trading frequency. It seems that investors are allured to submit their orders beforehand as their trading behavior near market closed can be restricted. However, we find that the periodic call trading mechanism can significantly improve the effectiveness of the market by comparing the results from the penultimate 5-minute trading data and the results of the last 10-minute trading data. Under the new trading mechanism, the periodic break-off mechanism works, and the effect of the market improvement is significant.

Our study examines the theoretical model proposed by Economides and Schwartz (1995). It makes up for the absence of empirical investigations on the impacts of a market-close call. It compares the two trading systems more accurately and insightfully via a delicate methodological design concerning the existing studies.In addition to the well-designed methodology, we further discuss the changes in the investor’s behavior due to the new mechanism. Most importantly, our study can inspect the fruitage of the new regulationand provide a comprehensive investigation concerning the impact on the market quality of the trading method revolution from a continuous to a call trading system.

Table 1

Highlight for Taiwan Stock Exchange in Period I, II, and III, respectively

	Period I	Period II	Period III
Market Capitalization* (NT $ billions)	10247.6	9094.94	12869.1
Daily Trading Value (NT $ billions)	75.23	88.20	81.66
Market Turnover Rate (%)	159.59	205.21	205.50
Number of listed companies*	584	638	669
Number of Trading Days	244	248	249

All the data are summarized from the FactBook published by Taiwan Stock Exchange Corporation.

* The figures are compiled at the end of the year.

Table 2

The sample size and the meantime laps between the last two trades under continuous trading (old rule) and call trading mechanism (new rule) on three different pre- and post-event periods, three-months, six-months, and one-year, respectively.

pre- and post-event periods	three-months	six-months	one-year
Panel A: Continuous Trading (Old Rule)			
N	34524	57348	88452
Mean (seconds)	144.19	155.21	189.11
Panel B: Call trading (New Rule)			
N	36168	63666	90636
Mean (seconds)	498.29	479.78	436.03

Table 3 The sample descriptions and statistics tests of TV, VOLA, LIQU under continuous trading (old rule) and call trading mechanism (new rule) on three different pre- and post-event periods, three-months, six-months, and one-year, respectively.

Panel A: pre- and post-event Sample Period_ One-year			
Firms	390		
trading days	489		
	TV	VOLA	LIQU
Continuous Trading (Old Rule)	0.0861	1.2548	1.5067
Call Trading (New Rule)	0.0636	1.0442	1.3989
Difference	-0.022	-0.211	-0.108
T-Statistic	-12.75***	-26.38***	-52.04***
Panel B: pre- and post-event Sample Period_ Six-months			
firms	486		
trading days	248		
	TV	VOLA	LIQU
Continuous Trading (Old Rule)	0.0761	1.187	1.5573
Call Trading (New Rule)	0.0611	1.0661	1.3614
Difference	-0.015	-0.121	-0.196
T-Statistic	-16.63***	-12.47***	-69.17***
Panel C: pre- and post-event Sample Period_ Three-months			
firms	548		
trading days	128		
	TV	VOLA	LIQU
Continuous Trading (Old Rule)	0.0773	1.1849	1.6592
Call Trading (New Rule)	0.062	1.0929	1.3892
Difference	-0.015	-0.092	-0.27
T-Statistic	-13.97***	-6.92***	-63.04***

where $TV_{i,t} = \frac{TV_{i,t,13:25-13:30}}{TV_{i,t,9:00-13:25}}$, $\Delta TV_i = TV_{i,NEW} - TV_{i,OLD}$, and

$$TV_{i,NEW} = \frac{1}{T_{NEW}} \sum_{t=1}^{T_{NEW}} TV_{i,t}, \quad TV_{i,OLD} = \frac{1}{T_{OLD}} \sum_{t=1}^{T_{OLD}} TV_{i,t}$$

$VOLA_{i,t} = \frac{|R_{i,t,13:25\sim13:30}|}{\sigma_{|R_{i,t,9:00\sim13:25}|}}$, $\Delta VOLA_i = VOLA_{i,NEW} - VOLA_{i,OLD}$, and

$$VOLA_{i,NEW} = \frac{1}{T_{NEW}} \sum_{t=1}^{T_{NEW}} VOLA_{i,t} \ , \ VOLA_{i,OLD} = \frac{1}{T_{OLD}} \sum_{t=1}^{T_{OLD}} VOLA_{i,t}$$

$$LIQ_{i,m,Old} = \frac{\sum_{t=1}^{T_{Old}} TV_{t,i,m}}{\sum_{t=1}^{T_{Old}} \left| R_{t,i,m} \right|}, \ LIQ_{i,m,New} = \frac{\sum_{t=1}^{T_{New}} TV_{t,i,m}}{\sum_{t=1}^{T_{New}} \left| R_{t,i,m} \right|},$$

$$\Delta LIQU_{i} = LIQU_{i,New} - LIQU_{i,Old} \text{, and}$$

$$LIQU_{i,New} = \frac{LIQ_{i,54,New}}{\frac{1}{53} \sum_{m=1}^{53} LIQ_{i,m,New}}, \ LIQU_{i,Old} = \frac{LIQ_{i,54,Old}}{\frac{1}{53} \sum_{m=1}^{53} LIQ_{i,m,Old}}$$

* Significant at 10% level

** Significant at 5% level

*** Significant at 1% level

Table 4

Subsample statistics tests of TV, VOLA, and LIQU under continuous trading (old rule) and call trading mechanism (new rule) on full sample period, which means one year pre- and post-event period—subsamples were grouped by trading volume, stock price, market value, number of trades per day, standard deviation of daily return, liquidity, and MB ratio, respectively.

	Small			Large		
	TV	VOLA	LIQU	TV	VOLA	LIQU
Panel A: T-Statistic of the Difference between Old and New Mechanisms--grouped by trading volume						
N	195			195		
Mean (1000shares)	1500.35			11216.31		
Difference	-0.022	-0.149	-0.184	-0.023	-0.272	-0.03
T-Statistic	-6.27***	-11.13***	-75.18***	-35.66***	-32.04***	-11.53***
Panel B: T-Statistic of the Difference between Old and New Mechanisms--grouped by stock price						
N	195			195		
Mean (NT $)	7.5206			31.045		
Difference	-0.031	-0.222	-0.087	-0.014	-0.199	-0.128
T-Statistic	-23.98***	-17.59***	-36.10***	-4.38***	-20.37***	-46.20***
Panel C: T-Statistic of the Difference between Old and New Mechanisms--grouped by market value						
N	195			195		
Mean (NT $ millions)	2144.44			33061.94		
Difference	-0.024	-0.169	-0.144	-0.021	-0.252	-0.07
T-Statistic	-6.71***	-12.98***	-60.54***	-31.39***	-27.30***	-27.01***
Panel D: T-Statistic of the Difference between Old and New Mechanisms--grouped by number of transactions per day						
N	195			195		
Mean	107.2485			288.331		
Difference	-0.026	-0.186	-0.117	-0.019	-0.235	-0.097
T-Statistic	-7.29***	-13.70***	-50.44***	-42.96***	-28.54***	-41.68***
Panel E: T-Statistic of the Difference between Old and New Mechanisms--grouped by standard deviation of daily return						
N	195			195		
Mean	1.8048			2.25362		
Difference	-0.02	-0.191	-0.174	-0.025	-0.229	-0.041
T-Statistic	-5.89***	-15.57***	-57.20***	-26.89***	-22.72***	-14.60***
Panel F: T-Statistic of the Difference between Old and New Mechanisms--grouped by liquidity						
N	195			195		
Mean	9947.12			69170.30		
Difference	-0.022	-0.151	-0.187	-0.023	-0.271	-0.027
T-Statistic	-6.33***	-11.22***	-76.88***	-35.52***	-31.89***	-10.30***
Panel G: T-Statistic of the Difference between Old and New Mechanisms--grouped by MB ratio						

N	194			194		
Mean	0.6233			1.8401		
Difference	-0.028	-0.202	-0.098	-0.017	-0.218	-0.117
T-Statistic	-22.69***	-16.52***	-39.77***	-5.15***	-21.16***	-40.18***

where $TV_{i,t} = \frac{TV_{i,t,_{13:25-13:30}}}{TV_{i,t,_{9:00-13;25}}}$, $\Delta TV_i = TV_{i,NEW} - TV_{i,OLD}$, and

$$TV_{i,NEW} = \frac{1}{T_{NEW}} \sum_{t=1}^{T_{NEW}} TV_{i,t}, \quad TV_{i,OLD} = \frac{1}{T_{OLD}} \sum_{t=1}^{T_{OLD}} TV_{i,t}$$

$VOLA_{i,t} = \frac{|R_{i,t,13:25\sim13:30}|}{\sigma_{|R_{i,t,9:00\sim13:25}|}}$, $\Delta VOLA_i = VOLA_{i,NEW} - VOLA_{i,OLD}$, and

$$VOLA_{i,NEW} = \frac{1}{T_{NEW}} \sum_{t=1}^{T_{NEW}} VOLA_{i,t}, \quad VOLA_{i,OLD} = \frac{1}{T_{OLD}} \sum_{t=1}^{T_{OLD}} VOLA_{i,t}$$

$$LIQ_{i,m,Old} = \frac{\sum_{t=1}^{T_{Old}} TV_{t,i,m}}{\sum_{t=1}^{T_{Old}} |R_{t,i,m}|}, \quad LIQ_{i,m,New} = \frac{\sum_{t=1}^{T_{New}} TV_{t,i,m}}{\sum_{t=1}^{T_{New}} |R_{t,i,m}|},$$

$\Delta LIQU_i = LIQU_{i,New} - LIQU_{i,Old}$, and

$$LIQU_{i,New} = \frac{LIQ_{i,54,New}}{\frac{1}{53}\sum_{m=1}^{53} LIQ_{i,m,New}}, \quad LIQU_{i,Old} = \frac{LIQ_{i,54,Old}}{\frac{1}{53}\sum_{m=1}^{53} LIQ_{i,m,Old}}$$

* Significant at 10% level,

** Significant at 5% level,

*** Significant at 1% level

Table 5

Regression models for the difference of TV, VOLA, LIQU between continuous trading and call trading mechanism regarding market characteristics such as stock price, size, trading volume, volatility, numbers

of transactions, liquidity, and MB ratio

Variable	Model 1	Model 2	Model 3
	y = DTV	y = DVOLA	y = DLIQU
Intercept	0.0655	0.0161	-1.4066
	(1.17)	(0.09)	(-3.62)***
Price	0.0123	0.0955	-0.0902
	(1.53)	(2.03)**	(-1.63)
Size	-0.0130	-0.0445	0.0827
	(-2.79)***	(-1.65)*	(2.60)***
Trading Volume		-3.02625E-7	0.00001
		(-0.02)	(4.23)***
Volatility	-0.0131		0.4342
	(-0.92)		(4.41)***
Number of transactions	0.00008	-0.0003	-0.0012
	(1.32)	(-1.03)	(-2.78)***
Liquidity	0.000001	-0.000002	
	(1.02)	(-0.06)	
MB ratio	-0.0012	-0.0201	0.0744
	(-0.21)	(-0.53)	(1.79)*
F-statistic	2.15	3.35	13.53
(p-value)	0.0475**	0.0031***	<.0001***
Adjusted R-square	0.0175	0.0352	0.1626

Model 1:

$$DTV_i = \alpha_i + \beta_{i,1} * \log(stock \quad price) + \beta_{i,2} * \log(size) + \beta_{i,3} * trading \quad frequency$$
$$+ \beta_{i,4} * volatility + \beta_{i,5} * liquidity + \beta_{i,6} * MB$$

where

$$DTV_i = \frac{1}{T_{NEW}} \sum_{t=1}^{T_{NEW}} TV_{i,t} - \frac{1}{T_{OLD}} \sum_{t=1}^{T_{OLD}} TV_{i,t}$$

Model 2:

$$DVOLA_i = \alpha_i + \beta_{i,1} * trading \quad volume + \beta_{i,2} * \log(stock \quad price) + \beta_{i,3} * \log(size)$$
$$+ \beta_{i,4} * trading \quad frequency + \beta_{i,5} * liquidity + \beta_{i,6} * MB$$

where

$$DVOLA_i = \frac{1}{T_{NEW}} \sum_{t=1}^{T_{NEW}} VOLA_{i,t} - \frac{1}{T_{OLD}} \sum_{t=1}^{T_{OLD}} VOLA_{i,t}$$

Model 3:

$$DLIQU_i = \alpha_i + \beta_{i,1} * trading \quad volume + \beta_{i,2} * \log(stock \quad price) + \beta_{i,3} * \log(size) + \beta_{i,4} * trading \quad frequency + \beta_{i,5} * volatility + \beta_{i,6} * MB$$

where

$$DLIQU_i = \frac{1}{T_{NEW}} \sum_{t=1}^{T_{NEW}} LIQU_{i,t} - \frac{1}{T_{OLD}} \sum_{t=1}^{T_{OLD}} LIQU_{i,t}$$

The figure in parenthesis is the t-statistic of each parameter.

where $TV_{i,t} = \frac{TV_{i,t,13:20\sim13:25}}{TV_{i,t,9:00\sim13:20}}$, $\Delta TV_i = TV_{i,NEW} - TV_{i,OLD}$, and

$$TV_{i,NEW} = \frac{1}{T_{NEW}} \sum_{t=1}^{T_{NEW}} TV_{i,t}, \quad TV_{i,OLD} = \frac{1}{T_{OLD}} \sum_{t=1}^{T_{OLD}} TV_{i,t}$$

$VOLA_{i,t} = \frac{|R_{i,t,13:20\sim13:25}|}{\sigma_{|R_{i,t,9:00\sim13:20}|}}$, $\Delta VOLA_i = VOLA_{i,NEW} - VOLA_{i,OLD}$, and

$$VOLA_{i,NEW} = \frac{1}{T_{NEW}} \sum_{t=1}^{T_{NEW}} VOLA_{i,t}, \quad VOLA_{i,OLD} = \frac{1}{T_{OLD}} \sum_{t=1}^{T_{OLD}} VOLA_{i,t}$$

$$LIQ_{i,m,Old} = \frac{\sum_{t=1}^{T_{Old}} TV_{t,i,m}}{\sum_{t=1}^{T_{Old}} |R_{t,i,m}|}, \quad LIQ_{i,m,New} = \frac{\sum_{t=1}^{T_{New}} TV_{t,i,m}}{\sum_{t=1}^{T_{New}} |R_{t,i,m}|},$$

$\Delta LIQU_i = LIQU_{i,New} - LIQU_{i,Old}$, and

$$LIQU_{i,New} = \frac{LIQ_{i,53,New}}{\frac{1}{52}\sum_{m=1}^{52} LIQ_{i,m,New}}, \quad LIQU_{i,Old} = \frac{LIQ_{i,53,Old}}{\frac{1}{52}\sum_{m=1}^{52} LIQ_{i,m,Old}}$$

* Significant at 10% level

** Significant at 5% level

*** Significant at 1% level

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