Massey University

Price Limits Are Not Always Bad

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Abstract

Regulators impose price limits on daily price movements to protect investors from excessive volatility, but several empirical studies have cast serious doubt on the benefits of such mechanisms. Using a large cross-sectional sample combined with intraday data from the Tokyo Stock Exchange, this study finds evidence that partially supports conventional criticisms that price limits spread out volatility, delay price discovery, and interrupt trading activities. More importantly, the transaction data analysis reveals that price limits help to reduce order imbalance and improve information asymmetry, justifying the existence of price limits on the Tokyo Stock Exchange.

JEL Classification: G10; G14

Keywords: Price limit; Order imbalance; Information asymmetry; Tokyo Stock Exchange.

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1. Introduction

As one of the commonly used market circuit breakers, price limits are used by many securities markets to protect investors from excessive volatility while restricting daily price movements to within a certain range[1]. There is, however, controversy on price limit performance, which remains unsettled. This study examines the value of price limits, by performing an extensive investigation on the Tokyo Stock Exchange based on a sample pool constructed from intraday and daily data. We find price limits improve order imbalance in the post limit-hit period and, also, that no particular magnet effect occurs on stocks whose prices hit the limits. Furthermore, we find that the market absorbs one-side orders, while price limits provide cooling-off periods for alleviating information asymmetry in the market. Combining these results with our tests on daily data, we also conclude that price limits can mitigate the volatility caused by uninformed trading, although we find that price limits delay fundamental volatility by temporarily controlling the daily price variation.

The important motivation for adopting price limits, is to calm fanatic trading during turbulent periods in stock markets; such as 1987 Black Monday, the 1997 Asian financial crisis and the 2000 Dot-com mania. Price limits halt trading activities when a pre-specified price boundary is exceeded, but still allow trading between the boundaries

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[1] In general, policy makers use circuit breakers to limit trading activities. These circuit breakers include price limits, trading halts, transaction taxes, collars, margin requirements and position limits. Stock exchanges that use price limits are those in Athens, Taiwan, Japan, China, Malaysia, Thailand, India, Korea and Paris, among others. Wide differences in percentages on price limits exist among the exchanges listed, from approximately 3.5% to 30% and, at times, even higher.

to continue. Regulators revise the limits when their perceptions of the market, or the macroeconomic environment change[2]. Also, advocators suggest that if excessive volatility is a result of uninformed trading, price limits provide uninformed traders with more time to reassess asset value and rationalise the estimation of new equilibrium prices before continuing their trades. An imperfect market suffers the problem of limited capacity when facing volume shocks, where informed value traders are concerned about price adjustments during the intervals between the time when an order is decided, submitted and executed. In this circumstance the benefit of price limits also comes from reducing the implementation risk caused by the massive volume, which encourages informed value traders to enter the market. (Greenwald and Stein, 1991; Kodres and O'Brien, 1994)

Nevertheless, early studies have raised criticisms regarding the relationships of price limit, volatility and market efficiency. Kyle (1988) and Fama (1989) both argue that circuit breakers stop prices from being adjusted promptly when fundamental values change greatly. Therefore, instead of mitigating large price fluctuations, price limits may induce a volatility spill-over. Furthermore, Fama (1989) points out that rational prices are not necessarily less volatile than irrational prices, and prevailing prices on the market may not reflect all the available information with the imposition of price limits. Thus, price limits may delay price discovery and reduce market efficiency in semi-strong form. Another proposition related to market efficiency is that the trading

[2] For example: the Stock Exchange of Thailand increased price limits from 10% to 30% in December 1997; and the Korean Stock Exchange has raised price limits from 4.6% to 15% in four steps since 1995.

process is interfered with when trades at prices outside the pre-assigned ranges are prohibited. The argument that price limits could reduce noise trading and achieve lower information asymmetry faces the criticism that equilibrium price can only be realised during continuous trading (Amihud and Mendelson, 1991; Gerety and Mulherin, 1992). Although French and Roll (1986) contend that the degree of information asymmetry is positively related to uninformed trading (noise) in the market, they also suggest it is more likely for private information to induce price variation when the market is open. Therefore, price limits possibly hold back rational trading from informed traders, however price limits do not stop the noise trading that increases transitory volatility (Harris 1998).

Based on the above discussions, most of the empirical studies on the impact of price limits on market economies show that price limits do not meet regulators' expectations on controlling volatility, but instead impose inefficiency issues on securities markets. For example, Kim and Rhee (1997) confirm volatility spill-over, delayed price discovery and trading interference hypotheses on the Tokyo Stock Exchange (TSE). The studies of Chung (1991) on the Korean stock market and Chen (1993) on the Taiwan Stock Exchange (TWSE) show that price limits do not bring significant benefit to markets. Nevertheless, most studies only look at the impact of price limits on total volatility, instead of separating transitory and fundamental volatility. It would be premature to draw conclusions on whether price limits are always bad for markets without further studying how informed decisions are affected (Harris, 1998).

Our study contributes to the existing literature by shedding light on the influence of price limits on intraday trading activities and the information content of prices. Chan, Kim, and Rhee (2005) conclude that price limits do not improve the price formation process and exacerbate order imbalance, based on the intraday data of the Kuala Lumpur Stock Exchange (KLSE). Nevertheless, the sample size for their paper is fairly small, with only upper limit-hit events included[3], which limits the applicability of their results. As a matter of fact, both regulators and investors are concerned with lower limit-hit events, as much as, if not more so, than they are concerned with upper events. This is because the large decrement on stock price often induces market panic, and also greatly affects rational investment decisions. Using transaction data of stocks that were actively traded on the TSE from 1999 to 2000, we test how price limits affect intraday activities, as well as the degree of information asymmetry; which is an important factor for maintaining equilibrium spread in an order-driven market (Harris, 2003).

This paper also fills a gap in the literature by conducting a recent investigation of price limit performance on volatility, price behaviours and trading volumes in the TSE during the last decade (1996 to 2005). The most recent study on TSE price limits (Kim and Rhee, 1997) uses a sample period of 1989 to 1992. It is necessary to re-examine this market and provide research which is more relevant to current regulators, as the economic environment of the stock market in Japan has changed since the Big Bang

[3] In Chan et al. (2005), only ninety-eight sample events with prices hitting upper limit (+30%) are included in the testing procedure, with six events with prices hitting lower limits being excluded from their tests.

reform[4]. The TSE also presents a very good platform, with sufficient sample magnitude and various price limit ranges, hence the test result can be more persuasive with lower bias. Compared with other major exchanges, the market liquidity in the TSE is mostly provided by limit-order traders, with no designated dealer or market maker. TSE also distinguishes itself with its elaborate market microstructure, including special quotes, maximum price variation rule and price limits. Thus, it is interesting to seek how price limits affect market efficiency and protect uninformed traders in this much regulated, but "...well-functioning financial market" (Lehmann and Modest, 1994, p. 982).

Our three findings on the daily data during the past decade are summarised below. Firstly, the volatility spill-over effect not only occurs with limit-hitting stocks, but also with stocks where the changes in price are within 90% of the limits. This result suggests that volatility spill-over may not be solely attributed to price limits. Secondly, price continuation occurs more frequently in stocks which hit the limits in previous trading days, especially when upper price limits are hit, which implies a delayed price-discovery effect. We find investors' under-reaction (momentum strategy) partially contributes to price continuation when the price is moving upward. Following the methodology of Kim and Sweeney (2002), however, our sample data does not lend support to the proposition that informed traders are inclined to delay trades after price limits are hit. Thirdly, the trading volume of stocks with prices hitting limits, decreases at a lower speed in comparison with other stocks which also experience large price

[4] After the rise and collapse of the economic bubble around 1990, a financial system reform was initiated in Japan in order to revitalise Japan's financial market. This reform, which has been in place since late 1996, is also known as the Japanese Big Bang.

variations without hitting limits. Unsurprisingly, these daily results confirm our findings based on transaction data about improved order imbalance and information asymmetry in the post limit-hit period.

The rest of this paper is organised as follows. The next section lays out institutional background information about the TSE, and then describes the sample data, our data filtering process, and the summary statistics of the sample. Section 3 outlines our empirical designs and presents the findings on the test of order imbalance and information asymmetry hypotheses on transaction data. In Section 4, three hypotheses are tested on daily data; volatility spill-over, delayed price discovery, and trading interference. Conclusions and future research suggestions are summarised in Section 5.

2. Tokyo Stock Exchange and Descriptions of Sample Data

2.1 Tokyo Stock Exchange

The Tokyo Stock Exchange was established on May 15, 1878, and is now the second largest stock exchange in the world. It has 2323 listed companies, and over US$4.5 billion in total market capitalisation. The exchange for domestic stocks is divided into three sections: First Section; Second Section; and Mothers. Assignment rules to place listed stocks in each section are based on trading volume, number of shares listed, market capitalisation, et cetera. The sample stocks investigated in this paper are from the First Section, where the most actively traded stocks are listed.

The Tokyo Stock Exchange is a pure order-driven market with no designated market maker, where all liquidity is provided through a limit order book. Market mechanisms, including special quotes, maximum variation rule and price limits, are designed to slow down the trading process when a large order imbalance is expected, or present. In the TSE, the full order book is not accessible for normal traders and the hidden orders are not presented to traders, either. Only the five best prices are presented by the exchange[5]. Special quotes, disseminated by a *saitori* exchange member at their own discretion, are often seen to be indicators of buying (selling) interest in the market, which compensates for the lack of transparency and improves market liquidity. In the TSE, a *saitori* member undertakes the responsibilities of supervising trading processes, logging and matching orders, and also maintaining the limit order book. The Tokyo Stock Exchange uses price limits to prevent "wild swings" in daily price movements, and provide investors with a "time-out" period when big fluctuations occur (Tokyo Stock Exchange, 2006). Price limits are set as the maximum daily price variation in absolute yen value, dependant on stock prices[6]. Price limits also apply to special quotes.

There are two trading sessions on the TSE: the morning session lasts from 9:00am until 11:00am, and the afternoon session lasts from 12:30pm until 3:00pm. Two transaction methods are used in off-hours trading and trading sessions; *itayose* and *zaraba*, respectively. The *itayose* method is used to decide opening and closing prices and

[5] Prior to June 2003, traders could only observe the three best trade prices.
[6] This feature is different from that where price limits are set at certain percentages in most exchanges that adopt this mechanism. We list the detailed price limits in Appendices; Table A2.

works by pooling all orders placed, without the time priority rule. The *zaraba* method is used in continuous trading, and works by matching pairs of buy and sell orders, following both of the time priority and price priority principles. All observations in the off-hours trading; that is, all trades under the *itayose* method; are excluded from our study sample.

2.2 Data Description

Firstly, we extract the historical daily data of 1695 stocks listed in the First Section of the TSE between 1996 and 2005 from Datastream. During this period, there are ups and downs in the market, but without extreme situations such as the 1990 market collapse, which was followed by severe stagnation[7]. This ten-year period provides a sample pool of sufficient magnitude to ensure the general applicability of our results. It is worth noting that during the sample period, both tick size and price limits on the TSE changed (see Table 1A and 2A for details).

The raw data includes the daily high, the daily low and the closing price of each stock, along with daily trading volumes and the market capitalisation. The percentile statistics of year end closing prices (presented in Table 3A) show that the mean prices are much higher than the medians, suggesting the left skewness of price distribution on the TSE. 90% of sample stocks are priced under ¥5000, and about 40% are priced under ¥500.

[7] We show the general trend in the market (1989 to 2005) by displaying the Nikkei 225 price index and its daily volatility, in monthly average (Figure 1A).

Price limits for stocks with a price between ¥100 and ¥500 vary from approximately 16% to 50%. With a stock price between ¥500 and ¥5000, the limits vary from 10% to 20%. This feature allows cheap stocks to be more volatile than high priced stocks.

We identify sample events as the occurrences of the limits being hit, by comparing the daily high, low and closing prices. There are 8390 occurrences of the upper limits being hit and 3355 occurrences of the lower limits being hit during the sample period, which construct our initial sample. As we can see from the summary statistics in Table 4A, downward price movements happen most frequently in the year 2000, due to the high-tech stock bubble burst after the first quarter, which caused a loss of approximately 30% on the Nikkei index. Overall, there are 1198 down-side events in that year. In the previous year, 1999, the Japanese stock market rose about 50%, due to booming of technology companies. As a result, the market saw the most upwards price movements in that year, with 2970 up-side events in total.

Due to events occurring densely in 1999 and 2000, we use the trade-by-trade data of these two years to test order imbalance and the degree of information asymmetry in Section 3, thus our study of the high frequency data can be applicable for either bull or bear market periods. We obtain this data, which includes trading price, bid and ask quotes, and trading volume of the 1399 stocks that were most actively traded from 1999 to 2000, from the Securities Industry Research Centre of Asia-Pacific (SIRCA). With no dealer or market maker in the TSE, we classify buy and sell orders according to the following rules: If the mid-point of the bid-ask spread is greater than the trading price, then the trade is indicated as being seller-initiated, otherwise the trade is indicated as being buyer-initiated; If the mid quote is equal to the trading price, and if there is an up-tick from the previous trade, then the trade is identified as being buyer-initiated, otherwise the trade is identified as being seller-initiated.

3. The Influence on Intraday Trading Activities and Information Asymmetry

3.1 Order Imbalance Hypothesis

From the perspective of regulators, price limits are partially designed to provide time for the market to absorb one-side heavy trading orders. However, as earlier noted by Lehmann (1989, p.207), price limits may "...create a systematic order imbalance between patient and impatient traders", before and after the limits are hit. Therefore, it is important to investigate how price limits affect order imbalance based on broad observations of both directions of price movement.

Following the methodology of Chan et al. (2005), we form two groups of stocks; the stocks with limit-hitting events into $Stock_{hit}$, and the stocks with prices changing over 90% of the limits but without actually hitting the limits into $Stock_{0.90}$, during the 1999 to 2000 period. We then identify the pre-hit period and the post-hit period of each event for the purpose of comparison. Based on the event session S_0 (defined as the trading session when the limit is hit), the pre limit-hit period S_{-1} starts from the previous trading session of S_0 and runs until when the limit is first hit in S_0; and the post period S_{+1} starts from the trade next to the limit-hitting trade in S_0 and runs until the end of the next session after S_0. This definition enables the inclusion of all the trade data, so that our comparison is more complete and, hence, more justifiable. We calculate the order imbalance ratio in the pre-hit period, by dividing the sum of buyer (seller) orders by the total trading volumes in that period for the upper (lower) limit-hit events. The same algorithm is then used for the post-period $Stock_{hit}$. We compute the order imbalance ratio for $Stock_{0.90}$ using the same procedure. In order to avoid the bias that occurs when there are only few observations, we filter events with less than five trades in either S_{-1} or S_{+1} from the sample. Due to this filtering, our sample of upper limit-hit events shrinks from 2084 to 1747, and the sample of $Stock_{0.90,}$ shrinks from 980 to 906, with the stock price moving upwards. In the circumstance that prices move downwards, the number of lower limit-hit events drops from 925 to 681, and from 507 to 448 for the events of $Stock_{0.90}$.

Table 1 summarises the mean and median statistics of the order imbalance ratio. As we can see from the table, both $Stock_{hit}$ and $Stock_{0.90}$ have fairly significant order imbalance in the pre-hit period, which is well above 50% where demand equals supply in the market. For upper events, the ratio of both groups decreases to a large extent in the post-hit period; approximately 14% for $Stock_{hit}$ and 19% for $Stock_{0.90}$. Nonetheless, the ratio of $Stock_{hit}$ stands at around 57% in the post-hit period, which means that order imbalance still exists for this group. The imbalance is better alleviated for $Stock_{0.90}$, with the ratio slightly over 50% in the post-hit period. The ratio reversal does not occur in either group. As for the lower events, the decrement on the order imbalance ratio is 19% for $Stock_{hit}$, and 23% for $Stock_{0.90}$, which are both larger than for the upper events. The ratio is lower than 50% for both groups in the post-hit period. The order imbalance ratios for both groups experience reversal from the pre-hit period to the post-hit period with lower limit-hit events, but stay above 0.50 in the post-hit period with upper events. Thus, no substantial difference exists between $Stock_{hit}$ and $Stock_{0.90}$ in this result, suggesting that no particular magnet effect exists for group $Stock_{hit}$, as found by Chan et al. (2005).

[Insert Table 1 here]

Apart from this result, because of the constraints from the price limits, some of the prevailing orders of the $Stock_{hit}$ group cannot be executed after limit-hit moments, which differs from the case where all trading orders of $Stock_{0.90}$ are executed from the pre-hit to the post-hit period. Table 1 shows, however, that the order imbalance ratio decreases largely for $Stock_{hit}$ in the post-hit period with both the upper and lower events. This suggests that price limits effectively lower the order imbalance ratio after limit-hitting, and that this effect is more significant in the case of lower limit-hit events.

In order to incorporate the influence from other factors on the order imbalance ratio and examine whether the decrement is specifically related to limit-hit, we use a similar cross-section regression to that used by Chan et al. (2005), with some different variables. The dependent variable (the change in the order imbalance ratio) is defined as:

$$\Delta \text{IMBAL}_j = \text{IMBAL}_{j,post} - \text{IMBAL}_{j,pre},$$

where $\text{IMBAL}_{j,post}$ stands for the order imbalance ratio in the post-hit period and $\text{IMBAL}_{j,pre}$ stands for the ratio in the pre-hit period for a certain event *j*. The regression function is constructed as follows:

$$\Delta \text{IMBAL}_j = \beta_0 + \beta_1 * \text{LHG}_j + \beta_2 * \text{MktCap}_j + \beta_3 * \Delta \text{Volume}_j + \beta_4 * \text{Weekday}_j + \beta_5 * \text{Month}_j + \beta_6 * \text{Volatility}_j + \varepsilon_j, \quad (1)$$

where: LHG is the dummy variable, and equals 1 if stock *j* comes from the Stock_{hit} group and 0 if stock *j* comes from the $\text{Stock}_{0.90}$ group; MktCap_j denotes the logarithm of stock *j*'s market capitalisation; ΔVolume_j is computed as the logarithm change on the trading volume from the pre-hit period to the post-hit period with stock *j*; Volatility_j is computed as the squared logarithm return between the closing price of the post-hit period and the opening price of the pre-hit period; Weekday_j and Month_j refer to the day of the week and the month when event j happens; and ε_j is the error term, on which heteroskedasticity is taken into consideration if there is some pattern in the error term.

[Insert Table 2 here]

Table 2 presents the results from the cross-section regression. The coefficients for the dummy variable LHG, of both upper events and lower events, are significantly positive, which implies that the change in the order imbalance ratio on $Stock_{hit}$ is not larger than for $Stock_{0.90}$. We can conclude that there is a smaller decrease in the order imbalance ratio for both upper and lower limit-hit events, and that the ratio reversal on lower events from the pre-hit to post-hit period is not entirely associated with price limits. This result is inconsistent with the findings of Chan et al. (2005) on the Kuala Lumpur Stock Exchange. In their study they discover that the coefficient for variable LHG is significantly negative to the dependent variable ΔIMBAL.

3.2 Information Asymmetry Hypothesis

Now we examine the degree of information asymmetry surrounding limit-hit events. Ahn, Cai, Hamao and Ho (2002, p.403 - p.404) argue that it is possible that price limits "...would reduce the amount of information asymmetry" in the market when the price discovery process is slowed down. The previous test on the order imbalance ratio is not able to explain to what extent price limits may also affect price transmission at the time when part of the one-side orders are suppressed. Therefore, it is necessary to extract information content from the transaction data by decomposing the bid-ask spread before and after the limit-hit moment, so that we can have an implicit understanding of the extent to which price limits influence informed trading.

Kim and Sweeney (2002), contend that informed traders with private information put off their orders during limit-hitting sessions until price ranges are revised in subsequent trading days, so that they may obtain higher profits from trading. Kim and Sweeney (2002) study the distribution of closing prices, price continuations and reversals. Their argument is supported by their test results, which are based on daily data from the Taiwan Stock Exchange. One caveat of their study, however, is that they fail to consider the adverse selection component of the bid-ask spread, which affects the decision of limit order traders who can be considered as liquidity providers in an order-driven market (Ahn et al., 2002). As noted by Ma, Rao and Sears (1989), it is difficult to evaluate price limit performance by only using daily data. It may be too early to imply the impact of price limits on informed traders without breaking down transaction price data.

Based on the transaction data, we begin by testing the degree of information asymmetry before, and after the limits are hit. This is done by estimating the adverse selection cost under the following decomposition model, which is provided by Glosten and Harris (1988) and, from here on is referred to as the GH88 model:

$$\Delta P_t = \mu + c_0 \Delta Q_t + c_1 \Delta(q_t Q_t) + z_0 Q_t + z_1 q_t Q_t + \varepsilon_t, \qquad (2)$$

where: P_t denotes the transaction price at time t; Q_t denotes the trading indicator of the trade at time t, which is valued at 1 with buyer-initiated orders and -1 otherwise; and q_t is the trading size, which is uniformly measured in thousands of shares, as per the minimum trading unit[8]. The GH88 model defines the adverse selection component as $z_0 + z_1q_t$; and the adverse selection cost, SYMM, as $(z_0 + z_1q_t) / (z_0 + z_1q_t + c_0 + c_1q_t)$. We calculate the coefficients z_0, z_1, c_0, and c_1 of the GH88 model by using the price, trading volume and indicator serials in both pre- and post-hit periods, for each event. Then we calculate SYMM ratios for the pre and post periods based on the corresponding coefficients and q_t, which is now defined as the median trading volume. In order to avoid influence on our estimation from the extreme trading size, we exclude trades with volumes larger than the 99th percentile, or smaller than the 1st percentile, from the actual computation of each event during the pre- and post-hit periods.

The means and medians of the SYMM ratio from the pre- and post-hit periods are presented in Table *3*. For events with prices moving up, the mean SYMM ratios of Stock_{hit} and $\text{Stock}_{0.90}$ in the pre-hit period are 0.4244 and 0.4314, respectively, correspondingly higher than 0.3691 and 0.4199, respectively, in the post-hit period. The reduction for Stock_{hit} is slightly larger than that for $\text{Stock}_{0.90}$. As for events with decreasing prices, the mean SYMM of Stock_{hit} is 0.4336 in the pre limit-hit period, dropping to 0.4087 in the post-hit period, while the ratio increases on $\text{Stock}_{0.90}$, from

[8] In the TSE, the trading unit varies between different companies, but over half of listed companies in the First Section use a trading unit of 1000 shares (e.g., 917 of a total 1595 companies in the First Section use 1000 shares as a trading unit by the end of 2004 (Tokyo Stock Exchange, April 22, 2005).

0.4039 to 0.4440. Medians of SYMM ratios for both groups show a similar pattern. Therefore, this result supports the proposition of Ahn et al. (2002), that price limits reduce information asymmetry on the TSE.

[Insert Table 3 here]

To confirm that the decrement in information asymmetry is specifically associated with limit-hit events, we construct the cross-section regression below:

$$\Delta SYMM_j = \beta_0 + \beta_1 * LHG_j + \beta_2 * MktCap_j + \beta_3 * \Delta Volume_j + \beta_4 * Weekday_j + \beta_5 * Month_j + \beta_6 * Volatility_j + \varepsilon_j, \quad (3)$$

where $\Delta SYMM_j$ denotes the change on the SYMM ratio between the pre- and post-hit period for event j ($\Delta SYMM_j = SYMM_{j,post} - SYMM_{j,pre}$), with all other variables being defined as in Equation (1). If the coefficient of variable LHG is shown to be negative, we can assume that the improvement on information asymmetry is more significant with the imposition of price limits.

Table *4* summarises the regression results. The coefficients of variable LHG for the upper and lower events are -0.0373 and -0.0612, respectively; which are both negative at the 5% and 1% levels of significance, respectively. The result suggests that price limits in the TSE contribute to the improvement of information asymmetry, which is again inconsistent with the conclusion of Chan et al. (2005) on the KLSE. Table 4 also shows that the coefficients of variable ΔVolume are significantly positive for both upper and lower events. This implies that the magnitude of the change in the degree of information asymmetry is negatively related to the change on trading volume. The decrement in information asymmetry increases when the change in trading volume decreases, and vice versa. This is consistent with the finding of Ahn et al. (2002), that the adverse selection component increases with larger trade sizes on the TSE.

[Insert Table 4 here]

So far, we discover that price limits help to correct order imbalance and lower the adverse selection component of the bid-ask spread. Price variations are strongly associated with the order imbalance between buyer- and seller-initiated orders (Kyle, 1985; Spiegel and Subrahmanyam, 1995). Also, considering the close relationship between information transmission and the price discovery process, it is necessary to examine the daily volatility and price behaviours, which may also provide a good foundation to compare our findings with other studies which also focus on daily data.

4. The Influence on the Daily Price Volatility and Trading Activities