The Effects of Price Limits on AB-shares on the Shanghai and Shenzhen Stock Exchanges

By:

Caiwei Ye

A thesis submitted in partial fulfilment of the requirements for the degree of Doctor of Philosophy

The University of Sheffield
Faculty of Social Sciences
Management School

June 2016

Abstract

The study examines the effects of price limits on return, volatility and liquidity by testing three hypotheses: delayed price discovery hypothesis, volatility spillover hypothesis and trading interference hypothesis (Kim and Rhee, 1997, JF). The delayed price discovery hypothesis states that if the price continues to move in the same direction in the subsequent period after a price-limit-hit, the existence of limits delays price discovery. The volatility spillover hypothesis argues that the stock will have a higher volatility after a price-limit-hit. The trading interference hypothesis asserts that a share that hits the price limits on day *t* will experience more trading on day *t+1*. The rationale behind price limits is to provide investors with a cooling-off period to counter noise trading and alleviate market panic. If price limits work, all three hypotheses should be rejected.

Firms on the Shanghai and Shenzhen Stock Exchanges can simultaneously issue two types of shares: A and B-shares. A-shares were initially traded only by domestic Chinese citizens, but opened to Qualified Foreign Institutional Investors (QFIIs) from July 2003 onwards. B shares were initially traded only by foreign investors but then by local Chinese citizens from June 2001. A and B-shares are subject to the same price limits but exhibit different risk and return characteristics. This study explores the effects of price limits on AB-shares using daily data (intraday data) over the period 2004-2012 (2010-2012). For the first time, this study estimates a GARCH model that explicitly incorporates truncation in the distribution of returns that is induced by price limits. The truncated-GARCH model provides a better fit than a conventional model.

Based on the study of daily data, the delayed price discovery and volatility spillover hypotheses are not rejected on either exchange. Similar results have been found in the study of intraday data that price limits are not effective in controlling volatility and counter noise trading. Regarding the trading interference hypothesis, price limits interfere with market liquidity but the level of interference depends on the choice liquidity measures.

Acknowledgement

I would like to express my sincere thanks to my supervisors, the great scholars, Professor Chris Adcock and Dr. Shuxing Yin. This thesis could not be completed without their invaluable supervision. I take this opportunity to appreciate my supervisors for their guidance, comments, suggestions, patience and encouragement throughout this thesis. In addition, I am grateful to all those in the University of Sheffield for their support.

Contents

List of Tables

List of Figures

List of Appendixes

Chapter 1

Introduction

1.1 Price Limits

The 19th October 1987, the so-called Black Monday, brought about crashes in all major global stock markets. By the end of the day, the S&P 500 index had plunged from 283 to 225 with total losses over 20 billion Dollars (Leland and Rubinstein, 1988). Roll (1988) showed that stock price indices tumbled by more than 20% in 19 international markets in October 1987, especially the Hong Kong stock market which suffered a 45.8% slump. After the market crash, regulators began to consider whether there was a mechanism that could protect markets from those catastrophic losses. The Brady Commission Report (1988) proposed circuit breaker mechanisms that play an important role in a market panic and hoped that they could provide a cooling-off period which allows investors adequate time to evaluate the current market information, impede potential losses and relieve fear.

Kim and Yang (2004) categorise circuit breaker mechanisms into three different types: price limits, firm-specific trading halts and market-wide trading halts. Under a price limit regime, the maximum daily price fluctuation in a trading session for individual stocks is established. Under a firm-specific trading halt regime, the trading on a specific stock is temporarily prohibited by the authority if a certain condition occurs. Under a market-wide trading halt regime, an interim stop on trading all securities is executed by exchange when there are extreme market movements. Three examples below are used to demonstrate these mechanisms, respectively.

> Price limits: price limit rate on the Shanghai stock exchange (SSE) is 10%. Price limit band = previous closing price × (1±price limit rate). SPD BANK's closing price was 18.57 RMB on 30 December 2015. The trading price can only fluctuate between 16.71 RMB and 20.43 RMB on 31 December 2015[1].

[1] Information is obtained from the websites of SSE and NASDAQ.

Firm-specific trading halts: National Association of Securities Dealers Automated Quotations (NASDAQ) halted trading in Titan Pharmaceuticals stock on 12 January 2016 due to the NASDAQ Advisory Committee meeting for new drug application[1].

Market-wide trading halts: the fall of DJIA index by 554 points on 27 October 1997 forced the markets to close (Goldstein and Kavajecz, 2000).

Price limits can be easily recognised according to the rate set by the authority. However, trading halts caused by firm-specific events and market-wide abnormalities are more complex. There are many categories for firm-specific events and the definitions for some categories are not very clear. For example, there are 35 categories on the New York Stock Exchange (NYSE) and NASDAQ (NASDAQ, 2016). They commonly include the release of material news, regulatory concern, corporate action, extraordinary market activity, and others. In the US after 8 April 2013, three levels of market-wide trading halts are implemented. Before 15:25, if S&P 500 index drops 7% (level 1) or 13% (level 2), all the trading on all exchanges will be halted for 15 minutes. At or after 15:25, if the index triggers the level 1 or level 2 drops, trading continues unless level 3 is triggered. If the index plunges 20% (level 3) at any time, trading will be halted for the reminder of day (NASDAQ, 2016).

Deb, Kalev and Marisetty (2010) show that there are 41 out of 58 global stock exchanges implementing price limits[2]. However, some major stock markets, for example the US, UK, Australian, Canadian, Hong Kong, do not have price limits. A preliminary analysis of stock market indices returns over the period 2003-2012 is conducted. According to Table 1.1, the number of days with extreme downward market movements in stock markets without price limits are less than those with price limit system. For example, there are 30, 36, 41, 47, 77 days with a decline more than 3% for the Australian, UK, Canadian, US and Hong Kong markets, respectively. However, the number of days for Germany, Japan, South Korea, France, Spain, Mainland China, Turkey and Greece are 54, 55, 59, 62, 66, 90, 102

[2] A detailed list is shown in Appendix 1.1.

and 115, respectively. The purpose of price limits is to prevent a stock market crash. Thus, the relatively small number of days may explain why those major stock markets do not require price limits. Although the US stock market does not apply price limits, the futures market implement price limits. The futures exchange requires an initial margin and if the margin account falls below the maintenance margin requirement after the daily settlement, extra funds to bring the margin back to the initial margin are required. Price limits in the futures market alleviate default risk by setting a maximum to the extra funds required.

[Insert Table 1.1 about here]

The critics argue that a price limit delays price discovery, increases stock volatility and interferes with trading (Fama, 1989; Lehmann, 1989; Kodres, 1993; Kim and Rhee, 1997). Whether price limits are effective, there is not a conclusive answer.

1.2 What Is an Effective Price Limit System?

The rationale behind price limits is to stop market crashes (Brady Commission report, 1988). Therefore, when a price limit system is in place, price reversals are expected after a lower price-limit-hit. For example, a price of 10 RMB falls to its limit 9 RMB on day *t*. Regulators and investors would like to see a price that is higher than 9 RMB rather than a price that continues to fall below 9 RMB on day *t+1*. Price continuation would simply suggest that a price limit system does not play its role to stop market falls but would just delay price discovery. In other words, price limits prevent the price from reaching its equilibrium value. For example, if the equilibrium value is 8.55 RMB. The price would continue to move to 8.55 RMB in the following day to reflect the equilibrium level.

Another purpose of price limits is to counter market overreaction when an extreme positive price movement is followed by negative price movement and vice versa. In other words, price limits prevent investors from market overreaction (Kim and Rhee, 1997). On the one hand, the huge fall of a price is due to the fact that investors overreact to lower price-limit-hits. If a share’s equilibrium value is higher than the lower limit, price limits restrict investors from selling the share at a price lower than the equilibrium value. On the other hand, the massive rise of a price is due to the fact that investors overreact to upper price-limit-hits. If a share's equilibrium value is lower than the upper limit, price limits prohibit investors from buying the share at a price higher than the equilibrium value.

Kim, Yagüe and Yang (2008, p.200) state that "*To date, the effectiveness of trading halts and price limits remains a subject of regulatory and academic debate. Because there is no way to know what would have happened without the circuit breakers, it is extremely difficult to examine their effectiveness empirically*". Therefore, when the price limit system is in place, price reversal is expected after a price-limit-hit because it means that price limits will protect investors from overreaction. If price continuation is observed after a price-limit-hit, it would simply imply that price limits prevent price from reaching its true value and delay price discovery. As stated by Roll (1989, p.232), "*of course, most investors would see little difference between a market that went down 20 percent in one day and a market that hit a 5 percent down limit four days in a row. Indeed, the former might very well preferable*." Last but not least, an effective price system should also bring about lower volatility and not interfere with trading.

1.3 Summary of Literature Review

Are price limits effective in the stock market? This is an on-going debate. The initial report by Brady Commission (1988) argues that if there had been a price limit system during the stock market crash in October 1987, the stock market could have been prevented from significant loss. Fama (1989), however, argues that if the price continues to move in the same direction to reflect the equilibrium level in the following period, price limits delay price discovery and interfere with trading. To examine price limit performance, existing studies investigate how price limits affect stock return, volatility and liquidity. This section presents a short review of the empirical evidence on price limit performance in terms of return, volatility and liquidity, respectively. A detailed review is shown in each chapter.

1.3.1 Return

Lee and Chung (1996) point out that price limits can be seen as testing the effect of price limits on market efficiency since they emphasise the positive serial correlations of stock returns. In other words, weak-form market efficiency will be rejected if there is stock return autocorrelation after price-limit-hits. Lee and Chung apply linear regression analysis to the South Korean stock exchange from January 1990 to December 1993 and show positive stock return autocorrelations after price-limit-hits. Kim and Rhee (1997) propose the delayed price discovery hypothesis which states that if the price continues to move in the same direction in the subsequent period after a price-limit-hit, the existence of limits delays price discovery. Kim and Rhee conduct an event study on the Tokyo stock exchange from 1989 to 1992 by comparing price limit performance from two groups of stocks, price-limit-hit stocks and near-limit-hit stocks which hit 90% of limits. They find that the price continues to move in the same direction after a large price movement, especially the price-limit-hit stocks. For the Taiwan stock exchange, Shen and Wang (1998) build a GARCH model to estimate the price behaviour after price-limit-hits from 1988 to 1995. They also find positive stock return autocorrelations. Similar to Shen and Wang's (1998) method, Henke and Voronkova (2005) also show positive stock return autocorrelations on the Warsaw stock exchange from 1996 to 2000. Ryoo and Smith (2002) also examine the South Korean stock market from 1988 to 1998. Their variance ratio tests confirm Lee and Chung's findings. Similar to Kim and Rhee (1997), Bildik and Gülay (2006) examine stocks in the Istanbul stock exchange from 1998 to 2002. The Istanbul stock exchange also shows evidence of price continuation after price-limit-hits.

The existing literature indicates that price continuation does not always occur. Different from Shen and Wang (1998), Huang (1998) conducts an event study for the period 1971 to 1993 on the Taiwan stock exchange. Huang shows that positive abnormal returns are followed by negative abnormal returns after price-limit-hits and vice versa. Based on Kim and Rhee's methodology, Chen, Rui and Wang (2005) and Kim, Yagüe and Yang (2008) provide the evidence that the price reverses only after lower price limits for A-shares in the Mainland Chinese stock market during the period 1996-2003 and the Spanish stock market over the period 1998-2001, respectively.

1.3.2 Volatility

Chung (1991) compares the monthly standard deviation of returns from three groups of stocks which have different price limit rates on the South Korean stock exchange from 1980 to 1989. He concludes that there is no evidence that price limits reduce volatility. Similar to Chung (1991), Chen (1993) and Kim (2001) show the same findings on the Taiwan stock exchange for the period 1970 to 1990: price limits do not reduce volatility. In addition to the delayed price discovery hypothesis, Kim and Rhee (1997) propose the volatility spillover hypothesis which states that stocks will have higher volatility after price-limit-hits. Kim and Rhee find that the stocks with price-limit-hits have higher volatility than the stocks of near-price-limit-hits. Based on Kim and Rhee's methodology, to compare price-limit-hits stocks to near-price-limit-hits stocks, Bildik and Gülay (2006) and Li, Zheng and Chen (2014) report the same findings for the Istanbul stock exchange and Mainland Chinese stock exchanges that price limits cause higher volatility, respectively. Different from the above studies, Phylaktis, Kavussanos and Manalis (1999) and Henke and Voronkova (2005) take time varying volatility into account and construct GARCH models to estimate the volatility after price-limit-hits on the Athens stock exchange over the period 1990-1996 and Warsaw stock exchange during the period 1996-2000, respectively. They show that price limits do not reduce stock volatility.

Different from Chung (1991), Lee and Kim (1995) also form three groups of stocks which have different price limit rates but the stocks in each group are updated every day according to their price levels. Lee and Kim show that stocks with stricter price limits tend to have lower volatility on the South Korean stock exchange from 1980 to 1989. A similar result has been found on the same stock exchange from 1994-1996 (Berkman and Lee, 2002). With the availability of trade-and-quote data in 2000 on the Taiwan stock exchange, Kim and Yang (2008) identify three types of price limit hits: closing price limit hits, single price limit hits and consecutive price limit hits. Kim and Yang find that price limits reduce volatility only when prices consecutively hit limits. Farag (2013) applies GARCH models to three indexes: 1998-2011 Egyptian EXG 30, 1995-2011 Thai SET and 1989-2011 South

Korean KOSPI. Farag finds that the volatility is lower during a period of stricter price limit regime.

1.3.3 Liquidity

In addition to the delay price discovery and volatility spillover hypotheses, Kim and Rhee (1997) propose the trading interference hypothesis which states that a share that hits the price limits on day *t* will experience more trading on day *t+1* due to trading interference on day *t*. In other words, price limits reduce market liquidity on the day of price-limit-hits. Kim and Rhee (1997) and Bildik and Gülay (2006) show that there is a statistically significant and positive percentage change of turnover ratio in the following day of price-limit-hit. As stated by Chordia, Roll and Subrahmanyam (2002, p.111), "*order imbalances in either direction, excess buy or sell orders, reduce liquidity*". Seasholes and Wu (2007) study A-shares on the Shanghai stock exchange over the period 2001-2003 and find that a negative order imbalance on the upper limit day is followed by a positive order imbalance on the following day, but the amount of order imbalance is reduced. That is to say, the large amount of order imbalance suggests that market is illiquid on the day of upper-limit-hit.

In contrast to Kim and Rhee (1997) and Bildik and Gülay (2006), Chen, Rui and Wang (2005) show opposite findings that the percentage change of turnover ratio is statistically significantly smaller than zero in Mainland Chinese stock market, which suggests that investors do not postpone their trading to the following day which will result in large trading. Lee and Chou (2004) argue that a liquid stock should be the stock with a higher trading volume but a lower level of volatility, which is the so-called Martin liquidity index. Lee and Chou use transaction data from 1997 in Taiwan stock market and show that price limits neither increase nor decrease liquidity.

1.3.4 Summary

As can be seen from the above discussion, the empirical evidence on performance of price limits is largely inconclusive. Some authors show that price limits delay price discovery, cause volatility spillover and interfere with trading. However, other authors show that price limits prevent investors from market overreaction, alleviate market volatility and facilitate trading. One of reasons for these inconclusive findings could be due to the fact that different markets implement different price limit rates. For example, they are10% in Mainland China, 10%-50% in Japan, 10%+20% in Spain and others. The important point that can be made from these different rates is that regulators cannot simply follows other markets to implement the price limit system in their own market. A thorough analysis of a specific market is necessary in order to evaluate the appropriate price limit system.

1.4 Institutional Framework in China

In Mainland China, there are six exchanges: China financial futures exchange (CFFEX), Shanghai futures exchange (SHFE), Dalian commodity exchange (DCE), Zhengzhou commodity exchange (ZCE), Shanghai stock exchange (SSE) and Shenzhen stock exchange (SZSE). They are under the supervision and administration of the China Securities Regulatory Commission (CSRC). Figure 1.2 shows that stocks are traded on the SSE and SZSE. These two stock exchanges were established in 1990. As of the end of 2015, there are 1,125 and 1,784 listed companies on the SSE and SZSE, respectively[3]. According to the annual report of CSRC (2012), the total market capitalisation reached about 23.04 trillion RMB (3.67 trillion USD). This made China the second largest stock market in the world. More specifically, the SSE with a market capitalisation about 15.87 trillion RMB (2.53 trillion USD) was ranked as the 7th largest stock market in the world, while the SZSE was ranked as the 11th with a market capitalisation of about 7.16 trillion RMB (1.14 trillion USD). The SZSE also operates the Small and Medium Enterprise (SME) Board and ChiNext in addition to the Main Board. ChiNext is mainly for hi-tech firms that cannot meet the listing standards of SME Board while the Main Board has the highest listing requirements.

The firms listed on the stock market in China can issue both A- and B-shares. A-shares are denominated in RMB and were initially traded by domestic citizens only, but by Qualified Foreign Institutional Investors (QFIIs) after 2002. The first trading of A-shares by QFIIs

[3] Information is obtained from the websites of the SSE and SZSE.

was executed in July 2003. B-shares are denominated in USD on the SSE and HKD on the SZSE. They were initially traded by foreign investors, but then by local Chinese citizens after 2000. B-shares have been available to all local citizens since June 2001. A firm can simultaneously issue A- and B-shares, collectively AB-shares. As of the end of 2015, there are 1,073 A-shares and 52 B-shares on the SSE, as well as 1,735 A-shares and 49-B-shares on the SZSE. SSE and SZSE have 44 and 42 pairs of AB-shares, respectively[4]. The trading status of A- and B-shares can be Normal or Special Treatment (ST or *ST). According to CSRC (2012, p.77), "ST and *ST: *Where financial and other abnormalities may lead to the delisting of a company, making it difficult for investors to evaluate the company's prospects and may have negative impact on investor interests*". The difference between the ST and *ST is that the company whose trading status is *ST suffers from more serious financial problems.

[Insert Figure 1.2 about here]

Price limits in the Chinese stock market can be traced back to 1990 when the SSE and SZSE were established. Throughout 1990s, these two exchanges experienced distinct price limit rates ranging from 1% to 10%. The SZSE even enforced different price limits upon upward and downward price movements. After 16th December 1996, the SSE and SZSE consistently implemented a single level of price limits, which is 10%. They also introduced 5% price limits after 22nd April 1998 when the rule of ST shares was promulgated. Overall, a relatively stable price limits with a 10% level was set up from 16th December 1996 on both A- and B-shares, while a 5% price limits was implemented against ST shares after 22nd April 1998. A detailed summary of the development of price limits is shown in Table 1.2.

There is no cross-listing mechanism on the Mainland Chinese stock exchanges. A stock can only choose the SSE or SZSE to be listed. Mainland Chinese stocks, however, are permitted to be listed on the Hong Kong exchanges (HKEx) and these cross-listed stocks

---

[4] The difference between 52 (49) and 44 (42) on the SSE (SZSE) is that some companies only issue B-shares.

are named as H-shares denominated in HKD and traded on the HKEx without price limits. Moreover, not all the shares on the SSE and SZSE are subject to daily price limits. According to SSE (2006, p.9), "*The price limit does not apply to any of the following cases on the first trading day: (1) IPO shares or closed-end funds; (2) further issue; (3) shares whose listing is resumed after suspension; (4) other cases as recognized by the Exchange.*" These events always come with extreme returns. For example, Fan, Wong and Zhang (2007) show that the mean and median value of the initial (first-day) stock returns over the period 1993-2001 is about 241% and 139%. Thus, price limits are not applicable to these events.

[Insert Table 1.2 about here]

Both exchanges are open for trading from Monday to Friday. The continuous trading hours are 9:30-11:30 and 13:00-15:00 on the SSE and 9:30-11:30 and 13:00-14:57 on the SZSE. There is an opening call auction period 09:15-09:25 on both exchanges. In addition, the SZSE has a closing call auction period 14:57-15:00. The purpose of the opening and closing call auction periods is to decide the opening price and closing price, respectively. On the SSE, the closing price is determined by the volume-weighted average price of all the trades one minute before the last trade, including the last trade. The Chinese stock market is an order-driven market which means there are not market makers.

There are clear codes to classify stocks from different boards and categories. First, codes of A-shares in the Main Board start with number 6 (6xxxxx) on the SSE and number 00 (00xxxx) on the SZSE. Secondly, codes of B-shares in Main Board start with number 9 (9xxxxx) on the SSE and number 2 (2xxxxx) on the SZSE. As mentioned before, there are also the SME Board and ChiNext on the SZSE. Stocks listed on the SME Board and ChiNext are identified by the codes that start with number 002 (002xxx) and 3 (3xxxxx), respectively. The structure of the Chinese stock market as of December 2015 is shown in Table 1.3.

[Insert Table 1.3 about here]

1.5 Why Choose the Chinese Stock Market?

As shown in Appendix 1.1, there are many stock exchanges implementing price limit systems. Mainland China's stock exchanges (Shanghai and Shenzhen stock exchanges) are the research subjects in this thesis. There are several reasons for choosing them as research subjects. First, AB-shares are unique in China. A firm listed on the Shanghai and Shenzhen stock exchanges can simultaneously issue two types of shares, A and B-shares (collectively referred to as AB-shares). A-shares are mainly for local citizens, while B-shares are primarily for foreign investors. They are denominated in different currencies. In addition, their risk and return characteristics are different to a certain extent. Even if there are disparities between A and B-shares, they are issued by the same company and subject to same price limit rate. Hence, if a price limit system is effective, it should have the same effect on AB-shares and on both exchanges. For example, Yip and Young (2012) show that the common effect of the adoption of International Financial Reporting Standards (IFRS) in 17 European countries is that information comparability has been improved. Overall, the A and B-shares and the two exchanges can act as a robustness check of price limit performance on each other.

Secondly, price limit performance can be confirmed from all 4 categories (Shanghai A and B-shares, Shenzhen A and B-shares) in the Chinese stock market. If price limits are not effective in all four categories, this sends some reassurance to regulators in countries like the US and UK without price limits to keep existing markets without price limits. Thirdly, if price limits have different effects on AB-shares, this suggests that the price limit system needs to be revised. In Tokyo stock exchange, different shares have different price limit rates which range from 10% to 50%. Therefore, different price limit rates may be applied to AB-shares, as well as different rates to different stock exchanges. The study of AB-shares in Chinese stock market could provide some evidence for those markets which only have a single price limit rate (such as Istanbul stock exchange, Athens stock exchange and others) that a flexible price limit rates may be more appropriate.

1.6 Motivations, Research Questions and Structure of the Thesis

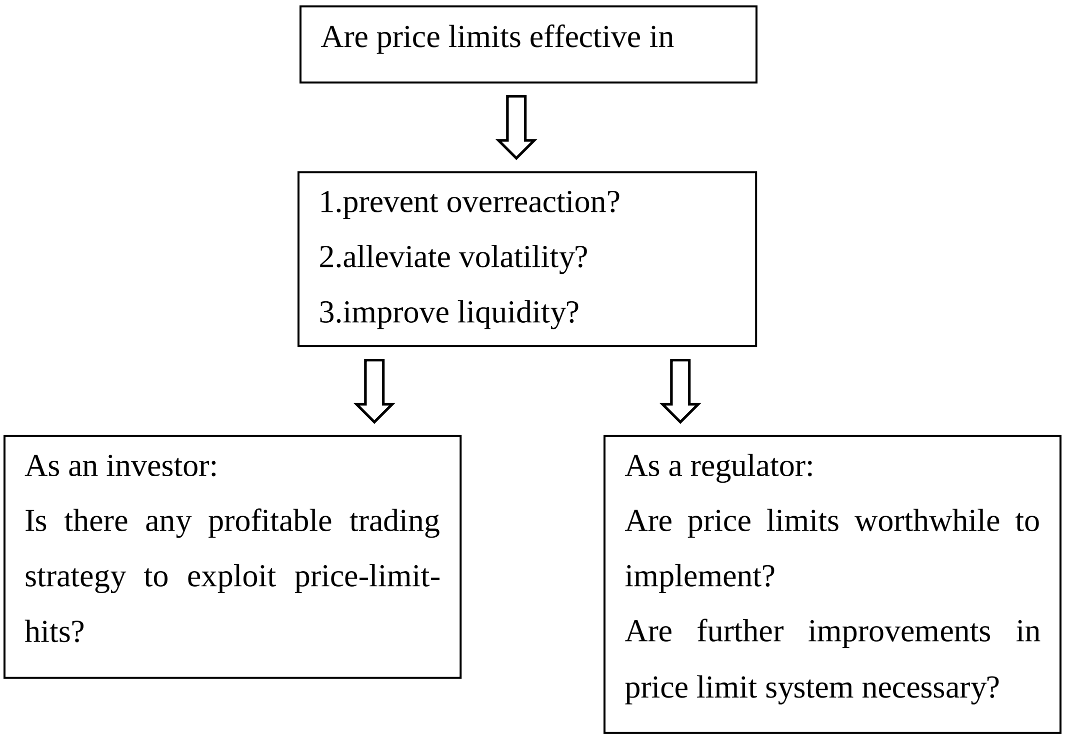
Return, volatility and liquidity are the most important factors to investors in the stock market. Under a price limit system, an investor needs to understand whether and how price limits affect the returns, volatility and liquidity. From the perspective of regulators, one of their responsibilities is to facilitate and monitor stock trading through pre-set rules. The regulator needs to know whether the trading has been interfered with by price limits and whether price limits are effective in preventing market crashes. Therefore, it is important to study the effect of price limits.

Deb, Kalev and Marisetty (2010) report 41 exchanges that implement price limits. Most of these exchanges are from developing countries. A common feature of emerging stock markets is the high volatility (Harvey, 1995). If a price limit can reduce stock volatility, it will benefit the overall market. The empirical evidence, however, does not give a clear answer. On the one hand some researches suggest that price limits reduce stock volatility (see, for example, Kim, Liu and Yang, 2013), on the other hand some researches argue that price limits cause higher stock volatility (Kim and Rhee, 1997). China has the fifth and sixth largest stock exchanges in the world in terms of market capitalisation as of December 2015 (World Federation of Exchange, 2015). To compete with successful exchanges, like the New York stock exchange (NYSE) and the London stock exchange (LSE), whether the current price limit performs effectively is important to the regulators.

Examining the effect of price limits in the Chinese stock market provides a unique way to thoroughly understand price limits. As a listed company in China can simultaneously issue two types of shares, AB-shares, which are subject to the same price limits. Price limits may have different effects on two types of shares. More interestingly, the A-shares market is dominated by the Chinese investors while the B-shares market is mainly driven by foreigners. Any differences between the effect of price limits on A- and B-shares helps explain the differences between Chinese and foreign investors.

Are price limits effective? How should investors and regulators response to price-limit-hits? Detailed research questions are illustrated in Figure 1.1.

Figure 1.1 Research Questions



To investigate these questions, Chapter 2 studies the effects of price limits on price behaviour and volatility based on daily data. Chapter 3 investigates the effects of price behaviour and volatility based on intraday data. Chapter 4 examines the effect of price limits on liquidity. Chapter 5 concludes.

1.7 Contributions and Implications

To examine the effect of price limits in the Chinese stock market, the study makes several contributions to the literature. First, this study is the first one to explore the effects of price limits on AB-shares and on both Chinese exchanges using daily data (intraday data) over the period 2004-2012 (2010-2012). This particular period is of interest to researchers and market participants as A-shares were initially traded only by domestic Chinese citizens only, but opened to Qualified Foreign Institutional Investors (QFIIs) from July 2003 onwards. Moreover, B shares were initially traded only by foreign investors but then by local Chinese citizens from June 2001. This study has important implications for market participants and researchers. It provides a reference for regulators in setting up price limits and guidance for investors in constructing trading strategies, especially for these two types of shares with different risk and return characteristics. In addition, Chapters 2 and 3 of this thesis use daily and intraday prices to demonstrate whether the effects of price limits are similar or different depending on the data frequency.

Secondly, this study recognises that stocks are subject to trading suspension in China, which can last for hours, days, weeks or even months. Allison (2001) points out that some researchers tend to delete the missing values. Some companies even design software packages to delete the missing values (Von Hippel, 2004). However, Allison, Von Hippel and Little and Rubin (2002) argue that any estimation based on the deletion of missing values can be biased. In this study, an imputation procedure is applied to estimate missing values. In addition, the returns on A- and B-shares are correlated. The modified F-test due to Pitman (1939) is used to test the difference in the volatility of pairs of A- and B-shares.

Thirdly, this study presents extensions to the GARCH models with price limit dummy variables that have been employed by Shen and Wang (1998) and Henke and Voronkova (2005) to study the effect of price limits. In the rest of this thesis, the model is referred to as the modified-GARCH-M model. In addition to the price-limit-hits dummies, the model also includes 90% of the price-limit-hits to differentiate the effects of price limits from extreme price movements.

Fourthly, in the presence of price limits, any trading price beyond the pre-specified range will be invalid and not be accepted by the trading system. Thus, in the presence of price limits the distribution of returns is doubly truncated. Models with dummy variables in all previous studies ignore this feature and are therefore mis-specified from a theoretical perspective. Ignoring the fact of truncation, the estimated results from the modified-GARCH-M model can lead to a misleading conclusion. This study presents a new model, referred to as the truncated-GARCH-M model, in which returns are truncated at values corresponding to both the upper and lower price limits. The study then uses the resulting model to estimate the probability of a return value beyond the truncation points. The estimated tail probability allows inferences to be made about price changes as if there were no price limits in place.

Fifthly, in examining the effect of price limits on liquidity, previous literature investigates single-dimension liquidity measures. Existing literature focuses on the comparison of price limit performance between price-limit-hit stocks and near-price-limit-hit stocks. For example, the value of changes in trading volumes after price-limit-hit is contrasted with the value after near-price-limits-hit. Liquidity, however, is a multi-dimension concept (Harris, 2003). In Chapter 4 of this thesis, multi-dimension measures are analysed. Different from existing studies, an ARMA model with price limit dummy variables and near-price limit dummy variables are constructed to examine the effects of price limits on liquidity.

Table 1.1 Market Downward Movements

This table summarises the number of days of market downward movements measured by market indexes in some major stock markets with and without price limit system during the period 31 December 2003 – 31 December 2012. The market indexes are DAX40 (Germany), NIKKEI225 (Japan), KOSPI (South Korea), CAC40 (France), IBEX35 (Spain), SSEA (Mainland China), BIST100 (Turkey), ATHEX Comp (Greece), ASX200 (Australia), FTSE100 (UK), TSX Comp (Canada), SP500 (US) and Hangseng (Hong Kong).

Panel A: Markets with price limits

Return	Germany	Japan	Korea	France	Spain	China	Turkey	Greece
<=-0.01	401	427	396	409	418	465	522	528
<=-0.02	139	152	157	156	173	206	234	238
<=-0.03	54	55	59	62	66	90	102	115
<=-0.04	28	27	27	28	33	49	46	56
<=-0.05	14	16	14	15	16	24	20	36

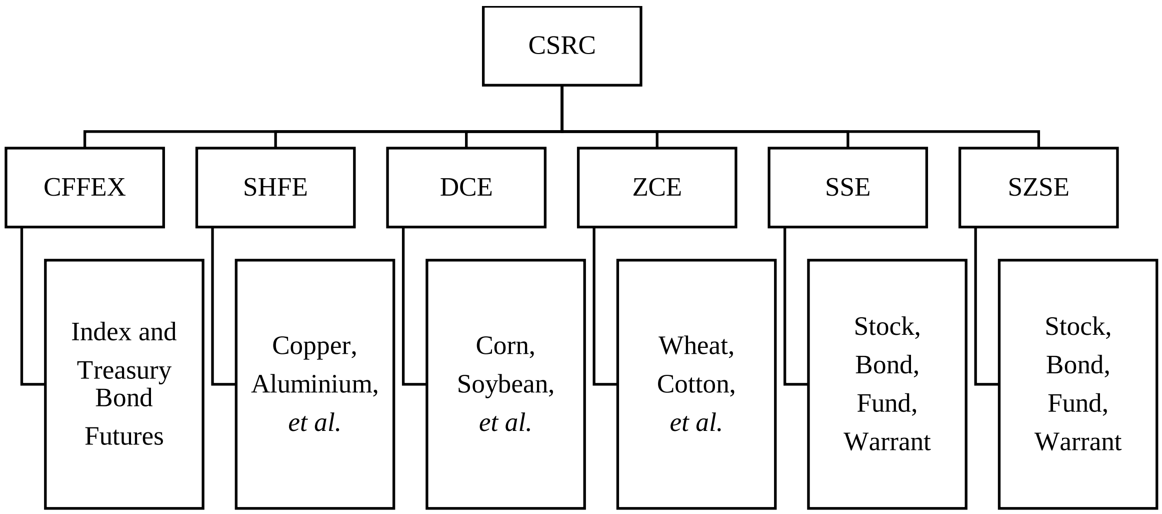
Panel B: Markets without price limits

Return	Australia	UK	Canada	US	Hong Kong
<=-0.01	314	325	310	320	427
<=-0.02	92	109	98	114	184
<=-0.03	30	36	41	47	77
<=-0.04	13	17	17	25	38
<=-0.05	5	11	11	13	17

Note: Data are collected from DataStream.

Figure 1.2 Structure of the Chinese Financial Market

This figure depicts the structure of institutional arrangement in China's financial markets. Six exchanges, China financial futures exchange (CFFEX), Shanghai futures exchange (SHFE), Dalian commodity exchange (DCE), Zhengzhou commodity exchange (ZCE), Shanghai stock exchange (SSE) and Shenzhen stock exchange (SZSE), are under the supervision and administration of China Securities Regulatory Commission (CSRC).



Source: Exchanges' website

Table 1.2 The Development of Price Limits[a]

This table summarises the price limit rates on the Shanghai stock exchange (SSE) and Shenzhen stock exchange (SZSE) from 1990s to present.

Shanghai stock exchange (SSE)	
Time period	Price limits
07/27/90 - 12/18/90	3%
12/19/90 - 12/26/90	5%
12/27/90 - 01/06/91	1%
01/07/91 - 04/25/91	0.5%
04/26/91 - 05/20/92	1%
05/21/92 - 12/15/96	No limits
12/16/96 - 04/21/98	10%
04/22/98 - 12/31/12	5%, 10%
01/01/13 - present	10%
Shenzhen stock exchange (SZSE)	
Time period	Price limits
05/30/90 - 06/17/90	10%
06/18/90 - 06/25/90	5%
06/26/90 - 11/20/90	+1%, -5%
11/21/90 - 12/13/90	5%
12/14/90 - 01/01/91	+5%, -2%
01/02/91 - 08/16/92	0.5%
08/17/92 - 12/15/96	No limits
12/16/96 - 04/21/98	10%
04/22/98 - present	5%, 10%

Note: [a] Source: Kim, Liu and Yang (2011, p.22)

Table 1.3 The Structure of the Chinese Stock Market

This table displays the structure of the Chinses stock market based on the Shanghai stock exchange (SSE) and Shenzhen stock exchange (SZSE) as of December 2015.

Exchange	SSE		SZSE			
Board	Main Board		Main Board		SME Board	ChiNext
Category	A-share	B-share	A-share	B-share	A-share	A-share
Codes	6xxxxx	9xxxxx	00xxxx	2xxxxx	002xxx	3xxxxx
Numbers	1073	52	467	49	776	492
Investor	Chinese, QFIIs	Chinese, Foreigners	Chinese, QFIIs	Chinese, Foreigners	Chinese, QFIIs	
Currency	RMB	USD	RMB	HKD	RMB	
Price limits	10%		10% or 5%			
Opening call auction	9:15-9:25		9:15-9:25			
Continuous auction	9:30-11:30 13:00-15:00		9:30-11:30 13:00-14:57			
Closing call auction	N/A		14:57-15:00			

Appendix 1.1 Price Limits in Global Exchanges
Excerpt from Deb, Kalev and Marisetty (2010, p.2465)

Country	Exchange (s)	Price limit exists (in main trading session)	Limit details
Australia	ASX	No	–
Austria	Wiener Borse AG	Yes	5%
Bahamas[a]	Bahamas International SE	No	–
Bangladesh	Dhaka SE, Chittagong SE	Yes	3%, 5%, 7.5%, 10%, 15%
Barbados[a]	Barbados SE	No	–
Belgium	Euronext Brussels	Yes	10%
Bermuda[a]	Bermuda SE	No	–
Brazil	Sao Paulo SE, Rio de Janeiro SE	No	–
Bulgaria[a]	Bulgarian SE	Yes	15%, 30%
Canada	Toronto SE	No	–
China	Shanghai SE, Shenzhen SE	Yes	10%
Croatia	Zagreb SE, Varaždin SE	No	–
Czech Republic	Prague SE	Yes	5%, 8%, 50%
Denmark	Copenhagen SE	No	–
Ecuador	Guayaquil SE	Yes	10–20%
Egypt	Cairo & Alexandria SE	Yes	5%, 20%
Estonia	Tallinn SE	Yes	15%
Finland	Helsinki SE	Yes	15%
France	Euronext Paris	Yes	10%
Germany	Frankfurt SE	Yes	Undisclosed[b]
Greece	Athens SE	Yes	8%
Hong Kong	Hong Kong SE	No	–
Hungary	Budapest SE	Yes	15%, 20%
Iceland[a]	Iceland SE	No	–
India	National SE, Bombay SE	Yes	2%, 5%, 10%, 20%
Indonesia	Jakarta SE	Yes	20%, 25%, 30%, 35%, 50%
Ireland[a]	Irish SE	Yes	2%, 3%, 5%, 6%, 10%, 205%
Israel	Tel Aviv SE[c]	No	–
Italy	Borsa Italiana S.p.A.	Yes	5–10%
Jamaica	Jamaica SE	Yes	15% + 5%[d]
Japan	Tokyo SE	Yes	10–50%
Kenya	Nairobi SE	Yes	10%
Korea[a]	Korea SE	Yes	15%
Latvia[a]	Riga SE	Yes	–
Lithuania	Vilnius SE	Yes	15%
Luxemburg[a]	Luxembourg SE	No	–
Malaysia	Bursa Malaysia	Yes	30%
Mauritius[a]	SE of Mauritius	Yes	15% to 20%
Mexico	Mexican SE	Yes	10%
Netherlands	Euronext Amsterdam	Yes	10%
New Zealand	New Zealand SE	No	–
Norway	Oslo SE	No	–
Pakistan[a]	Lahore SE, Karachi SE	Yes	5%
Peru	Lima SE	Yes	15%
Philippine	Philippine SE	Yes	Upper: 50%, lower: 40%
Poland[a]	Warsaw SE	Yes	10%
Portugal[a]	Euronext Lisbon	Yes	10%
Romania	Bucharest SE	Yes	15%
Singapore	Singapore SE	No	–
South Africa	Johannesburg SE	Yes	5%, 10% and no limit
Spain	Madrid SE/ BME Spanish	Yes	10% + 20%[d]
Sweden[a]	Stockholm SE	No	–
Switzerland	SWX-Swiss	Yes	2%, 25%
Taiwan[a]	Taiwan SE	Yes	7%
Thailand	SE of Thailand	Yes	30%, 100%
Turkey	Istanbul SE	Yes	10%
UK	London SE	No	–
US	NYSE, NASDAQ, AMEX	No	–

Chapter 2

Price Discovery and Volatility Spillover for AB-shares on the Shanghai and Shenzhen Stock Exchanges: Daily Study

2.1 Introduction

To prevent markets from catastrophic losses like Black Monday, price limits are implemented by market regulators to confine security price movements. A price limit is usually defined as a percentage of the closing price on the previous trading day. The Brady Commission Report (1988) proposes that a price limit system play an important role in a market panic since it provides a cooling-off period which allows investors adequate time to evaluate current market information, impedes potential losses and relieves fear. Proponents of price limits assert that investors overreact to extreme price movements. According to De Bondt and Thaler (1985), extreme positive price movements will be followed by subsequent negative price movements and vice versa. Hence, price limits will prevent investors from irrational trading. Moreover, the daily volatility is restricted in the presence of price limits. Some rumours about forthcoming events, like the publication of annual reports, economic indicators and mergers and acquisitions, could make the market more volatile because investors are inclined to overreact to the price sensitive news. Price limits would then alleviate this excess volatility by restricting noise trading (Ma, Rao and Sears, 1989).

Price limits, however, only retard the adjustment of prices to changes in fundamental values (Fama, 1989). In the presence of price limits, a price is prevented from reaching its equilibrium value when the closing price reaches the limits (Kodres, 1993). Opponents of price limits argue that if the equilibrium price falls outside the pre-specified range on the day of a price-limit-hit, the bounded price will continue to move to reflect the equilibrium value in the following period. If the restricted price moves in the same direction in the subsequent day, price limits delay trading and result in a higher trading cost. Furthermore, the price continuation also implies that the pent-up volatility on the day of a price-limit-hit will spill over into the subsequent period. Therefore, price limits delay price discovery and cause volatility spillover. As stated by Roll (1989, p.232), "*of course, most investors would see little difference between a market that went down 20 percent in one day and a market that hit a 5 percent down limit four days in a row. Indeed, the former might very well preferable.*" In the downward price movement, supply orders dominates the demand orders. Hence, immediate corrections in order imbalance are prevented by price limits.

To examine the performance of price limits, the delayed price discovery hypothesis and volatility spillover hypothesis are tested by Kim and Rhee (1997). The delayed price discovery hypothesis states that if the price continues to move in the same direction in the subsequent period after a price-limit-hit, the existence of limits delays price discovery. The volatility spillover hypothesis argues that the stock will have a higher volatility after a price-limit-hit. Both of the hypotheses should be rejected if price limits work. While the existing theoretical arguments remain ambiguous, the empirical evidence on performance of the price limit is largely inconclusive. Price continuation has been evidenced by a positive return autocorrelation in the South Korean, Warsaw, Tokyo and Istanbul stock markets (see for example, Lee and Chung, 1996; Henke and Voronkova, 2005; Bildik and Gulay, 2006). However, price reverses have also been documented by Huang (1998) for the Taiwan stock exchange. Chen, Rui and Wang (2005) also report price reverses after lower price-limits-hits in the Mainland Chinese stock market. The majority of the studies, including those by Chung (1991), Chen (1993), Kim (2001), Kim and Rhee (1997) and Li, Zheng and Chen (2014) show that price limits cause high volatility. There are, however, some exceptions reported for the Mainland Chinese market (Chen, Rui and Wang, 2005; Kim, Liu and Yang, 2013) and South Korean market (Lee and Kim, 1995; Berkman and Lee, 2002).

China has two major stock exchanges: the Shanghai Stock Exchange (SSE henceforth) and Shenzhen Stock Exchange (SZSE). A firm listed on the Chinese stock exchanges can simultaneously issue two types of shares, A- and B-shares (referred to collectively as AB-shares), but they are subject to the same price limits. A-shares are denominated in the

Renminbi (RMB), while B-shares are denominated in USD (HKD) on the SSE (SZSE). Despite some well-documented differences in risk and return between A- and B-shares (Lu *et al.*, 2007; Chan, Menkveld and Yang, 2008; Mei, Scheinkman and Xiong, 2009), none of these studies investigate the effects of price limits on these shares. Different from existing studies on the Chinese market, such as Chen, Rui and Wang (2005) who compare stocks of price-limit-hits and stocks of non-price-limit-hits, a new method with explicit consideration of truncation to examine the effects of price limits is applied in this chapter due to the fact that price is truncated above and below price limits.

The study reported in this chapter makes contributions to the literature in three areas. First, this chapter explores the effects of price limits on both AB-shares and on both Chinese exchanges during the period 2004-2012. This particular period is of interest to researchers and market participants as A-shares were initially traded only by domestic Chinese citizens only, but opened to Qualified Foreign Institutional Investors (QFIIs) from July 2003 onwards. Moreover, B shares were initially traded only by foreign investors but then by local Chinese citizens from June 2001.

Secondly, this chapter presents extensions to the GARCH models with dummy variables that have been employed by Shen and Wang (1998) and Henke and Voronkova (2005) as the main analytical methods to study the effect of price limits. The model is referred to the modified-GARCH-M model. In addition to the price-limit-hits dummies, the model also includes 90% of the price-limit-hits to differentiate the effects of price limits from extreme price movements. In addition to these extensions, this study also recognises that in China stocks are subject to trading suspension, which can last for hours, days, weeks or even months. Allison (2001) points out that some researchers tend to delete the missing values. Some companies even design software packages to delete the missing values (Von Hippel, 2004). However, Allison, Von Hippel and Little and Rubin (2002) argue that any estimation based on the deletion of missing values can be biased. In this chapter an imputation procedure is applied to estimate missing values. In addition, the returns on A- and B-shares are correlated. The modified F-test due to Pitman (1939) is used to test the difference in the volatility of pairs of AB-shares.

Thirdly, in the presence of price limits, any trading price beyond the pre-specified range will be invalid and not be accepted by the trading system. Thus, in the presence of price limits the distribution of returns is doubly truncated. Models with dummy variables in all previous studies ignore this feature and so are mis-specified from a theoretical perspective. This chapter therefore presents a new version of the model, referred to as the truncated-GARCH-M model, in which returns are truncated at values corresponding to both the upper and lower price limits. The chapter uses the resulting model to estimate the probability of a return value beyond the truncation points. The estimated tail probability allows inferences to be made about price changes as if there were no price limits in place. Ignoring the fact of truncation, the estimated results from the modified-GARCH-M model could lead to a misleading conclusion.

For the daily data studied in this chapter, the truncated-GARCH model suggests that there is about a 25%-30% chance of price continuation after a price-limit-hit. Based on the truncated-GARCH model, the results show that prices continue to move in the same direction after price-limit-hits on both exchanges, especially after upper price-limits-hits. The price continuation rejects the efficient market hypothesis. In addition, price limits give rise to an increase in volatility on both exchanges. For A- and B-shares, they show similar pattern in price behaviour. However, A-shares are more likely to experience a volatility increase than B-shares, especially on the SSE. Overall, both the delayed price discovery hypothesis and volatility spillover hypotheses are not rejected. The rationale behind price limits is to provide investors with a cooling-off period in order to counter noise trading and to alleviate market panic. However, no price reversal or systematic reduction of volatility after price-limit-hits is observed in this chapter.

In the Chinese stock market, Chen, Rui and Wang (2005) report price continuation after upper price-limits-hits but price reversal after lower price-limit-hits. They also find that the effect of price limits on volatility depends on the whole market condition (bull or bear) and the directions of limit-hits. Kim, Liu and Yang (2013) show that price limits can counter market overreaction and alleviate market volatility. In other words, price limits protect investor from large price movement which is followed by the opposite price movement. Li, Zheng and Chen (2014) also find that price limits can prevent market overreaction but cause high market volatility. The findings of this chapter are consistent with the previous findings to a certain extent. On the one hand, the difference between the outcomes is due to the different study periods; for example 1996-2003 and 1992-2000 in the studies of Chen, Rui and Wang (2005) and Kim, Liu and Yang (2013), respectively. As mentioned before, there are significant changes in the stock market after 2003, for example QFIIs can invest A-shares. On the other hand, Li, Zheng and Chen (2014) compare the price limit performance between A- and H-shares. A- and H-shares are issued by the same company, but H-shares are listed on the Hong Kong stock exchange and are not subject to price limits. Different from H-shares, price limits are also applied to B-shares in addition to its respective A-shares. Thus, it is straightforward to compare price limit performance between A- and B-shares. What is more, both A and B-shares are listed on Mainland Chinese stock market.

The effects of price limits have important implications to investors and regulator. Under price limit system, an investor could make profits or avoid losses by correctly responding to a price-limit-hit. As price continuation is discovered, a long strategy is suggested to the investor when there is an upper price-limit-hit on the AB-shares[5]. The original rationale behind price limits is to prevent market from large losses. There is no price reversal and decrease of volatility after price-limit-hits. Therefore, regulators could consider whether is worthwhile to implement price limits in Chinese stock market or whether further development of the system of limits and accompanying regulation is indicated.

The remainder of the chapter is organised as follows. Section 2.2 reviews the existing literature with theoretical background and empirical evidence. Section 2.3 describes the data and Section 2.4 presents the methodology with modified- and truncated-GARCH-M models. Section 2.5 discusses the empirical results with trading rules and Section 2.6 concludes.

[5] Short strategy is not implemented. More details are discussed later.

2.2 Literature Review

The main objective of this section is to conduct a comprehensive literature review and critically discuss the empirical work done on the effect of price limits on price behavior and volatility from the perspective of low frequency data[6]. Section 2.2.1 reviews the delayed price discovery and volatility spillover hypotheses. Section 2.2.2 reviews the empirical evidence of the hypotheses. Section 2.2.3 shows other studies on circuit breakers. Section 2.2.4 summarises.

2.2.1 The Delayed Price Discovery and Volatility Spillover Hypotheses

Daily maximum and minimum price changes have been set by price limits. This means that in the presence of price limits the daily volatility of a share is restricted. According to the Brady Commission Report (1988), this boundary plays an important role in a market panic since it provides investors with a cooling-off period. However, Fama (1989) argues that it only retards the adjustment of prices to changes in fundamental values. Kodres (1993) claims that a price is prevented from reaching its true or equilibrium value when the closing price reaches the limits. Phylaktis, Kavussanos and Manalis (1999) propose that the arrival and accessibility of information are the driving force of equilibrium price and volatility. They state that the information brought by a price-limit-hit cannot be absorbed in one day. In other words, if the equilibrium price falls outside the pre-specified range on the day of a limit-hit, the bounded price will continue to move to reflect the true price in the following periods. If the restricted price moves in the same direction in the subsequent day, price limits delay trading and results in a higher trading cost. These arguments lead to the *delay price discovery hypothesi*s that there is a price continuation on day $t+1$ for the stock whose price hits the limits on day t. (Kim and Rhee, 1997).

French and Roll (1986) assert that volatility is influenced by public and private information. In stressful circumstances, investors are more inclined to overreact to price sensitive news,

---

[6] Low frequency means daily, weekly, monthly or annually. A high frequency review is in Chapter 3.

which makes the market more volatile. As noted by the Brady Commission Report (1988), a cooling-off period provides investors with more time to think and behave rationally. Price limits would then alleviate this excess volatility by restricting noise trading (Ma, Rao and Sears, 1989). However, there is a higher demand for a share when the price is close to the upper limit and a higher supply when the price is close to the lower limit. The supply and demand imbalances induce a price-limit-hit (Lehmann, 1989). Lehman claims that orders uncompleted due to the imbalance will be completed in the following day. The completion of the previous order at an existing higher or lower price implies that the pent-up volatility on the day of limits hit spills over into the subsequent day. Fama (1989) also argues that volatility will spread out in the following period to reflect changes in fundamental values due to the interference in price discovery process on the day of a price-limit-hit. These arguments give rise to the *volatility spillover hypothesis* that there is a high volatility on day *t+1* for the stock whose price hits the limits on day *t*. (Kim and Rhee, 1997).

The delayed price discovery hypothesis should be rejected, provided that price limits work. For an upper price-limit-hit, the price continuation means that a buyer will need to wait and pay more for the share. For a lower price-limit-hit, it implies that a seller will receive less for the share. More importantly, the price limit does not prevent market from decline. The rejection of the delayed price discovery hypothesis is a necessary, but not sufficient, condition for the effectiveness of price limits. An effective price limits mechanism should reveal price reversal. That is to say, price limits prevent investors from market overreaction. De Bondt and Thaler (1985) find that the extreme positive price movements will be followed by the subsequent negative price movement and vice versa. In addition, the rejection of the volatility spillover hypothesis is also a necessary, but not sufficient condition for the effectiveness of price limits. Volatility after price limits hit should be reduced if price limits are helpful. There are other names for the hypotheses, for example the information hypothesis and overreaction hypothesis proposed by Phylaktis, Kavussanos and Manalis, (1999). Similar to the delayed price discovery hypothesis and volatility spillover hypothesis, the hypotheses also test the effects of price limits on serial correlations of stock returns and volatility.

2.2.2 Empirical Evidence

This section reviews the empirical evidence of the delayed price discovery and volatility spillover hypotheses from international stock markets.

2.2.2.1 South Korea, Egypt and Thailand

For the delayed price discovery hypothesis, Lee and Chung (1996) point out that it can be seen as testing the effect of price limits on market efficiency since they emphasise the positive serial correlations of stock returns. In other words, weak-form market efficiency will be rejected if the delayed price discovery hypothesis holds. They apply linear regression analysis to 30 stocks in the South Korean stock market from January 1990 to December 1993. These stocks are from different industries. They show that price limits induce positive stock return autocorrelation.

Different from Lee and Chung (1996), Ryoo and Smith (2002) examine the random walk hypothesis under price limits using the variance ratio test. They study a longer period from March 1988 to December 1998 which has different price limit rates (that is, 6% from Jan 1995 to Nov 1996, 8% from Nov1996 to Jan 1998). 55 actively traded stocks from a wide range of industries are selected. The random walk hypothesis is rejected by showing first-order autocorrelation. They show that the number of stocks rejecting the hypothesis during the periods of stricter price limits is greater than the number of stocks during the periods of less restrictive price limits. Thus, return autocorrelation is affected by price limits.

Price limits in the South Korean stock market were applied differently to different stocks during the period 1980-1989. For instance, stock prices ranging from 3000 to 5000 South Korean Won (KRW) have 200 KRW price limits based on their previous closing prices. This indicates that price limit rates were set at 6.67% to 4%. 81 stocks from three different price levels are randomly selected by Chung (1991). He shows that the volatility of returns which have stricter price limits is not lower than those that have less restrictive price limits. Volatility is measured by the standard deviation of returns. Similar to Chung’s approach, Berkman and Lee (2002) show that stricter price limits moderate weekly volatility from 1994 to 1996.

Lee and Kim (1995) use the same study period as Chung (1991), but they form three portfolios based on all stocks listed on the exchange: high price limits portfolio (HPLP), medium price limits portfolio (MPLP) and low price limits portfolio (LPLP). These portfolios are updated in each day according to stocks’ prices. Instead of using monthly standard deviation, Lee and Kim compare the standard deviation of returns between the HPLP and the LPLP in short holding intervals:1, 2, 3 and 6 days. Lee and Kim show that the volatility of the LPLP is significantly smaller than the volatility of the HPLP in all holding intervals, which implies that stricter price limits reduce volatility.

Farag (2013) examines the effect of price limits on the Egyptian (EGX), Thai (SET) and South Korean (KRX) stock exchanges. The common feature of these three markets is that they have different price limit rates in different periods. The indices’ data of EXG30, SET and KOSPI during the period 1998-2011, 1995-2011 and 1989-2011 are selected. Farag applies modified EGARCH and PARCH models and finds that the conditional volatility is increased on all stock exchanges when a stricter price limits is revised to a less restrictive price limits.

In the Egyptian market since 21 July 2003, the price limit system is accompanied by a trading halt system, which is a circuit breaker regime. Farag and Cressy (2001) investigate the information dissemination and volatility under price limit and circuit breaker systems for the EGX30 stocks from 1998 to 2008. They apply a modified TGARCH and use Hansen’s (1982) Generalized Method of Moments (GMM). They show that information spreads immediately under the price limit system, whereas the information disseminates over a period of several days under the circuit breaker system which also increases price volatility.

2.2.2.2 Taiwan

Huang (1998) conducts an event study using all listed shares from 1971 to 1993 on the Taiwan stock exchange. The abnormal returns are estimated through the market model. He shows that positive abnormal returns are followed by negative abnormal returns, and vice versa. The market overreacts to the large price movement. Different from Huang's study, Huang, Fu and Ke (2001) take the overnight returns (opening price on day *t+1 /* closing price on day *t*) and intraday returns (closing price on day *t+1 /* opening price on day *t+1*) of all listed shares during the period 1990-1996 into account. They find that positive overnight returns are followed by negative intraday returns, which suggests price reversal follows price continuation.

Campbell, Grossman and Wang (1993) show that higher trading volume will cause lower daily stock returns autocorrelation. Blume, Easley and O'Hara (1994) demonstrate that the performance of traders who treat trading volume as part of their analytical information set is better than those who do not. LeBaron (1992) and Sentana and Wadhwani (1992) find that returns autocorrelation is affected by volatility. Shen and Wang (1998) argue that the autocorrelation of stock returns is not just affected by trading volume and volatility but also by price limits. They build a AR(1)-GARCH(1,1) model to estimate the price behaviour after price-limit-hits over the period 1988-1995. They find positive stock return autocorrelations.

In the 1970s, the Taiwan stock market experienced different price limit rates. Similar to Chung (1991), Chen (1993) investigates stock market volatility during the period 1979-1990. He finds that the period with stricter price limits experiences lower volatility. Volatility is measured by the standard deviation of returns. Chen also estimates the time-varying volatility which is similar to the form of ARCH error and show that price limits do not reduce volatility. Kim (2001) also finds that stricter price limits do not reduce volatility over the period 1975-1996.

Price limits that delay price discovery are not considered to be an issue if the equilibrium indicators, mean and variances of return, stay the same. However, the indicators may have changed on limit-hit-days. Chung and Gan (2005) define a cooling-off (heating-up) effect when the absolute price changes are decreased (increased). Due to the latent information that affect returns, they adopt a normal mixture density to estimate the returns in addition to a simple normal density. They select 96 continuously traded stocks over the period 1987-1997. The find that price limits have some cooling-off effect under the simple normal density. However, price limits have no effect on the variance under the mixture normal density.

2.2.2.3 Japan and Turkey

Kim and Rhee (1997) conduct an event study by comparing price limit performance from three groups of stocks on the Tokyo stock exchange (TSE) from 1989 to 1992. Three groups of stocks are *StockH* that hits price limits, *Stock90* that reaches at least 90% of limits but does not hit the limits and *Stock80* that reaches at least 80% of limits but does not attain 90% of limits They find that prices continue to move in the same direction after price-limit-hits and near-limit-hits in all the groups, but there is a stronger price continuation in the *StockH* group. In addition, they use daily returns-squared as a volatility measure and find that the *StockH* group has higher volatility than other two groups in the following days. Similar to Kim and Rhee, Bildik and Gülay (2006) conduct a study on the Istanbul stock exchange over the period 1998-2002. Bildik and Gülay report the same findings that price continuation and the increase of volatility are present after price-limit-hits.

George and Hwang (1995) study the volatility of 24-hour returns, open-to-open and close-to-close returns. The dataset contains all stocks on the TSE over the period January 1975-December 1989. They use Hansen’s (1982) Generalized Method of Moments (GMM) and find that the volatility of open-to-open is consistently higher than that of close-to-close for the most actively traded stocks. The higher volatility is due to the strong price continuation that is a result of implementation of price limit system. Price limits delay price discovery and prevent price from reaching its equilibrium value.

2.2.2.4 Greece

Phylaktis, Kavussanos and Manalis (1999) investigate the impact of price limits through GARCH models on the Athens stock exchange which applies price limit system in August 1992. They study 10 representative stocks which are from different sectors and consist of heavily traded stocks and less active stocks. Their study period is from January 1990 to June 1996. They find that the period that has a price limit regime does not show lower volatility. There are, however, significant serial correlations of stock returns in that period.

2.2.2.5 Poland

The Warsaw stock exchange implements call and continuous action trading processes. Henke and Voronkova (2005) point out that the characteristic of a call auction system is to provide investors with a time-out period which allows them to evaluate market information and optimise their decision making. This feature is similar to the rationale behind the implementation of price limits. Thus, they propose that price limits will not add any value to investors under the call auction system and do not expect any reduction of volatility after price-limit-hits. Moreover, price limits will only retard price discovery and then result in volatility spillover in the following trading day. 92 individual stocks from January 1996 to November 2000 are selected using specific selection criteria which can separate the call auction trading from the continuous auction trading. They apply an AR(1)-GARCH(1,1) model in the study and find that stocks experience greater volatility and present stronger price continuation after price-limit-hits.

2.2.2.6 Mainland China

The first paper that investigates the effectiveness of price limits on the Shanghai stock exchange (SSE) and Shenzhen stock exchange (SZSE) is from Chen, Rui and Wang (2005). They explore the effectiveness of price limits in bullish and bearish market periods. The bullish market period is defined from 1996 to 2000 with Shanghai A-share index booming from 954.98 to 2192.38 and then slumping from 1712.54 in 2001 to 1419.12 in 2002. A similar situation is also observed for the Shenzhen A-share index. A-shares during the period of December 1996 to December 2003 are selected. Similar to Kim and Rhee (1997), the groups *StockH, Stock90 and Stock80* are formed. They find that price limits in the bullish (bearish) period reduce volatility only when prices hit lower (upper) limits. They also show that price continuation only exists after upper price-limit-hits. Wong, Liu and Zeng (2009) apply the event study in the context of market model and also find that price continuation only exists after upper price-limit-hits in 2000 on the SSE.

Kim, Liu and Yang (2013) also investigates the effectiveness of price limits in the Chinese stock market. Two unique periods are selected, which are the non-price limits period 1st September 1992-31st August 1996 and price limits period 1st January 1997-31st December 2000. A threshold-hit rate that equals to price limit rate is applied in the non-price limits period. The Grossman's (1988) volatility measure, natural log of high price divided by low price, is employed. They find that the volatility after threshold-hit is significantly greater than that of price-limit-hit, which indicates that price limits play an important role to moderate volatility. They also show that invertors overact after an upper threshold-hit, which suggests that a large positive return is followed by a large negative return.

Li, Zheng and Chen (2014) examine price limits by comparing cross-listed stocks, 37 A-, 37 H- and 7 N-shares, which are listed on Mainland China stock market, Hong Kong stock market and New York stock market. There are no price limits for H- and N- shares. The data covers the period from the listing dates of each firm to 30 May 2011. An event study in the context of market model is applied. Different from Kim and Rhee (1997), they compare the price behavior and volatility between A- and H-shares (N-shares). They find that price limits prevent price continuation, but that volatility spillover is still present on the following day. They also show that press release, for example GDP growth, CPI, annual financial report, merger and acquisition *et al.,* have significant impact on price-limit-hits.

2.2.3 Other Studies on Circuit Breakers

The US stock market does not have price limits, but implements firm-specific trading halts and market-wide circuit breakers as of February 2013. Howe and Schlarbaum (1986) study the SEC-initiated suspensions over the period 1959-1979. There were 1038 companies with a total number of 1186 trading suspensions in that period. They show that the suspensions have significantly devaluate the companies' value and the companies also experience a prolonged negative abnormal returns in the following period. Lee, Ready and Seguin (1994) examine 449 firms in 1988 which violate trading rules of New York stock exchange (NYSE) and then trigger a total number of 852 trading halts. They find that both volume and volatility are significantly increased by trading halts. Subrahmanyam (1994) investigates the market-wide circuit breakers and shows that the regime increases price variability. He claims that this perverse effect is due to those strategic traders who secure their trades by submitting a high value before the price reaches its limit.

Ma, Rao and Sears (1989) investigate the effect of price limits on four futures contracts, corn, soybeans, silver and treasury bonds, on the Chicago Board of Trade (CBT) in 1980s. They find that price either is stabilised or reversed after price-limit-hits. There is also significant decline in volatility. Park (2000) examines price limit performance for four futures contracts, corn, oat, soybean and wheat, on the CBT during the period 1986-1998. In contrast to Ma, Rao and Sears, Park finds that price continues to move in the same direction after upper-limit-hit for corn and soybean and the price return volatility is increased after price-limit-hits for soybeans and wheat.

2.2.4 Summary

This section reviews the existing literature of the effect of price limits on price behavior and volatility from the perspective of a low frequency data. Proponents of price limits maintain that price limits can counter market overreaction due to an extreme price movement. Moreover, price limits can also relieve investors' fear in a volatile market since the maximum permitted daily price fluctuation has been set up. Opponents, however, argue that price limits delay price discovery because price continues to move in the same direction after limit-hits. Furthermore, volatility that is not fully reflected on the price-limit-day will spill over into next day. There are mainly five types of studies in examining the effect of price limits on price behavior and volatility. The first focuses on the comparison between price-limit-hit stock and near-price-limit-hit stock. The second is based on regression analysis, OLS and GARCH. The third conducts an event study in the usual way. The fourth applies variance ratio analysis. The fifth is similar to the first, but it compares price limits performance between different time periods that have different price limit rates. To summarise, there is no a conclusive finding about the effectiveness of price limits from the existing studies.

2.3 Data

This chapter examines the effect of price limits on companies issuing both A-and B-shares, collectively AB-shares, on the SSE and SZSE. Daily time series data that covers the period 31st December 2003 to 31st December 2012 are used. A-shares became available to QFIIs in November 2002. B-shares were made eligible to all local citizens in June 2001. The first trading of A-shares by QFIIs was executed in July 2003. The starting point of the study period excludes this transitional phase. During the study period, 44 companies issued AB-shares on the SSE and 42 companies issued AB-shares on the SZSE.

Daily closing prices, trading volume, trading turnover, market value, negotiable market value and trading status are collected from the Chinese Stock Market & Accounting Research (CSMAR) database. Logarithmic returns are calculated in the usual way using the daily closing prices. The free float rate is defined as daily negotiable market value divided by daily market value. The turnover ratio or negotiable turnover ratio is defined as daily trading turnover divided by daily market value or daily negotiable market value.

Summary statistics for the data are reported in Tables 2.1 and 2.2 for the SSE and SZSE respectively. According to Table 2.1, A-shares have a lower daily mean return of 0.0021% than the 0.0132% of B-shares during the whole sample period of 2004-2012 on the SSE. Interestingly, both A- and B-shares have positive daily mean returns of 0.0916% and 0.0647% respectively during the sub-prime mortgage crisis period of 2007-2009. The results are more pronounced for the A-shares. Wong and Li (2010) point out that the expectation of appreciation in the RMB from late 2007 resulted in massive capital inflows into the Chinese stock market. However, these positive mean returns reverse to -0.0572%

and -0.0254% and move far from normality (large skewness and kurtosis) in the following years 2010-2012.

In the A-shares market, a company's shares are separated into tradable and non-tradable shares. The market value is the sum of the value of tradable and non-tradable shares, while the negotiable market value is the value of tradable shares. For market value and negotiable market value, A-shares are higher than B-shares. It is important to note that the equity reform for A-shares in the Chinese stock market from 2005 has resulted in a significant increase of tradable shares in the following years (Li *et al.*, 2011). The purpose of equity reform is to transform those non-tradable shares into tradable shares. The mean negotiable market value of A-shares has jumped from 626,714 thousands RMB during 2004-2006 to 2,919,253 thousands RMB during 2007-2009 with a future increase to 5,090,834 thousands RMB during 2010-2012. The free float rate reflects the level of a firm's shares that are non-tradable, the higher the rate the smaller proportion of non-tradable shares. Table 2.1 shows that the free float rate for A-shares has increased significantly from 0.235 during 2004-2006 to 0.4714 during 2007-2009 and 0.8254 during 2010-2012. The turnover ratio and negotiable turnover ratio in the A-shares market are higher than those on the B-shares market during our sample periods. The highest turnover (negotiable turnover) ratios are reported during the financial crisis period with 0.0144 (0.0357) in A-shares and 0.0092 (0.0092) in B-shares. Similar findings on the SZSE are summarised in Table 2.2.

The Jarque-Bera test shows that the overall returns of A- and B-shares on both exchanges follow normal distribution over the period 2004-2012. The p-values are 0.293 (0.500) and 0.222 (0.500) for A- and B-shares on the SSE (SZSE). The normal distribution, however, is not the case for individual shares. The summary statistics of returns for individual shares are reported in Table 2.3 and 2.4. The Jarque-Bera test shows that almost all the returns do not follow normal distribution. All the p-values are smaller than 0.001 with only two exceptions being 0.014 and 0.018 for a B-share on the SSE and SZSE, respectively. The extreme returns, like 121.94% for the share 600272 and -72.25% for the share 600320, suggest the existence of events that are not subject to price limits. As mentioned in Chapter 1, four events are not subject to price limits; IPO, further issue, resumption and other cases recognised by the exchanges. The non-normal property is mainly attributes to the truncation where the price cannot go above or below the upper or lower limits. From Figure 2.1, returns are truncated at upper and lower limits. In addition, there are humps around the limits. This feature leads to the truncated normal distribution with upper and lower limit-hits, which will be discussed in the next section.

[Insert Tables 2.1, 2.2, 2.3 and 2.4 about here]

[Insert Figure 2.1 about here]

Table 2.5 reports a comparison between A- and B-shares in terms of mean return, return variance and negotiable market value. As A- and B-shares are issued by the same firm, they may be correlated with each other to a certain extent. We therefore apply the paired sample t-test and Pitman's modified F-test[7]. As B-shares are denominated in USD on the SSE and HKD on the SZSE, so their negotiable market value is converted into RMB using the daily exchange rates which are obtained from CSMAR. The results show that the mean returns for A-shares are not significantly different from that of B-shares on both stock exchanges. This finding is also documented by Lu *et al.* (2007) who show that the return difference between A- and B-shares is diminishing due to the opening of B-shares to domestic investors. However, the A-shares tend to have a higher variance than that of B-shares, especially after 2006. Chan, Menkveld and Yang (2008) indicate that the lower variance of B-shares arises because foreign investors can diversify oversea. Due to capital restrictions domestic investors cannot diversity oversea. Panel A (B) of Table 2.5 shows that 42 out of 44 (36 out of 42) A-shares on the SSE (SZSE) have higher variance than that of B-shares at 1% significance level during the whole sample period. Table 2.5 also shows that A-shares tend to have a higher negotiable market value than their B-shares on both stock exchanges, except in the period 2004-2006. Specifically on the SSE (SZSE), 29 out of 44 (13 out 42) B-shares' negotiable market values are significantly larger than those of A-shares at 1% significance level during 2004-2006. However, the situation has completely

[7] $D = X_1 - X_2$, $S = X_1 + X_2$. $X_{1,2}$ are two samples of size n. If $\text{correlation}(D, S) > 0, then\ \sigma_1^2 > \sigma_2^2$; if $\text{correlation}(D, S) < 0, then\ \sigma_1^2 < \sigma_2^2$. Degree of freedom is n-2.

changed since the equity reform for A-shares from 2005. During 2010 to 2012, there are 43 out of 44 (42 out of 42) A-shares' negotiable market values are significantly larger than those of B-shares at 1% significance level on the SSE (SZSE).

Pearson's correlation coefficients between returns and other variables for the SSE and SZSE are summarised in Table 2.6. The results show a positive linear relationship between the turnover ratio (negotiable turnover ratio) and return for both A- and B-shares and on both stock exchanges. Almost all the sample firms have a positive correlation coefficient between (negotiable) turnover ratio and return which is statistically significant at the 1% level. A few firms show a positive linear relationship between the market value (negotiable market value) and return on both A- and B-shares and on both stock exchanges. Specifically, 4 out of 44 (2 out of 44) A-shares have a positive correlation coefficient between (negotiable) market value and return which is statistically significant at 1% level during 2004-2006 on the SSE. These numbers increase to 6 (3) during 2010-2012 on the SSE. Only 3 out of 44 B-shares show a positive linear relationship between (negotiable) market value and return at 1% significance level during 2004-2006. Similar results are found on the SZSE. Almost all the sample firms show no correlation between free float rate and return for both A- and B-shares and on both stock exchanges.

[Insert Tables 2.5 and 2.6 about here]

The ±10% and ±5% daily return limits are not always satisfied exactly either by normal or ST stocks. This is because daily returns can be more (less) than 10% or 5% (-10% or -5%) when the price reaches a limit. For instance, the tick sizes for trading A-shares on the both stock exchanges are 0.01, but 0.001 for trading B-shares on the SSE and 0.01 on the SZSE. Hence, the daily maximum or minimum returns may be slightly lower or higher than the ±10% (±5%). For example, if the closing price of a normal share is 12.01 RMB, the next day maximum (minimum) price is 13.21 RMB (10.81 RMB) and the return is 9.52% (-10.53%). To exactly identify price-limit-hits, the procedures applied are shown in Panel A of Table 2.7. This chapter uses daily closing price rather than high and low price to identify price-limit-hits. This is because the theory states that the price is prevented from reaching its equilibrium value when the closing price stays at the limits, so price limits delay price discovery (Fama, 1989; Kodres, 1993). According to Panel B of Table 2.7, the number of upper-limits-hits is larger than that of the lower-limits-hits. In total there are 4,042 and 3,759 upper-limit-hits against 2,700 and 2,817 lower-limit-hits on the SSE and SZSE respectively. Moreover, A-shares are more inclined to hit price limits than B-shares. A-shares on the SSE and SZSE have 3,859 and 3,550 price-limit-hits, whereas B-shares have 2,883 and 3,026 price-limit-hits. The chi-squared test in Panel C of Table 2.7 show that the number of limit-hits in A-shares are significantly (p-value 0.0008) greater than that of B-shares. The test also shows that the number of limit-hits on the SSE are significantly (p-value 0.0011) larger than that of the SZSE.

Panel D of Table 2.7 summarises the number of price-limit-hits. First, the number of limit-hits varies largely in different shares. For instance, the mean values of upper-limit-hits are 54, 38, 49 and 41 for A- and B-shares on the SSE and SZSE, respectively. The standard deviations, however, are 44, 35, 46 and 58. Similar results are found for lower-limit-hits. Figure 2.2 shows that there is not a clear linear relationship between the market values and the number of price-limit-hits. Even though the correlation coefficients are -0.1968 on the SSE and -0.1909 on the SZSE, the p-values are 0.0661 and 0.0820. Last but not least, Panel D also reports that the mean (median) values of the number of days between consecutive limit-hits are 30, 30, 39, 49 (16, 12, 26, 20) for A- and B-shares on the SSE and SZSE, respectively. This suggests that it is likely to see more than one limit-hit in two months on average and investors are more active to trade on the SSE.

[Insert Table 2.7 about here]

2.4 Methodology

This section first describes the method used to impute missing values. It then outlines the modified- and truncated-GARCH-M model used to investigate the effects of limits on price discovery and volatility. The section also contains a description of the computation of tail probabilities; that is, the probability that a price limit would be breached if it were not in place.

2.4.1 Imputation of Missing Values

Stocks in China are subject to trading suspensions due to the release of price sensitive news, major corporate issues and other official recognised extraordinary circumstances. The suspension may last for hours, days, weeks or even months. Allison (2001) points out that due to the simplicity of the procedure, it is common practice to delete missing values. Von Hippel (2004) also shows that some software suppliers even specifically design package for users to delete missing values. However, Allison, Von Hippel and Little and Rubin (2002) all argue that any estimation based on the deletion of missing values can be biased. In this chapter, missing values are imputed using the following method. The model for missing values is assumed to be

$$\hat{X}_t = \hat{\mu} + \hat{\sigma} Z , \tag{2.1}$$

where $\hat{\mu}$ and $\hat{\sigma}$ are, respectively, the estimated sample mean and volatility based on data up to time *t-1* and *Z* is a single simulated observation from the standard normal distribution.

Details on missing values of AB-shares on the SSE and SZSE are reported in Appendix 2.1 and 2.2. There are a total of 2,187 daily observations from Jan 2004 to Dec 2012. If the number of missing values for a share during the sample period is greater than 328 (15% of 2,187), the firm is excluded from the analysis. Therefore, three pairs of shares have been deleted on both exchanges due to there being 15% of missing values in total observations. One pair of shares has also been deleted on both exchanges due to the lack of data for the independent variables. The final sample contains 40 AB-shares on the SSE and 38 AB-shares on the SZSE. The two-sample Kolmogorov-Smirnov (KS) test is carried out to examine and ensure the newly generated data and original data are from the same continuous distribution (Massey, 1951). In addition, two-sample t-test (T-test) also shows that mean and variance of the newly generated data are not significantly different from those of original data. As a robustness check this procedure was repeated 100 times for each stock[8]. From Table 2.8, only 1 pair of AB-shares is rejected on both exchanges for the KS test and only 1 pair of AB-shares is rejected on the SSE for the T-test. It is important to note that the significance level is 10% in this test. This is because 0.1%, 1% or 5% significance levels may not lead to a rejection and thus inflate the accuracy of imputation method. Therefore, the imputation method applied here is quite solid.

[Insert Table 2.8 about here]

2.4.2 The Modified- and Truncated-GARCH-M Models

As shown in the literature review, there are mainly five types of studies examining the effect of price limits on price behavior and volatility. They are (i) a comparison between price-limit-hit stock and near-price-limit-hit stock; (ii) regression analysis using OLS and GARCH; (iii) event study; (iv) variance ratio analysis; (v) a comparison of return and volatility between different time periods that have different price limit rates. The first type of study has been applied in A-shares market by Chen, Rui and Wang (2005). To make a contribution to the existing literature, it is not advisable to replicate the study in the same market. As shown in the Panel D of Table 2.7, the days between the adjacent price-limit-hits are about 30-50 days on average. An event study which has a 250 days' estimation window for the daily stock return (Brown and Warner, 1985), is not suggested in this chapter. The variance ratio is applied to test the random walk hypothesis in different periods that have different price limit rates. In this study period, price limit rates are stable, which implies that the fourth and fifth types of studies are not applicable. Therefore, the second type of study, GARCH modelling, is applied.

To model time varying volatility, a modified GARCH process is used, which is similar to the one employed in Shen and Wang (1998) and Henke and Voronkova (2005). The model introduced by Shen and Wang employs dummy variables to indicate price-limit-hits in the mean equation in conjunction with a standard GARCH (1,1) model for the variance. This model is extended by Henke and Voronkova who add the limits dummies to the variance

[8] Note that more complex models could be employed, if wished, to estimate the missing values.

equation. In addition, the model implemented in this chapter does not just simply consider the price-limit-hits dummies but also takes 90% of the price-limit-hits into account. This thus allows the model to differentiate the effects of price limits from the effects of extreme price movements. The modified GARCH-M model employed in this chapter is as follows

$$R_t = \mu_t + \varepsilon_t \quad \varepsilon_t |\ \Omega_t \sim N(0, \sigma_t^2), \tag{2.2}$$

with

$$\mu_t = \beta_1 + (\beta_2 + \beta_3 Tor_{t-1} + \beta_4 \sigma_{t-1} + \beta_5 Up_{t-1} + \beta_6 Lo_{t-1} + \beta_7 Up9_{t-1} + \beta_8 Lo9_{t-1})R_{t-1}\ ,$$
$$\sigma_t^2 = \beta_9 + \beta_{10}\varepsilon_{t-1}^2 + \beta_{11}\sigma_{t-1}^2 + \beta_{12}Up_{t-1} + \beta_{13}Lo_{t-1} + \beta_{14}Up9_{t-1} + \beta_{15}Lo9_{t-1}\ ,$$

the estimated parameters $\hat{\theta}$ are achieved by maximising the following log-likelihood function ($logL$)

$$\hat{\theta} = arg\max_{\theta} logL(\theta; X).$$
$$logL = -\frac{T}{2}\log(2\pi) - \frac{1}{2}\sum_{t=1}^{T}\log(\sigma_t^2) - \frac{1}{2}\sum_{t=1}^{T}\frac{\varepsilon_t^2}{\sigma_t^2} = \sum_{t=1}^{n}\log\{\emptyset(r_t, \mu_t, \sigma_t^2)\}, \tag{2.3}$$

where Ω_t denotes information available at time t. R_t is the daily stock return on day *t*. Tor_{t-1} is the daily negotiable turnover ratio on day *t-1*, which is measured by daily negotiable turnover divided by daily negotiable market value. Up_{t-1} ($Up9_{t-1}$) and Lo_{t-1} ($Lo9_{t-1}$) are upper (90% upper) and lower (90% lower) price limit hits dummy variables taking value of one on day *t* if a share reaches the limit (90% of the limit) on day *t-1* and zero otherwise. Estimated parameters are denoted with the $\wedge$ symbol and referred to collectively as $\hat{\theta} = \{\hat{\beta}_1, \hat{\beta}_2, \dots, \hat{\beta}_{15}\}$. The notation $\emptyset(x, \mu, \sigma^2)$ denotes the probability density function (pdf) of a normally distributed variable with mean μ and variance σ^2 evaluated at *x*. As reported in the next section, several different GARCH formulations and assumptions for the conditional distributions of the residuals are investigated in addition to the standard model at equation (2.2).

In Equation (2.2), the estimated coefficient $\hat{\beta}_2$ measures the relationship between current return and its previous value without price-limit-hit, while $\hat{\beta}_2 + \hat{\beta}_5$ ($\hat{\beta}_2 + \hat{\beta}_6$) measures the correlation between current return and its previous value when price hits upper (lower) limits. $\hat{\beta}_3$ and $\hat{\beta}_4$ measure how the negotiable turnover ratio and conditional standard deviation would affect stock return autocorrelations. Moreover, $\hat{\beta}_{12}$ and $\hat{\beta}_{13}$ measure the volatility after upper- and lower-limit-hits. In order to show the effects that indeed come from price limits rather than extreme price movements, it is necessary to compare the estimated coefficients between limit-hits and near-hits dummies. For example, if upper price-limit-hit induces price continuation, $\hat{\beta}_2 + \hat{\beta}_5$ needs to be significantly greater than 0 and $\hat{\beta}_5$ also needs to be significantly greater than $\hat{\beta}_7$. A detailed constructions of the hypotheses are illustrated below.

The null hypotheses for upper price limits that are tested are as follows:

Price continuation (PC): $H_0{:}\,\beta_2 + \beta_5 = 0\ vs\ H_1{:}\,\beta_2 + \beta_5 > 0$ and $H_0{:}\,\beta_5 = \beta_7\ vs\ H_1{:}\,\beta_5 > \beta_7$.

Price reversal (PR): $H_0{:}\,\beta_2 + \beta_5 = 0\ vs\ H_1{:}\,\beta_2 + \beta_5 < 0$ and $H_0{:}\,\beta_5 = \beta_7\ vs\ H_1{:}\,\beta_5 < \beta_7$.

Volatility increase (VI): $H_0{:}\,\beta_{12} = 0\ vs\ H_1{:}\,\beta_{12} > 0$ and $H_0{:}\,\beta_{12} = \beta_{14}\ vs\ H_1{:}\,\beta_{12} > \beta_{14}$.

Volatility decrease (VD): $H_0{:}\,\beta_{12} = 0\ vs\ H_1{:}\,\beta_{12} < 0$ and $H_0{:}\,\beta_{12} = \beta_{14}\ vs\ H_1{:}\,\beta_{12} < \beta_{14}$.

The null hypotheses for lower price limits that are tested are as follows:

Price continuation (PC): $H_0{:}\,\beta_2 + \beta_6 = 0\ vs\ H_1{:}\,\beta_2 + \beta_6 < 0$ and $H_0{:}\,\beta_6 = \beta_8\ vs\ H_1{:}\,\beta_6 < \beta_8$.

Price reversal (PR): $H_0{:}\,\beta_2 + \beta_6 = 0\ vs\ H_1{:}\,\beta_2 + \beta_6 > 0$ and $H_0{:}\,\beta_6 = \beta_8\ vs\ H_1{:}\,\beta_6 > \beta_8$.

Volatility increase (VI): $H_0{:}\,\beta_{13} = 0\ vs\ H_1{:}\,\beta_{13} > 0$ and $H_0{:}\,\beta_{13} = \beta_{15}\ vs\ H_1{:}\,\beta_{13} > \beta_{15}$.

Volatility decrease (VD): $H_0{:}\,\beta_{13} = 0\ vs\ H_1{:}\,\beta_{13} < 0$ and $H_0{:}\,\beta_{13} = \beta_{15}\ vs\ H_1{:}\,\beta_{13} < \beta_{15}$.

The model defined at equation (2.2) allows the hypotheses described in the previous paragraph to be tested. However, from a theoretical perspective the model at (2.2) is likely to induce bias in the results. This is because the price limits result in a set of time series data for which the observation at time *t* cannot deviate from its predecessor by more than ±10%. As shown in Figure 2.1, returns do not follow normal distribution and are truncated at the limits. Wei (2002) proposes a censored-GARCH model to address this issue. According to Long (1997), latent, censored and truncated variables present different characteristics. For instance, if the threshold value is V*, latent variable means that any values smaller than V* are not known. Censored variable means that any values smaller than V* are equal to zero. Truncated variable means that the values cannot get below/above the V*. Thus, the return is more like a truncated variable.

To mitigate the truncation effect, a truncated-GARCH-M model is also built for the model at Equation (2.2). The difference between the modified-GARCH-M and truncated-GARCH-M models is the truncated normal distribution (*TN*). The model is specified as follow

$$R_t = \mu_t + \varepsilon_t \qquad \varepsilon_t |\ \Omega_t \sim TN(0, \sigma_t^2), \tag{2.4}$$

with

$$\mu_t = \beta_1 + (\beta_2 + \beta_3 Tor_{t-1} + \beta_4 \sigma_{t-1} + \beta_5 Up_{t-1} + \beta_6 Lo_{t-1} + \beta_7 Up9_{t-1} + \beta_8 Lo9_{t-1}) R_{t-1} ,$$
$$\sigma_t^2 = \beta_9 + \beta_{10} \varepsilon_{t-1}^2 + \beta_{11} \sigma_{t-1}^2 + \beta_{12} Up_{t-1} + \beta_{13} Lo_{t-1} + \beta_{14} Up9_{t-1} + \beta_{15} Lo9_{t-1} ,$$

the estimated parameters $\hat{\theta}$ are achieved by maximising the following log-likelihood function (*logL*)[9]

$$\hat{\theta} = arg \max_{\theta} logL(\theta; X).$$

$$logL = \sum_{t'=1}^{n'} \log\{\emptyset(r_{t'}, \mu_{t'}, \sigma_{t'}^2)\} - \sum_{t'=1}^{n'} \log\{\Phi\left(\frac{U_{t'} - \mu_{t'}}{\sigma_{t'}}\right) - \Phi\left(\frac{L_{t'} - \mu_{t'}}{\sigma_{t'}}\right)\}$$
$$+ \sum_{tl=1}^{nl} \log\{\Phi\left(\frac{L_{tl} - \mu_{tl}}{\sigma_{tl}}\right)\} + \sum_{tu=1}^{nu} \log\{1 - \Phi\left(\frac{U_{tu} - \mu_{tu}}{\sigma_{tu}}\right)\}, \tag{2.5}$$

where $n' + nl + nu = T$, n' is the number of values which lie between the upper and lower limit, nl and nu are respectively the number of values which are truncated at the lower limit and upper limit. The variables in the three summations are indexed by t', tl and tu respectively. Return is denoted by *r*, U and L are the upper and lower limits. μ_t and σ_t^2 are the mean and conditional volatility at time *t*. The notation *Φ* represents distribution function (df) of the standard normal distribution.

2.4.3 Tail Probabilities

An important and interesting question is what would happen without price limits? To investigate this question, it is necessary to estimate the tail probability; that is, the probability that the price would move beyond the restricted level on the days of price-limit-

[9] The derivation of the log-likelihood function is shown in Appendix 2.5

hits if there were no limits in place. The mean and conditional variance can be estimated from equations (2.2) and (2.4). Assuming there were no limits in place, then the tail probabilities corresponding respectively to upper and lower price-limit-hits are computed as follows

$$P(x > U_t) = 1 - \int_{-\infty}^{U_t} \frac{1}{\sqrt{2\pi}\hat{\sigma}_t} exp^{\left\{-\frac{1}{2\hat{\sigma}_t^2}(x-\hat{\mu}_t)^2\right\}} dx, \quad (2.6)$$

and

$$P(x < L_t) = \int_{-\infty}^{L_t} \frac{1}{\sqrt{2\pi}\hat{\sigma}_t} exp^{\left\{-\frac{1}{2\hat{\sigma}_t^2}(x-\hat{\mu}_t)^2\right\}} dx, \quad (2.7)$$

where x denotes the return on the day of a price-limit-hit on which the upper and lower limits are U_t and L_t respectively.

For the Chinese stock market, when price limits are in operation, the maximum absolute daily return is restricted to about 10%. If the estimated tail probability shows that there is a very high chance (0.99 say) for the absolute return to exceed 10%, it may be inferred that the price would continue to move in the same direction if there was no restriction. By contrast, if the tail probability is 0.01 or less, there is a very low chance of price continuation. In equation (2.6) and (2.7), a threshold value for the tail probability has to be chosen in order to make a judgment. The cases *P=0.99* and *P=0.01* are the extreme situations. In this chapter, the threshold used is *P=0.50*. That is, if the upper (lower) tail probability is greater than 0.5, it is concluded that the price would continue to move in the same direction in the absence of price limits. As the theory suggests that price limits prevent a price from reaching its equilibrium value on the price-limit-day the true value will be reflected in the next day. In other words, the upper (lower) tail probability which is greater than 0.5 provides a hint that the true value is higher (lower) than the closing price. Therefore, there will be a price continuation in the next day due to a price-limit-hit in the previous day.

2.5 Empirical Results

There are three sub-sections. Section 2.5.1 provides the diagnostics tests for the models. In Section 2.5.2, there is a comparison of the results from the modified- and truncated-

GARCH-M models. This is followed by an analysis of price discovery and volatility spillover for AB-shares based on the truncated model in Section 2.5.3. Section 2.5.4 shows a case study for the trading rules.

2.5.1 Diagnostic Tests

Several studies, including the pioneering work of Fama (1965), show that daily stock return series are heteroskedastic: large (small) price changes followed by large (small) price changes. The presence of conditional heteroscedasticity on the A- and B-shares markets during the sample period is confirmed by the Ljung-Box Q^2-test (LBQ) and Engle's ARCH test. Panel A of Table 2.9 shows that more than half the A- and B-shares on both the exchanges show ARCH effect. At the 0.1% significance level, there are still 19 A-shares, 25 B-shares, 16 A-shares and 20 B-shares showing ARCH effects based on Engle's test. Panel B of Table 2.9 shows that A- and B-shares indexes even exhibit stronger ARCH effects. There might be asymmetric effect in volatility in response to positive and negative shocks. The asymmetric effect leads to the models such as EGARCH, GJR-GARCH, TGARCH. Panel C of Table 2.9, however, does not show the asymmetric effect on AB-shares at 1% significance level. Another important type of GARCH model is GARCH-M model which emphasises that the conditional variance has an effect on the conditional mean equation. The framework of a GARCH-M model will be applied in this chapter.

As stated by Brooks (2008, p.394), "*GARCH (1,1) will be sufficient to capture the volatility clustering in the data, and rarely is any higher order model estimated or even entertained in the academic finance literature.*"[10] More importantly, the first lag relationship is the focus of this research because any effects beyond first lags may not be the effects from price-limit-hits. There is a long overnight period for investors to realise that the closing prices hit the limits on previous trading day. Hence, the first lag relationship could indicate how the investors will response to the limit-hits.

---

[10] As stated by Brooks (2008), GARCH(1,1) model is a very parsimonious model. For example, $\sigma_t^2 = \omega + \alpha\varepsilon_{t-1}^2 + \beta\sigma_{t-1}^2(1)$; $\sigma_{t-1}^2 = \omega + \alpha\varepsilon_{t-2}^2 + \beta\sigma_{t-2}^2(2)$, then substituting (2) into (1) for σ_{t-1}^2, then $\sigma_t^2 = \omega + \alpha\varepsilon_{t-1}^2 + \beta\omega + \beta\alpha\varepsilon_{t-2}^2 + \beta^2\sigma_{t-2}^2$ the same procedures can continue for σ_{t-2}^2, σ_{t-3}^2 *et al.*

[Insert Table 2.9 about here]

Before estimating the models (2.2) and (2.4), comparisons among the OLS, GARCH and truncated GARCH estimations without dummy variables are conducted. The purpose is to show which estimation is better. The estimations are as follow

$$R_t = \beta_1 + (\beta_2 + \beta_3 Tor_{t-1} + \beta_4 \sigma_{t-1}) R_{t-1} + \varepsilon_t, \quad (2.8)$$

where the notations are the same as equation (2.2). The equation (2.8) is estimated based on three methods, OLS, modified-GARCH-M(MGM) and truncated-GARCH-M (TGM). For OLS estimation, σ_{t-1} is equal to $\sqrt{R_{t-1}^2}$. The log-likelihood (LL) ratio statistics are equal to 2*(LL_{MGM}-LR_{OLS}), 2*(LL_{TGM}-LL_{OLS}) and 2*(LL_{TGM}-LR_{MGM})

[Insert Table 2.10 about here]

According to Table 2.10, the truncated-GARCH-M estimation is superior to OLS and the modified-GARCH-M estimations for AB-shares on both exchanges. For example, the first quartile values of LL ratio statistics are 218.14 (449.97) for MGM-OLS, 582.35 (679.65) for TGM-OLS and 292.55 (165.89) for TGM-MGM for A-shares (B-shares) on the SSE. Similar results are found on the SZSE.

The equation (2.8) is built on an AR (1) return process, which will be sufficient to explain whether the return autocorrelation is affected by price limits. It is interesting, however, to investigate how an AR (2) return process would affect the model. So, an AR (2) return process is as follow

$$R_t = \beta_1 + (\beta_2 + \beta_3 Tor_{t-1} + \beta_4 \sigma_{t-1}) R_{t-1} + (\beta_5 + \beta_6 Tor_{t-2} + \beta_7 \sigma_{t-2}) R_{t-2} + \varepsilon_t, \quad (2.9)$$

where the notations are the same as equation (2.2). The equation (2.9) is estimated based on truncated-GARCH-M (TGM) model. To compare the AR (1) and AR (2) return process, the log-likelihood (LL) ratio statistics is equal to 2*(LL_{eq9}-LR_{eq8}).

As can be seen from Table 2.11, an AR (2) return process does not add more benefits into the model but destabilise the results. For instance, the median values of statistics are 9.54, 8.43, 5.45 and 5.09 for A- and B-shares on the SSE and SZSE, respectively. This suggests that there is no significant difference between the models for half of the AB-shares. Moreover, the minimum (maximum) statistics are -84.16 (73.82), -149.27 (41.86), -126.55 (747.51) and -21.25 (442.12). This implies a very unstable estimation for the different shares. Therefore, an AR (1) return process is applied in equations (2.2) and (2.4). As discussed in Section 2.2.2, Shen and Wang (1998) and Henke and Voronkova (2005) apply the AR(1) which is a standard procedure to estimate the effects of price limits.

[Insert Table 2.11 about here]

2.5.2 Comparison of the Modified- and Truncated-GARCH-M Models

The empirical results using the modified-GARCH-M model and truncated-GARCH-M model at equations (2.2) and (2.4) are reported in Tables 2.12 and 2.13. In terms of the effect of price limits on price discovery, the two models show similar results. About half of the AB-shares on both exchanges show price continuation (PC) after price-limit-hits at the 5% significance level. There are still about more than a quarter of the AB-shares showing price continuation at the 1% significance level on both exchanges. There is no strong evidence for price reversal (PR). The main difference between the models is in the number of stocks that show volatility increase (VI) or volatility decrease (VD) after price-limit-hits. For example, at the 5% level of significance, there are 4 (7) out of 40 A-shares on the SSE showing a volatility increase after upper (lower) price-limit-hits according to the modified-GARCH-M model, while the corresponding number of stocks is 17 (15) according to the truncated-GARCH-M model. On the SZSE, also at the 5% level of significance, 10 (4) A-shares and 15 (11) A-shares show volatility increase after upper (lower) price-limit-hits using the modified GARCH-M and truncated-GARCH-M models, respectively. B-shares on both exchanges also show a similar pattern: 7 (4) shares against 15 (7) shares on the SSE and 5 (3) shares against 16 (6) shares on the SZSE. At the 1% significance level, a similar difference persists between the two models. Overall, the effect of price limits on price behaviour are similar between the models but are different on volatility.

Table 2.14 reports the tail probabilities on the day of price-limit-hit using the modified- and truncated-GARCH-M models. There is a vertical panel for each model. In each panel, there are eight columns. These contain results for upper and lower limit-hits for AB-shares on each exchange. According to the 70% vigintile, the truncated-GARCH-M model panel of the table indicates that there are 30% of tail probabilities which are larger than 0.44, 0.48, 0.49, 0.43, 0.45, 0.51, 0.50 and 0.50 averaged across all the shares on both exchanges. If the threshold value for the tail probability $P=0.50$ is chosen to determine the effect of price limits on price behaviour, the truncated-GARCH-M model suggests that there will be a 25-30% chance of price continuation after a price-limit-hit. These results are consistent with the price continuation after upper price-limit-hits shown in Table 2.12 and 2.13. The price continuation after lower price-limit-hits, however, are not consistent with the lower tail probabilities. According to Table 2.7, the number of upper price-limit-hits dominates the number of lower price-limit-hits. So, a more conservative threshold value for the lower tail probability should be used. The modified-GARCH-M model shows that there are only 5% of tail probabilities larger than 0.27, 0.22, 0.26, 0.17, 0.24, 0.17, 0.18 and 0.15 across all the shares on both exchanges. The modified-GARCH-M model suggests that the observation of price continuation after a price-limit-hit is unlikely. The results thus contradict to a significant extent the price continuation results shown in Table 2.12 and 2.13. The key inputs for computing the tail probabilities are estimated return and volatility. The results show that the volatility presents different patterns between the models, which results in the large difference between tail probabilities. That is, the modified-GARCH-M model significantly underestimates the tail probabilities.

[Insert Tables 2.12, 2.13 and 2.14 about here]

The modified and truncated GARCH models have the same independent variables and thus a higher R-squared value indicates a better model fit. Table 2.15 reports the adjusted R-squared and p-values of the overall F-test for two models. A comparison of the R^2 columns in Table 2.15 indicates that the truncated-GARCH-M model results in a higher value of R-squared in 75% to 85% of cases. The table also reports the p-values of the F-test for the 312 regression models which have been estimated. For nine of these models (3% of the total), the p-value is greater than 0.01. Eight out of these nine are modified-GARCH-M models. Note that the R-squared values are typically low, as expected for this type of regression model in finance. Nonetheless, using the truncated-GARCH-M model results in R-squared values of at least 10% for over 70% of all A and B stocks on both exchanges. An R-squared of 10% is considered by practitioners to be the minimum value at which a regression model in finance may be used for practical applications[11].

[Insert Table 2.15 about here]

2.5.3 Analysis of Price Discovery and Volatility Spillover for AB-shares

The analysis in previous section indicates that the truncated-GARCH-M model has superior explanatory power to the modified-GARCH-M model. The comments in the following paragraphs are based on the results from the truncated-GARCH-M model. From Table 2.13, at the 5% significance level, there are 22 (9) out of 40 A-shares showing price continuation after upper (lower) price-limits-hits, while the number of stocks are 21(4) for B-shares on the SSE. On the SZSE, A and B-shares also have similar pattern that 17 (7) out of 38 A-shares and 19 (9) out of 38 B-shares showing a price continuation after upper (lower) price-limit-hits. The number of shares showing price continuation decreases to 14 (2) for SSE A-shares and 15 (1) for SSE B-shares at 1% significance level, as well as 12 (4) for SZSE A-shares and 10 (6) for SZSE B-shares. Almost no firms experience price

[11] Titman and Tiu (2010) find that a low R-squared portfolio has larger Sharpe ratio than a high R-squared portfolio. For example, Sharpe ratio is 0.92 for the R-squared of 12.5%, while only 0.10 for the R-squared of 80%.

reversal after price-limit-hits. Overall, the results show that price limits delay price discovery on both exchanges, especially after upper price-limit-hits.

For volatility, 17 (15) A-shares experience higher volatility after upper (lower) price-limit-hits on the SSE, while 15 (7) B-shares undergo higher volatility at 5 % significance level. Similar pattern is found on the SZSE, 15 (11) A-shares against 16 (6) B-shares after upper (lower) price-limit-hits. The number of shares showing volatility increase declines on both exchanges at 1% significance level, especially for B-shares. On the one hand there are 13 (9) A-shares on the SSE and 8 (7) A-shares on the SZSE, but on the other hand only 3 (0) B-shares on the SSE and 4 (2) B-shares on the SZSE are observed. These figures imply that A-shares are more incline to suffer from the increase of volatility than B-shares after price-limits-hits on both exchanges. A very few shares show volatility decrease. Overall, the results show that price limits result in higher volatility.

In Table 2.16, a closer examination for the individual parameters reveals that turnover ratio has a negative effect on stock return autocorrelation, especially for A-shares on both exchanges. For example, looking at the 1% significance results there are 15 out of 40 A-shares and 10 out of 38 A-shares on the SSE and SZSE respectively, while the numbers in B-shares decrease to 6 and 3. This finding is consistent with Campbell, Grossman and Wang (1993). Some stocks show that conditional variance induces positive stock return autocorrelation. For instance, 6 (4) and 4 (2) A (B)-shares on the SSE and SZSE. Moreover, almost all the shares show significant GARCH effect.

Overall, price limits give rise to price continuation and volatility increase for AB shares on both exchanges. More importantly, the increase of volatility after price-limit-hits is more profound in A-shares market, especially on the SSE.

[Insert Table 2.16 about here]

2.5.4 Trading Rules

The tail probabilities in Table 2.14 provide evidence of price continuation. This suggests that trading strategies could be formed based on the computed tail probabilities. The detailed investigation of practical trading strategies is beyond the scope of this chapter: a practical strategy would, for example, usually include the regular revision of the model specification and re-estimation of its parameters as well as the investigation of different trading rules. Nonetheless this section provides a short case study to demonstrate the concept of using tail probabilities in trading. Specifically, the case study demonstrates the effect of taking a long position in a stock at time *t* when its forecast tail probability for time $t+1$ is large enough. Short positions, corresponding to forecasts of the left-hand tail probability, are not considered in this case study. This is because (1) there is a high margin requirement (500,000RMB, approximately 76,335USD) and (2) only part of A-shares is allowed to be sold short[12]. The assumption of the trading strategy is that the stock is traded at the closing price. The inputs for the computation of the tail probabilities are a threshold value for return, mean and variance. The procedures are as follows:

(i) Set the threshold value for return, which is 1.5%. This follows Mei, Scheinkman and Xiong (2009) who suggest that the transaction cost is about 1.4% in Chinese stock market. Thus, the aim of the long position is to at least cover transactions costs.

(ii) For each stock, forecast the mean and variance at time T+1, T+2, ……., T+20 using estimated parameters $\hat{\theta} = \{\hat{\beta}_1, \hat{\beta}_2, \dots, \hat{\beta}_{15}\}$ from the truncated-GARCH-M model based on data to time T,

(iii) Delete stocks which have unusual forecasting values[13].

(iv) Compute the probability of exceeding the threshold value (1.5%) using the forecast mean and variance for times T+1, T+2, ….., T+20.

---

[12] 1 USD ≈ 6.55 RMM.
Details about the margin finance in China can be found here:
http://www.ft.com/cms/s/0/7d667138-9fd3-11e4-aa89-00144feab7de.html#axzz490vfBdcP

[13] For example, stock 600751 resumed trading on 18 Oct 2005 and there was a 87.32% return due to no price limits on the first trading day. This extreme value caused an unusually large forecasted expected return and conditional variance.

(v) For days T+1, ….., T+20, take a long position in the stock if the forecast tail probabilities are greater than a set probability *P* (for example, 0.5), Otherwise do nothing. If on day T+*i* a long position is indicated in more than one stock, the available capital is invested equally.

(vi) Closing the position on the following day.

To demonstrate this trading strategy, its performance for days +1 to +20 starting at day T is reported in Table 2.17 and is based on a probability equal to 0.5. For this case study day T is 31st December 2012. The table has four vertical sections. The first is for SSE A shares for which the maximum number of long positions is two on days +3, +4 and +8. The other vertical sections are for SSE B [5 on day +3], SZSE A [2 on +3] and SZSE B [4 on +3]. Cells containing the symbol "~" correspond to doing nothing. A numeric entry in a given cell indicates the gross return from a long position in a stock for that day. Thus, for example, on day T+1 in the SSE A section, there was one long position and the stock return was -4.44%. The last row in Table 2.17 shows the sum of the returns from all long positions taken over the 20 days. As the table shows, without transaction costs the trading strategy generates positive returns in each of the four sets of stocks. Before the deduction of transactions costs, for the period considered the results of the trading strategy are stronger for B-shares.

A meaningful trading strategy should take the transactions costs into account. A single transaction cost is about 0.7%. Assuming that 100 RMB are available to invest in each category of shares, the net values from the trading strategy over the 20 days in AB-shares on both exchanges are shown in Table 2.18. On days when there are no long positions, it is assumed that the accumulated capital earns the risk free rate. The 3-month treasury bill rate is about 2.29%[14] and so the daily risk-free rate is about 0.0062%.

[Insert Tables 2.17, 2.18 and 2.19 about here]

[14] Source: http://gks.mof.gov.cn/redianzhuanti/guozaiguanli/gzfxgzdt/201510/t20151009_1493322.html

As Table 2.18 shows, after taking transactions costs into account, the model generates positive profit on day 3 with a total of 402.66 RMB. Thereafter the trading rule is not profitable. It may be noted that the performance of the rule is generally better for B-shares, for which there is also a larger number of positions. The trading rules above are based on the forecast tail probabilities that are greater than 0.5. A sensitivity analysis with different forecast tail probabilities is reported in Table 2.19. According to Table 2.19, the model systematically generates positive profit with different forecast tail probabilities on day 3. The totals are summarized below.

RMB	*P>0.5*	*P>0.6*	*P>0.7*	*P>0.8*	*P>0.9*
V_3	402.66	404.62	408.05	407.29	409.28

When the forecasted tail probabilities *P>0.9*, the model generates relatively larger returns leading to a total value, after costs, 409.28 RMB, a gain of 2.32% over three days. The choice of a larger value for the forecast tail probability reduces the chance of taking a position I a stock with subsequent negative return. For example, a forecast tail probability equal to 0.51 comes with a negative return -4.94%[15]. In addition, the selection of a larger forecast tail probability reduces the risk of buying a stock with a smaller but positive return which is then offset by the transactions costs. For example, the forecast tail probability equal to 0.64 leads to a positive return of 1.24%, but the net return is -0.17% (=1.0124*0.993*0.993-1). Detailed returns with respective forecasted tail probabilities are reported in Appendix 2.14.

The holding period for the trading rules above is 1-day. The autocorrelation function which is in the four panels in Figure 2.3 shows the autocorrelation function for the all the stocks. Each figure also reports the number of stocks for which the sample autocorrelation is significantly greater than zero at the 1% level of significance. Figure 2.3 shows that most stocks exhibit first-order autocorrelation. There are few A-shares (B-shares) which show significant autocorrelations at the lags greater than 1 (3). Based on this observation, a

[15] The return is calculated as $\ln(P_{T+1}/P_T)$

trading rule with a holding period of 3-days is suggested for B-shares. The results of this strategy are reported in Table 2.20. The table has two panels. The set probability equals 0.50 in Panel A and 0.9 in Panel B. Each panel has two vertical sections, for SSE B and SZSE B shares respectively. The table contents are explained by examples taken from the SSE B section of Panel A. On days +1 and no positions are taken. As above, these cells are denoted with ~. On day +2 a position is taken in five stocks, consistent with the corresponding row in Table 2.17. The returns on the three following days are shown in the three columns headed T+1, T+2 and T+3. As this section of Panel A shows, on the following days, fewer positions are taken and, when they are, the results are inferior. Section 2 of Panel A shows the corresponding results for SZSE B-shares. Panel B shows the results when the set probability equals 0.9. Panel A of the table shows that out of the 20 positions taken the number of negative returns on days +1, +2 and +3 is 7, 8 and 12 respectively. This is supported to some extent by the finding of Seasholes and Wu (2007) who indicate that a positive return from +1 day holding period on the SSE is followed by negative returns from a longer holding.

[Insert Figure 2.3 about here]

[Insert Table 2.20 about here]

To sum up: the case study generates a superior return before considering transactions costs. After taking the transaction costs of 1.4% round trip into account, the model provides a useful signal up to three days which produces an overall profit. This may suggest that the efficient market hypothesis should be rejected and further development of trading rules based on the tail probabilities could be a topic for further study. In contrast with the costs in developed stock markets like the US and UK (0.48% and 0.57% round trip, respectively according to Pollin and Heintz, 2011), the costs are too high in China. Thus, in order to attract global investors, a lower cost system should possibly be implemented.

2.6 Conclusion

Whether or not price limits play a positive role in the stock market remains an ongoing debate. The Chinese stock exchanges, SSE and SZSE, allow a company to issue two types of shares, A- and B-shares, which are subject to the same price limits. The purpose of this chapter is to investigate whether price limits have the same effects on price behaviour and volatility on both shares and exchanges during the period of 2004-2012. In the presence of price limits, stock returns follow a distribution which is truncated above and below at limits corresponding to the maximum permitted rise and fall in price respectively. Indeed, the analysis reported in this chapter shows that truncated-GARCH-M model has better performance than the modified-GARCH-M model. The modified-GARCH-M model, which ignores the need for truncations underestimates the tail probabilities and wrongly estimates the volatility pattern.

The results based on the truncated-GARCH-M model show that the delayed price discovery hypothesis is not rejected after price-limit-hits, especially after upper price-limit-hits. In addition, the volatility spillover hypothesis is also not rejected for either exchange. Comparing A-shares with B-shares, A-shares are more inclined to experience an increase of volatility than B-shares after price-limit-hits on both exchanges, but they have similar patterns of price continuation. The evidence of price continuation and volatility increase in the Chinese A-shares market is consistent with the findings of Chen, Rui and Wang (2005) to a certain extent. As A- and B-shares are issued by the same company, it is expected to observe the same effects of price limits on price behavior and volatility. Therefore, price limits delay price discovery.

As suggested by Kim and Rhee (1997), the delayed price discovery hypothesis and volatility spillover hypothesis should be rejected provided that price limits work. The results, however, do not show the rejection of either hypothesis. It is widely acknowledged that the purpose of stock exchanges to apply price limits is to counter noise trading and alleviate market panic. In the presence of price limits, investors would expect to see a price reversal and lower volatility after the price-limit-hits. This is because they would appreciate price limits preventing them from any unnecessary loss. However, the results reported in this chapter do not indicate price reversal or systematic reduction of volatility after price-limit-hits. Therefore, policy makers could reconsider whether is worthwhile to implement price limits in Chinese stock market or whether further development of the system of limits and accompanying regulation is indicated.

Lee and Chung (1996) point out that testing the effect of price limits on price behavior can be deemed to testing the market efficiency hypothesis. In other words, weak-form market efficiency will be rejected if the delayed price discovery hypothesis holds. The findings of price continuation on both shares and exchanges implies that market efficiency is rejected when there is a price limit system. Thus, an investor could realise a positive return by buying the desired stocks on the day of upper price-limit-hits and selling them on the next day. Moreover, an investor could avoid a large loss by selling the unwanted stocks on the day of lower price-limit-hits at a relatively high price. It is important to note that the benefits of these trading strategies are not guaranteed to every investor as there will be a large number of demand orders for upward price movement and supply orders for downward price movement.

Table 2.1 Summary Statistics for AB-Shares on the SSE

This table reports summary statistics of daily return, market value, negotiable market value, free float rate, total turnover ratio and negotiable turnover ratio for AB-shares listed on the Shanghai Stock Exchange (SSE). AB-share means an A-share has a corresponding B-share. As B-shares listed on the SSE are denominated in USD the market values are converted into RMB in order to facilitate comparisons across markets. The summary statistics are based on the whole sample period: 2004-2012 and three sub-sample periods: 2004-2006 (pre-crisis), 2007-2009 (crisis) and 2010-2012 (after-crisis).

		SSE 44 A-Shares					SSE 44 B-Shares				
		Mean	SD	Skewness	Kurtosis	JB[c]	Mean	SD	Skewness	Kurtosis	JB[c]
	Daily Return (%)	0.0021	0.0003	-0.42	2.59	0.293	0.0132	0.0003	-0.40	3.65	0.222
	Daily Market Value (Thousands RMB)	5,004,755	4,757,727	2.70	10.36	0.001	1,012,473	867,385	2.49	9.81	0.001
	Daily Negotiable Market Value (Thousands RMB)	2,922,464	2,955,587	2.51	9.38	0.001	1,012,473	867,385	2.49	9.81	0.001
2004-2012	Daily Free Float Rate[a]	0.5182	0.1304	-0.61	4.11	0.048	1.0000	0.0000	N/A	N/A	0.000
	Daily Turnover Ratio[b]	0.0099	0.0049	1.10	4.11	0.012	0.0057	0.0016	0.80	4.47	0.019
	Daily Negotiable Turnover Ratio[b]	0.0231	0.0071	0.59	2.55	0.107	0.0057	0.0016	0.80	4.47	0.019
	Daily Return (%)	-0.0278	0.0007	-0.41	3.03	0.395	0.0019	0.0006	0.34	2.59	0.435
	Daily Market Value (Thousands RMB)	2,577,015	2,279,221	2.56	10.39	0.001	619,451	525,425	2.49	10.43	0.001
	Daily Negotiable Market Value(Thousands RMB)	626,714	790,753	2.93	13.5	0.001	619,451	525,425	2.49	10.43	0.001
2004-2006	Daily Free Float Rate	0.2350	0.1492	0.65	2.54	0.083	1.0000	0.0000	N/A	N/A	0.000
	Daily Turnover Ratio	0.0042	0.0023	0.38	2.05	0.126	0.0039	0.0012	-0.06	2.43	0.500
	Daily Negotiable Turnover Ratio	0.0193	0.0058	0.38	1.91	0.092	0.0039	0.0012	-0.06	2.43	0.500
	Daily Return (%)	0.0916	0.0005	-0.19	2.68	0.500	0.0647	0.0005	-0.29	5.14	0.018
	Daily Market Value (Thousands RMB)	6,077,899	7,419,735	3.14	13.11	0.001	1,292,014	1,332,306	3.10	13.08	0.001
	Daily Negotiable Market Value (Thousands RMB)	2,919,253	4,056,712	3.55	16.67	0.001	1,292,014	1,332,306	3.10	13.08	0.001
2007-2009	Daily Free Float Rate	0.4714	0.1700	-0.14	2.81	0.500	1.0000	0.0000	N/A	N/A	0.000
	Daily Turnover Ratio	0.0144	0.0076	1.21	4.93	0.005	0.0092	0.0029	0.96	3.80	0.022
	Daily Negotiable Turnover Ratio	0.0357	0.0144	1.34	5.27	0.003	0.0092	0.0029	0.96	3.80	0.022
	Daily Return (%)	-0.0572	0.0006	1.04	5.21	0.005	-0.0254	0.0005	1.96	11.70	0.001
	Daily Market Value(Thousands RMB)	6,267,387	5,173,167	2.14	7.71	0.001	1,125,534	876,253	1.78	6.15	0.001
	Daily Negotiable Market Value (Thousands RMB)	5,090,834	4,578,795	2.06	7.37	0.001	1,125,534	876,253	1.78	6.15	0.001
2010-2012	Daily Free Float Rate	0.8254	0.2454	-1.46	4.20	0.004	1.0000	0.0000	N/A	N/A	0.000
	Daily Turnover Ratio	0.0107	0.0078	1.46	4.59	0.003	0.0041	0.0018	1.78	8.26	0.001
	Daily Negotiable Turnover Ratio	0.0147	0.0097	1.09	3.63	0.017	0.0041	0.0018	1.78	8.26	0.001

[a] The daily free float rate is defined as daily negotiable market value divided by daily market value.

[b] The daily turnover ratio (negotiable turnover ratio) is defined as daily trading turnover divided by market value (negotiable market value).

[c] The p-value of the Jarque-Bera test is computed by Matlab which restricts the p-value within the range [0.001, 0.50].

Table 2.2 Summary Statistics for AB-Shares on the SZSE

This table reports summary statistics of daily return, market value, negotiable market value, free float rate, total turnover ratio and negotiable turnover ratio for AB-shares listed on the Shenzhen Stock Exchange (SZSE). AB-share means an A-share has a corresponding B-share. As B-shares listed on the SZSE are denominated in HKD, the market values are converted into RMB in order to facilitate comparisons across markets. The summary statistics are based on the whole sample period: 2004-2012 and three sub-sample periods: 2004-2006 (pre-crisis), 2007-2009 (crisis) and 2010-2012 (after-crisis).

		SZSE 42 A-Shares					SZSE 42 B-Shares				
		Mean	SD	Skewness	Kurtosis	JB[c]	Mean	SD	Skewness	Kurtosis	JB[c]
	Daily Return (%)	0.0045	0.0004	0.29	2.85	0.500	0.0126	0.0004	0.21	2.69	0.500
	Daily Market Value (Thousands RMB)	7,353,538	11,427,001	4.14	22.76	0.001	1,565,067	2,378,788	2.98	12.31	0.001
	Daily Negotiable Market Value (Thousands RMB)	4,912,750	10,267,590	5.33	32.40	0.001	1,565,067	2,378,788	2.98	12.31	0.001
2004-2012	Daily Free Float Rate[a]	0.5634	0.1541	-0.12	2.85	0.500	1.0000	0.0000	N/A	N/A	0.000
	Daily Turnover Ratio[b]	0.0113	0.0052	0.53	3.45	0.155	0.0061	0.0024	0.25	2.45	0.500
	Daily Negotiable Turnover Ratio[b]	0.0238	0.0086	0.32	3.43	0.226	0.0061	0.0024	0.25	2.45	0.500
	Daily Return (%)	-0.0268	0.0008	0.39	5.75	0.007	-0.0092	0.0008	0.27	6.20	0.004
	Daily Market Value (Thousands RMB)	3,195,035	3,352,107	1.87	6.17	0.001	987,822	1,440,013	3.48	17.97	0.001
	Daily Negotiable Market Value (Thousands RMB)	1,211,730	2,121,152	4.17	21.70	0.001	987,822	1,440,013	3.48	17.97	0.001
2004-2006	Daily Free Float Rate	0.3385	0.1726	0.87	2.92	0.043	1.0000	0.0000	N/A	N/A	0.000
	Daily Turnover Ratio	0.0060	0.0028	0.69	2.92	0.088	0.0051	0.0019	0.82	3.17	0.050
	Daily Negotiable Turnover Ratio	0.0187	0.0069	0.43	2.43	0.226	0.0051	0.0019	0.82	3.17	0.050
	Daily Return (%)	0.2203	0.0075	6.12	39.00	0.001	0.0688	0.0007	0.09	2.51	0.500
	Daily Market Value (Thousands RMB)	9,201,478	17,767,195	4.77	27.67	0.001	1,781,488	2,869,063	3.02	12.20	0.001
	Daily Negotiable Market Value (Thousands RMB)	5,620,375	15,878,264	5.81	36.32	0.001	1,781,488	2,869,063	3.02	12.20	0.001
2007-2009	Daily Free Float Rate	0.5377	0.1899	-0.05	2.59	0.500	1.0000	0.0000	N/A	N/A	0.000
	Daily Turnover Ratio	0.0164	0.0088	0.74	3.37	0.063	0.0087	0.0037	0.28	2.92	0.500
	Daily Negotiable Turnover Ratio	0.0324	0.0123	0.19	2.48	0.500	0.0087	0.0037	0.28	2.92	0.500
	Daily Return (%)	-0.0581	0.0006	0.41	2.52	0.305	-0.0199	0.0006	0.56	2.45	0.120
	Daily Market Value (Thousands RMB)	9,501,239	13,885,205	3.58	18.18	0.001	1,929,619	3,077,108	2.81	10.25	0.001
	Daily Negotiable Market Value (Thousands RMB)	7,770,650	13,001,181	4.45	25.30	0.001	1,929,619	3,077,108	2.81	10.25	0.001
2010-2012	Daily Free Float Rate	0.8102	0.2108	-0.98	2.86	0.029	1.0000	0.0000	N/A	N/A	0.000
	Daily Turnover Ratio	0.0117	0.0059	0.29	2.46	0.442	0.0047	0.0026	1.29	5.81	0.002
	Daily Negotiable Turnover Ratio	0.0166	0.0118	1.72	6.61	0.001	0.0047	0.0026	1.29	5.81	0.002

[a] The daily free float rate is defined as daily negotiable market value divided by daily market value.

[b] The daily turnover ratio (negotiable turnover ratio) is defined as daily trading turnover divided by market value (negotiable market value).

[c] The p-value of the Jarque-Bera test is computed by Matlab which restricts the p-value within the range [0.001, 0.50].

Table 2.3 Summary Statistics of Return for individual AB-Shares on the SSE

This table reports summary statistics of daily return for individual AB-shares listed on the Shanghai Stock Exchange (SSE) over the period 2004-2012.

A-share	Mean	SD	Min	Median	Max	Skew	Kurt	JB[a]	B-Share	Mean	SD	Min	Median	Max	Skew	Kurt	JB[a]
600054	0.03%	0.03	-38.43%	0.14%	9.54%	-1.98	27.71	0.001	900942	0.05%	0.02	-36.26%	0.00%	9.56%	-1.57	28.08	0.001
600094	0.03%	0.04	-10.54%	0.00%	56.26%	3.08	49.07	0.001	900940	0.01%	0.03	-22.13%	0.00%	26.73%	0.22	9.91	0.001
600190	-0.03%	0.03	-22.72%	0.16%	9.63%	-0.61	7.58	0.001	900952	-0.02%	0.03	-19.40%	0.00%	9.65%	-0.44	8.02	0.001
600221	-0.01%	0.03	-16.61%	0.00%	9.66%	-0.12	4.87	0.001	900945	0.01%	0.03	-10.59%	0.00%	9.79%	-0.04	5.72	0.001
600272	0.02%	0.05	-10.62%	0.14%	121.94%	9.31	256.60	0.001	900943	0.01%	0.03	-10.63%	0.00%	9.67%	-0.15	5.82	0.001
600295	0.03%	0.03	-10.57%	0.07%	9.61%	-0.20	4.29	0.001	900936	0.04%	0.03	-10.68%	0.00%	9.59%	-0.17	6.09	0.001
600320	-0.07%	0.04	-72.25%	0.00%	9.57%	-6.99	127.48	0.001	900947	-0.07%	0.04	-73.59%	0.00%	9.56%	-6.87	126.16	0.001
600555	-0.04%	0.04	-69.68%	0.13%	9.63%	-3.68	61.22	0.001	900955	-0.04%	0.03	-74.34%	0.00%	9.69%	-5.31	110.68	0.001
600602	-0.05%	0.03	-21.54%	0.11%	9.72%	-0.28	5.42	0.001	900901	-0.03%	0.03	-17.07%	0.00%	9.72%	-0.37	6.82	0.001
600604	0.02%	0.03	-38.46%	0.15%	9.71%	-0.92	13.29	0.001	900902	0.01%	0.03	-10.78%	0.00%	9.69%	-0.01	5.39	0.001
600610	0.04%	0.03	-10.59%	0.16%	9.64%	-0.02	3.64	0.001	900906	0.01%	0.03	-10.75%	0.00%	9.79%	0.05	4.48	0.001
600611	-0.02%	0.03	-33.17%	0.08%	9.61%	-1.11	13.94	0.001	900903	-0.01%	0.03	-32.18%	0.00%	9.62%	-1.55	21.75	0.001
600612	0.05%	0.03	-20.60%	0.05%	9.60%	-0.17	5.39	0.001	900905	0.08%	0.03	-22.13%	0.00%	9.64%	-0.34	8.10	0.001
600613	0.06%	0.04	-32.38%	0.20%	9.58%	-0.44	6.65	0.001	900904	0.06%	0.03	-38.17%	0.00%	9.67%	-0.88	15.07	0.001
600614	0.00%	0.04	-51.76%	0.15%	9.61%	-2.58	34.45	0.001	900907	0.00%	0.03	-48.19%	0.00%	9.64%	-2.65	39.22	0.001
600617	0.02%	0.04	-10.57%	0.09%	81.65%	4.93	108.14	0.001	900913	0.03%	0.03	-10.71%	0.00%	12.56%	-0.08	5.37	0.001
600618	0.00%	0.04	-10.58%	0.18%	9.62%	-0.09	4.24	0.001	900908	0.01%	0.03	-10.72%	0.00%	9.76%	-0.13	6.26	0.001
600619	-0.01%	0.03	-28.40%	0.20%	9.59%	-0.62	7.19	0.001	900910	0.01%	0.03	-18.49%	0.00%	9.59%	-0.52	8.24	0.001
600623	0.00%	0.04	-22.40%	0.10%	9.64%	-0.20	4.95	0.001	900909	0.01%	0.03	-10.59%	0.00%	9.70%	-0.11	5.96	0.001
600639	0.01%	0.03	-15.45%	0.15%	9.58%	-0.27	4.84	0.001	900911	0.02%	0.02	-12.33%	0.00%	9.55%	-0.33	7.37	0.001
600648	0.00%	0.03	-21.69%	0.00%	9.58%	-0.08	5.19	0.001	900912	0.02%	0.03	-10.59%	0.00%	9.62%	0.00	6.57	0.001
600650	0.00%	0.03	-26.83%	0.12%	9.56%	-0.67	8.71	0.001	900914	0.03%	0.02	-13.78%	0.00%	9.56%	-0.33	8.11	0.001
600663	0.01%	0.03	-10.61%	0.00%	9.58%	0.04	5.00	0.001	900932	0.03%	0.02	-10.58%	0.00%	9.62%	-0.01	6.90	0.001
600679	-0.04%	0.04	-32.78%	0.00%	9.67%	-0.32	5.86	0.001	900916	0.01%	0.03	-10.89%	0.00%	9.87%	-0.09	5.76	0.001
600680	0.00%	0.04	-36.65%	0.12%	9.59%	-0.61	9.34	0.001	900930	0.00%	0.03	-10.73%	0.00%	9.65%	-0.18	6.65	0.001
600689	0.02%	0.04	-25.90%	0.22%	9.66%	-0.30	5.45	0.001	900922	0.03%	0.03	-10.61%	0.00%	9.65%	-0.18	5.56	0.001
600695	-0.01%	0.03	-10.61%	0.12%	45.08%	1.10	18.74	0.001	900919	0.01%	0.03	-10.59%	0.00%	9.74%	-0.21	4.59	0.001
600698	0.03%	0.03	-55.96%	0.15%	5.21%	-3.22	58.17	0.001	900946	0.02%	0.03	-9.61%	0.00%	5.41%	-0.12	2.75	0.014
600726	-0.04%	0.03	-26.47%	0.00%	9.72%	-0.51	9.98	0.001	900937	-0.04%	0.02	-10.67%	0.00%	9.67%	-0.10	7.68	0.001
600751	0.03%	0.03	-5.32%	0.15%	87.32%	7.93	201.73	0.001	900938	0.01%	0.03	-5.53%	0.00%	33.02%	0.82	13.83	0.001
600754	0.04%	0.03	-16.77%	0.10%	9.55%	-0.37	5.57	0.001	900934	0.05%	0.02	-10.54%	0.00%	9.60%	-0.10	7.71	0.001
600776	-0.01%	0.04	-70.77%	0.19%	9.68%	-3.51	66.31	0.001	900941	0.00%	0.03	-66.72%	0.00%	9.74%	-4.27	92.68	0.001
600801	0.04%	0.04	-72.73%	0.13%	9.64%	-3.62	76.03	0.001	900933	0.05%	0.03	-72.85%	0.00%	9.59%	-4.46	97.37	0.001
600818	0.02%	0.03	-32.85%	0.06%	9.61%	-0.42	8.07	0.001	900915	0.03%	0.03	-11.42%	0.00%	9.66%	-0.17	6.42	0.001
600819	-0.04%	0.03	-45.91%	0.00%	9.64%	-1.19	18.46	0.001	900918	-0.02%	0.03	-46.62%	0.00%	9.59%	-2.33	41.34	0.001
600822	-0.03%	0.03	-40.43%	0.12%	9.59%	-1.08	13.75	0.001	900927	0.01%	0.03	-45.95%	0.00%	9.64%	-2.12	35.96	0.001
600827	-0.01%	0.03	-27.81%	0.00%	9.58%	-0.73	9.71	0.001	900923	0.02%	0.03	-25.98%	0.00%	9.58%	-0.48	10.73	0.001
600835	-0.01%	0.03	-33.03%	0.00%	9.61%	-0.71	10.80	0.001	900925	0.01%	0.03	-18.55%	0.00%	9.62%	-0.42	7.48	0.001
600841	0.01%	0.04	-49.70%	0.13%	9.60%	-1.28	20.17	0.001	900920	0.01%	0.03	-51.15%	0.00%	9.62%	-2.40	43.39	0.001
600843	-0.01%	0.04	-52.67%	0.14%	9.63%	-1.55	23.77	0.001	900924	0.00%	0.03	-14.99%	0.00%	9.68%	-0.33	6.37	0.001
600844	0.03%	0.04	-67.15%	0.00%	82.62%	2.25	115.49	0.001	900921	0.05%	0.04	-66.88%	0.00%	70.69%	0.42	112.79	0.001
600845	0.01%	0.03	-31.99%	0.03%	9.58%	-0.67	13.01	0.001	900926	0.03%	0.03	-29.61%	0.00%	9.61%	-0.71	12.58	0.001
600848	0.02%	0.04	-38.17%	0.19%	9.64%	-0.73	10.29	0.001	900928	0.03%	0.03	-10.62%	0.00%	9.64%	-0.14	5.59	0.001
600851	-0.04%	0.04	-65.92%	0.00%	9.65%	-2.85	51.25	0.001	900917	-0.02%	0.03	-65.49%	0.00%	9.68%	-3.50	70.92	0.001

[a] The p-value of the Jarque-Bera test is computed by Matlab which restricts the p-value within the range [0.001, 0.50].

Table 2.4 Summary Statistics of Return for individual AB-Shares on the SZSE

This table reports summary statistics of daily return for individual AB-shares listed on the Shanghai Stock Exchange (SSE) over the period 2004-2012.

A-share	Mean	SD	Min	Median	Max	Skew	Kurt	JB[a]	B-Share	Mean	SD	Min	Median	Max	Skew	Kurt	JB[a]
000002	0.02%	0.03	-44.78%	0.10%	9.58%	-3.62	48.77	0.001	200002	0.04%	0.03	-44.94%	0.00%	9.62%	-3.41	44.39	0.001
000011	0.03%	0.03	-10.62%	0.17%	9.63%	-0.01	3.47	0.001	200011	0.03%	0.03	-10.67%	0.00%	9.72%	-0.06	4.64	0.001
000012	0.01%	0.04	-57.42%	0.08%	9.63%	-2.76	41.10	0.001	200012	0.01%	0.03	-59.09%	0.09%	9.66%	-4.70	81.91	0.001
000016	-0.04%	0.03	-72.12%	0.23%	9.59%	-5.63	122.24	0.001	200016	-0.03%	0.03	-68.13%	0.00%	9.58%	-6.87	165.58	0.001
000017	0.02%	0.04	-5.33%	0.00%	89.02%	10.25	248.50	0.001	200017	0.00%	0.03	-18.85%	0.00%	5.83%	-0.15	2.94	0.018
000018	-0.01%	0.03	-35.04%	0.12%	9.65%	-0.79	12.52	0.001	200018	-0.01%	0.03	-10.80%	0.00%	9.72%	0.15	4.84	0.001
000019	0.02%	0.04	-38.14%	0.22%	9.64%	-0.81	10.32	0.001	200019	0.03%	0.03	-10.58%	0.00%	9.68%	-0.08	5.10	0.001
000020	0.00%	0.04	-10.55%	0.16%	114.21%	11.63	332.96	0.001	200020	0.00%	0.03	-10.57%	0.00%	9.63%	-0.10	3.49	0.001
000022	-0.03%	0.03	-33.53%	0.00%	9.57%	-1.61	21.09	0.001	200022	-0.01%	0.02	-37.43%	0.00%	9.55%	-2.94	46.42	0.001
000024	0.05%	0.03	-41.45%	0.12%	9.56%	-1.08	15.00	0.001	200024	0.06%	0.03	-38.15%	0.00%	9.54%	-1.41	21.14	0.001
000025	0.01%	0.04	-22.47%	0.17%	9.66%	-0.15	4.68	0.001	200025	0.00%	0.03	-10.62%	0.00%	9.69%	0.05	5.18	0.001
000026	-0.01%	0.03	-47.01%	0.06%	9.60%	-1.96	26.58	0.001	200026	0.03%	0.03	-35.94%	0.00%	9.76%	-0.87	15.14	0.001
000028	0.09%	0.03	-10.56%	0.03%	9.59%	-0.03	4.44	0.001	200028	0.09%	0.03	-10.55%	0.06%	9.64%	-0.03	4.92	0.001
000029	-0.02%	0.03	-18.53%	0.18%	9.70%	-0.22	4.55	0.001	200029	0.00%	0.03	-10.59%	0.00%	9.80%	-0.05	5.13	0.001
000030	0.07%	0.03	-24.30%	0.25%	5.24%	-0.41	4.28	0.001	200030	0.06%	0.03	-5.94%	0.00%	5.56%	-0.03	2.05	0.001
000037	-0.06%	0.03	-27.13%	0.15%	9.68%	-0.43	7.88	0.001	200037	-0.06%	0.03	-10.61%	0.00%	9.74%	-0.27	6.61	0.001
000039	-0.03%	0.04	-67.87%	0.07%	9.57%	-4.88	88.42	0.001	200039	-0.02%	0.03	-66.41%	0.10%	9.53%	-6.03	112.94	0.001
000045	-0.01%	0.04	-43.73%	0.16%	9.62%	-1.37	17.72	0.001	200045	0.00%	0.03	-45.38%	0.00%	9.66%	-1.74	30.13	0.001
000055	-0.02%	0.04	-47.31%	0.26%	9.62%	-1.36	16.72	0.001	200055	-0.02%	0.03	-42.95%	0.00%	9.70%	-1.54	23.00	0.001
000056	0.05%	0.04	-13.39%	0.11%	9.62%	-0.15	3.90	0.001	200056	0.06%	0.03	-10.75%	0.00%	9.76%	-0.02	4.67	0.001
000058	-0.03%	0.03	-39.57%	0.00%	9.65%	-0.93	14.45	0.001	200058	-0.02%	0.03	-10.89%	0.00%	9.68%	-0.12	4.46	0.001
000413	0.05%	0.03	-28.14%	0.07%	9.68%	-0.22	6.16	0.001	200413	0.04%	0.03	-10.65%	0.00%	10.06%	0.02	4.89	0.001
000418	0.02%	0.03	-46.59%	0.06%	9.64%	-2.12	31.10	0.001	200418	0.04%	0.03	-43.38%	0.00%	9.71%	-1.60	29.92	0.001
000429	-0.02%	0.02	-23.98%	0.00%	9.61%	-0.96	12.29	0.001	200429	-0.01%	0.02	-10.60%	0.00%	9.63%	-0.31	8.82	0.001
000488	-0.04%	0.03	-41.59%	0.00%	9.56%	-1.59	23.63	0.001	200488	-0.04%	0.03	-40.11%	0.00%	9.63%	-1.97	32.95	0.001
000505	0.00%	0.03	-27.42%	0.07%	9.73%	-0.32	5.82	0.001	200505	0.01%	0.03	-10.80%	0.00%	9.84%	-0.09	4.55	0.001
000513	0.08%	0.03	-10.55%	0.09%	9.57%	-0.09	4.68	0.001	200513	0.09%	0.02	-10.56%	0.13%	9.60%	-0.06	6.13	0.001
000521	0.00%	0.03	-18.14%	0.16%	9.66%	-0.35	5.30	0.001	200521	0.01%	0.03	-17.68%	0.00%	9.78%	-0.29	6.58	0.001
000530	0.00%	0.03	-18.65%	0.16%	9.60%	-0.28	5.21	0.001	200530	0.01%	0.02	-10.62%	0.00%	9.65%	-0.34	6.37	0.001
000539	-0.03%	0.03	-20.60%	0.00%	9.65%	-0.34	7.07	0.001	200539	-0.02%	0.02	-10.50%	0.00%	9.55%	-0.16	6.45	0.001
000541	-0.03%	0.03	-54.33%	0.09%	9.56%	-3.47	51.62	0.001	200541	-0.02%	0.03	-51.14%	0.08%	9.57%	-5.12	86.91	0.001
000550	0.03%	0.03	-12.43%	0.00%	9.62%	-0.02	4.11	0.001	200550	0.05%	0.03	-10.50%	0.00%	9.63%	0.00	4.82	0.001
000553	0.00%	0.04	-73.00%	0.15%	9.62%	-3.94	73.36	0.001	200553	0.00%	0.03	-65.36%	0.00%	9.68%	-4.38	93.24	0.001
000570	0.00%	0.03	-37.03%	0.16%	9.67%	-1.08	13.88	0.001	200570	0.01%	0.03	-37.96%	0.00%	9.81%	-1.15	17.85	0.001
000581	0.05%	0.03	-27.94%	0.09%	9.59%	-0.41	6.99	0.001	200581	0.05%	0.03	-24.50%	0.00%	9.68%	-0.38	6.87	0.001
000596	0.07%	0.04	-72.24%	0.11%	9.59%	-3.71	72.48	0.001	200596	0.09%	0.03	-68.80%	0.00%	9.66%	-4.39	96.10	0.001
000613	0.01%	0.03	-5.44%	0.14%	68.24%	4.68	103.73	0.001	200613	0.03%	0.03	-6.45%	0.00%	5.88%	-0.08	2.38	0.001
000625	-0.04%	0.04	-62.34%	0.00%	9.61%	-2.98	52.31	0.001	200625	-0.04%	0.03	-59.39%	0.00%	9.78%	-3.20	57.36	0.001
000725	-0.09%	0.04	-40.91%	0.00%	24.62%	-1.56	20.76	0.001	200725	-0.07%	0.03	-44.09%	0.00%	9.89%	-2.20	29.12	0.001
000726	-0.01%	0.03	-60.61%	0.11%	9.56%	-3.42	66.41	0.001	200726	0.01%	0.03	-61.45%	0.14%	9.63%	-6.16	143.51	0.001
000761	-0.02%	0.03	-22.96%	0.00%	9.61%	-0.27	6.85	0.001	200761	-0.02%	0.02	-11.96%	0.00%	9.64%	-0.19	6.72	0.001
000869	0.07%	0.03	-37.24%	0.00%	9.54%	-2.15	31.64	0.001	200869	0.09%	0.03	-34.23%	0.03%	9.53%	-2.06	26.91	0.001

[a] The p-value of the Jarque-Bera test is computed by Matlab which restricts the p-value within the range [0.001, 0.50].

Figure 2.1 Return Distribution

This figure displays the return distribution of the A- and B-shares on Shanghai Stock Exchange (SSE) and Shenzhen Stock Exchange (SZSE) over the period 2004-2012.

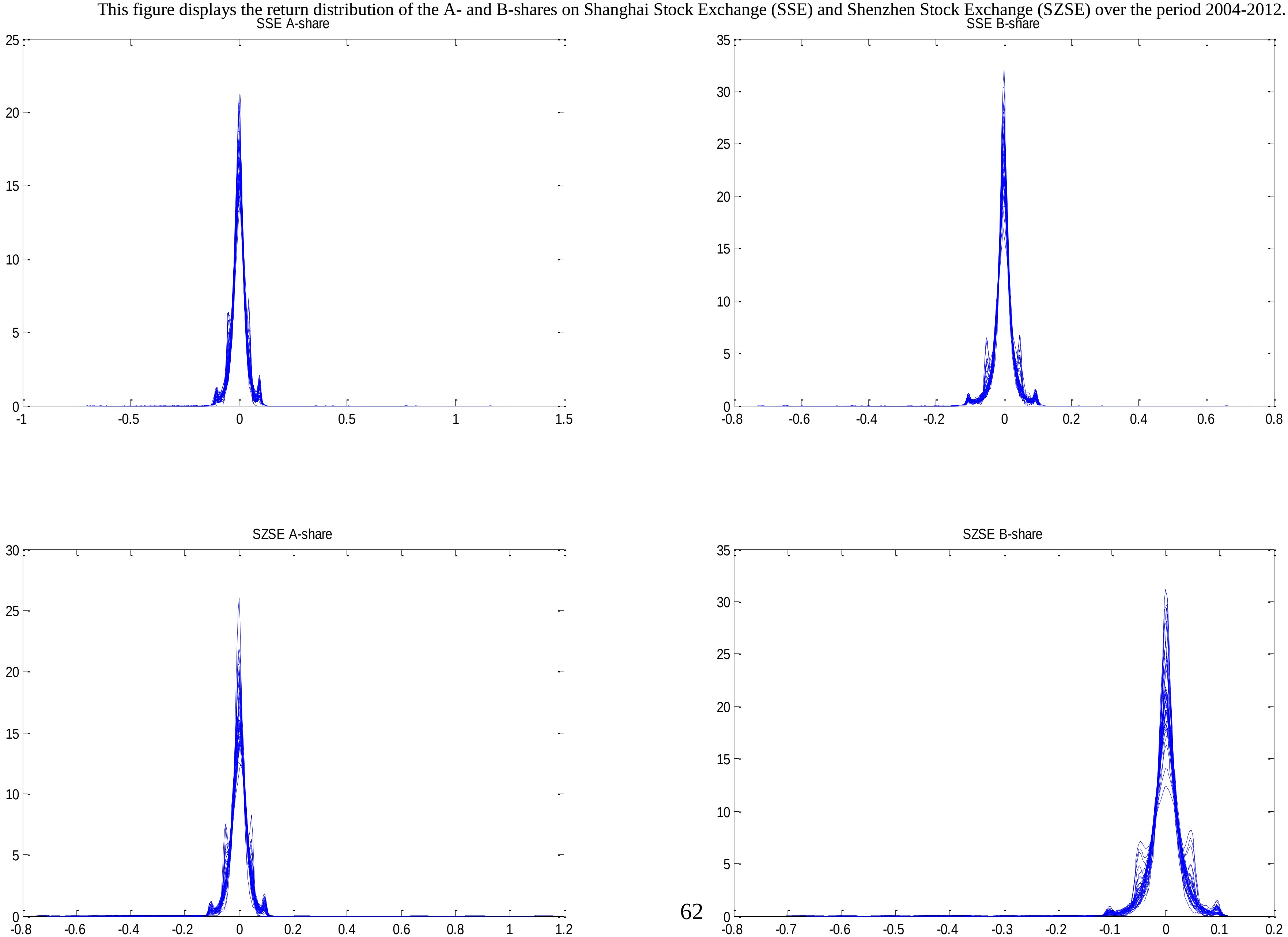


Table 2.5 Sample Comparisons between A- and B-shares on the SSE and SZSE

This table reports sample return mean, return variance and market value comparisons between A- and B-shares. AB-share means an A-share has a corresponding B-share. As B-shares are denominated in USD (HKD) on the SSE (SZSE), the market values are converted into RMB in order to facilitate comparisons across markets. These three comparisons summarise the numbers of AB-shares which have significant different return mean, return variance and market value. The comparisons are based on the whole sample period: 2004-2012 and three sub-sample periods: 2004-2006 (pre-crisis), 2007-2009 (crisis) and 2010-2012 (after-crisis).

Significance Level	1%	5%	1%	5%	1%	5%
Panel A: SSE (N=44)						
Return Mean	$\mu_A < \mu_B$		$\mu_A \neq \mu_B$		$\mu_A > \mu_B$	
2004-2012	0	1	0	0	0	0
2004-2006	0	1	0	0	0	0
2007-2009	0	0	0	0	0	1
2010-2012	0	0	0	0	0	0
Return Variance[a]	$S_A^2 < S_B^2$		$S_A^2 \neq S_B^2$		$S_A^2 > S_B^2$	
2004-2012	0	0	42	42	42	42
2004-2006	0	0	30	34	30	34
2007-2009	0	0	34	36	34	36
2010-2012	0	0	42	42	42	42
Negotiable Market Value[b]	$MV_A < MV_B$		$MV_A \neq MV_B$		$MV_A > MV_B$	
2004-2012	1	1	44	44	43	43
2004-2006	29	30	42	44	13	14
2007-2009	5	5	41	42	37	37
2010-2012	1	1	44	44	43	43
Panel B: SZSE (N=42)						
Return Mean	$\mu_A < \mu_B$		$\mu_A \neq \mu_B$		$\mu_A > \mu_B$	
2004-2012	0	0	0	0	0	0
2004-2006	0	0	0	0	0	0
2007-2009	0	0	0	0	0	0
2010-2012	0	1	0	0	0	0
Return Variance[a]	$S_A^2 < S_B^2$		$S_A^2 \neq S_B^2$		$S_A^2 > S_B^2$	
2004-2012	0	1	36	37	36	36
2004-2006	1	1	23	26	22	25
2007-2009	2	2	37	37	35	35
2010-2012	1	1	33	35	32	34
Negotiable Market Value[b]	$MV_A < MV_B$		$MV_A \neq MV_B$		$MV_A > MV_B$	
2004-2012	0	0	41	42	42	42
2004-2006	13	13	40	40	27	27
2007-2009	2	2	42	42	40	40
2010-2012	0	0	42	42	42	42

[a] Return variance is based on the modified F-test (Pitman, 1939) which takes the correlated variables into account.

[b] Mean and negotiable market value are based on the paired sample t-test

Table 2.6 Summary Statistics for Pearson's Correlation Coefficient

This table reports summary statistics of Pearson's correlation coefficients between five pairs of variables: return with market value, negotiable market value, free float rate, turnover ratio and negotiable turnover ratio. The summary statistics are the numbers of AB-shares presenting significant positive correlation coefficients (0,1] and negative correlation coefficients [-1,0). AB-share means an A-share has a corresponding B-share. The summary statistics are based on the whole sample period: 2004-2012 and three sub-sample periods: 2004-2006 (pre-crisis), 2007-2009 (crisis) and 2010-2012 (after-crisis).

Panel A: SSE (N=44)		A-Shares				B-Shares			
	Correlation Coefficient Value	[-1,0)		(0,1]		[-1,0)		(0,1]	
	Significance Level	1%	5%	1%	5%	1%	5%	1%	5%
	Market Value	0	0	1	9	0	0	0	0
	Negotiable Market Value	0	0	0	1	0	0	0	0
2004-2012	Free Float Rate	0	0	0	0	0	0	0	0
	Turnover Ratio	0	0	43	44	0	0	44	44
	Negotiable Turnover Ratio	0	0	43	44	0	0	44	44
	Market Value	0	0	4	12	0	0	3	8
	Negotiable Market Value	0	0	2	8	0	0	3	8
2004-2006	Free Float Rate	1	2	0	1	0	0	0	0
	Turnover Ratio	0	0	39	42	0	0	44	44
	Negotiable Turnover Ratio	0	0	39	42	0	0	44	44
	Market Value	0	0	1	2	0	0	0	0
	Negotiable Market Value	0	0	0	1	0	0	0	0
2007-2009	Free Float Rate	0	1	0	0	0	0	0	0
	Turnover Ratio	0	0	42	43	0	0	43	44
	Negotiable Turnover Ratio	0	0	42	43	0	0	43	44
	Market Value	0	0	6	12	0	0	0	4
	Negotiable Market Value	0	0	3	10	0	0	0	4
2010-2012	Free Float Rate	1	1	0	0	0	0	0	0
	Turnover Ratio	0	0	41	42	0	0	34	35
	Negotiable Turnover Ratio	0	0	41	42	0	0	34	35
Panel B: SZSE (N=42)		**A-Shares**				**B-Shares**			
	Correlation Coefficient Value	[-1,0)		(0,1]		[-1,0)		(0,1]	
	Significance Level	1%	5%	1%	5%	1%	5%	1%	5%
	Market Value	0	0	0	3	0	0	0	2
	Negotiable Market Value	0	0	0	1	0	0	0	2
2004-2012	Free Float Rate	0	0	0	0	0	0	0	0
	Turnover Ratio	0	0	41	42	0	0	42	42
	Negotiable Turnover Ratio	0	0	41	42	0	0	42	42
	Market Value	0	0	4	9	0	0	4	10
	Negotiable Market Value	0	0	4	9	0	0	4	10
2004-2006	Free Float Rate	0	0	0	1	0	0	0	0
	Turnover Ratio	1	1	37	39	0	0	37	37
	Negotiable Turnover Ratio	1	1	37	39	0	0	37	37
	Market Value	0	0	0	2	0	0	1	3
	Negotiable Market Value	0	0	1	1	0	0	1	3
2007-2009	Free Float Rate	1	4	0	0	0	0	0	0
	Turnover Ratio	0	0	38	38	0	0	39	41
	Negotiable Turnover Ratio	0	0	38	38	0	0	39	41
	Market Value	0	0	2	5	0	0	3	4
	Negotiable Market Value	0	0	3	6	0	0	3	4
2010-2012	Free Float Rate	0	0	0	1	0	0	0	0
	Turnover Ratio	0	0	38	39	1	1	31	34
	Negotiable Turnover Ratio	0	0	38	39	1	1	31	34

Table 2.7 Price-Limit-Hits

The Panel A of this table shows the procedures to exactly identify price limits. $P_{c,t-1}$ is closing price on day *t-1*; P_{max} and P_{min} are permissible maximum and minimum prices rounded to two decimal places (three decimal places for B-shares on the SSE). The Panel B of this table reports the total numbers of upper and lower limits hits of AB-shares on both stock exchanges[a]. The Panel C shows the chi-squared tests in terms of the number of price-limit-hits between A- and B-shares, as well as between the SSE and SZSE. The Panel D summarises the number of price-limit-hits.

Panel A: Procedures to Identify Price Limits Hits

Price limits hits	Step 1	Step 2	Trading Status
Upper	$P_{c,t-1}\times1.1 \approx P_{max,t}$	$P_{max,t} = P_{c,t}$	Normal
	$P_{c,t-1}\times1.05 \approx P_{max,t}$	$P_{max,t} = P_{c,t}$	ST
Lower	$P_{c,t-1}\times0.9 \approx P_{min,t}$	$P_{min,t} = P_{c,t}$	Normal
	$P_{c,t-1}\times0.95 \approx P_{min,t}$	$P_{min,t} = P_{c,t}$	ST

Panel B: Numbers of Price Limits Hits

	SSE (N=44)				SZSE (N=42)		
	Upper	Lower	Total		Upper	Lower	Total
A	2388	1471	3859	A	2047	1503	3550
B	1654	1229	2883	B	1712	1314	3026
Total	4042	2700	6742	Total	3759	2817	6576

Panel C: Chi-squared test

	Upper	Lower	Total	Marginal Probability		Upper	Lower	Total	Marginal Probability
A	4435	2974	7409	0.5563	SSE	4042	2700	6742	0.5062
B	3366	2543	5909	0.4437	SZSE	3759	2817	6576	0.4938
Total	7801	5517	13318		Total	7801	5517	13318	
Marginal Probability	0.5857	0.4143			Marginal Probability	0.5857	0.4143		
Expected values	Upper	Lower	Total	p-value	Expected values	Upper	Lower	Total	p-value
A	4340	3069	7409	0.0008	SSE	3949	2793	6742	0.0011
B	3461	2448	5909		SZSE	3852	2724	6576	
Total	7801	5517	13318		Total	7801	5517	13318	
chi-squared statistics=11.3595					chi-squared statistics=10.6803				

Panel D: Summary Statistics[a]

	SSE A			SSE B		
	Upper	Lower	Days Between[b]	Upper	Lower	Days Between
Mean	54	33	30	38	28	30
SD	44	34	38	35	32	39
Min	4	2	2	5	3	0
Median	40	23	16	23	15	12
Max	177	153	197	133	141	157
	SZSE A			SZSE B		
	Upper	Lower	Days Between	Upper	Lower	Days Between
Mean	49	36	39	41	31	49
SD	46	42	42	58	48	72
Min	4	2	2	2	1	0
Median	29	14	26	17	10	20
Max	184	170	204	235	187	335

[a] A detailed number of price-limit-hits for individual shares are shown in Appendix 2.1 and 2.2.

[b] It means the number of days between consecutive limit-hits.

Figure 2.2 Price-Limit-Hits and Market Value

This figure plots the data of market value in y-axis against the number of limit-hits in x-axis The correlation coefficients are -0.1968 (p-value 0.0661) and -0.1909 (p-value 0.0820) on the SSE and SZSE, respectively.

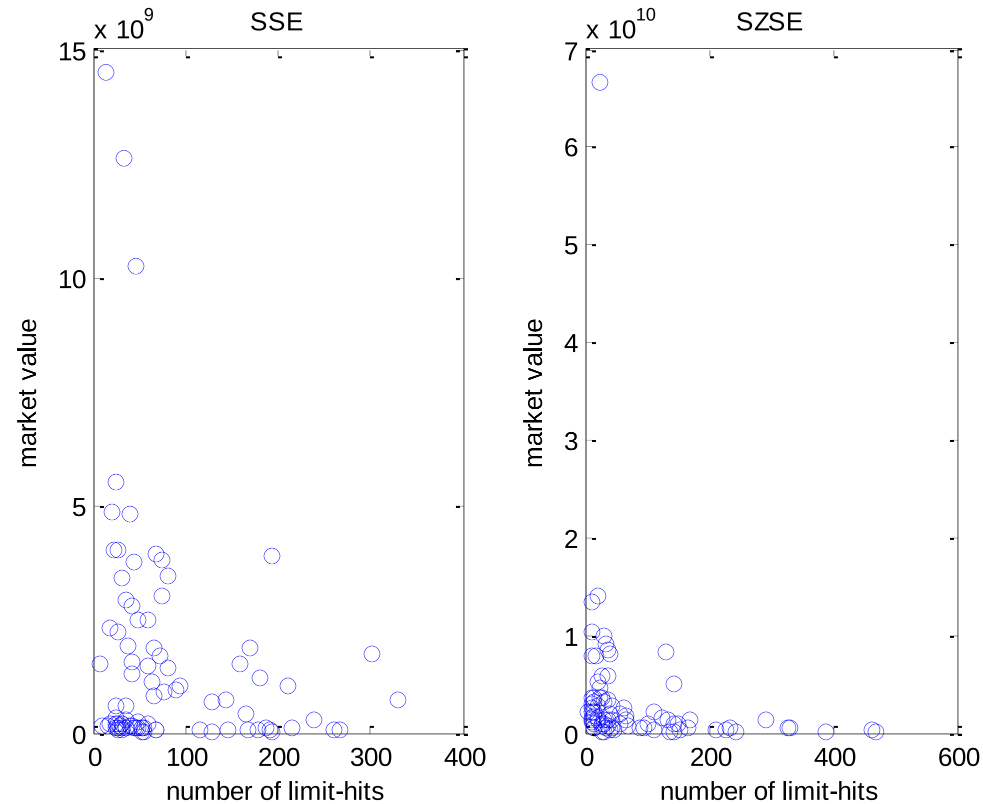


Table 2.8 Tests for the Imputation[a]

This table summarises the results of the two-sample Kolmogorov-Smirnov (KS) test and the two-sample t-test. The null hypothesis of KS test is that the newly generated data (return) and original data are from the same continuous distribution. The null hypothesis of T-test is that mean and variance of the newly generated data (return) are not significantly different from those of original data. The newly generated data are repeated for 100 times. The number of rejections and non-rejections based on the number of shares and number of times are reported. 10% significance level is chosen.

	Two-sample Kolmogorov-Smirnov (KS)[a]		Two-sample t-test (T-test)[b]	
	Number of Shares/Number of Times		Number of Shares/Number of Times	
SSE	A	B	A	B
Reject	1/100	1/100	1/45	1/56
Do not reject	39/3900	39/3900	39/3900	39/3900
SZSE				
Reject	1/100	1/100	0/0	0/0
Do not reject	37/3700	37/3700	38/3800	38/3800

[a] Detailed results are shown in Appendix 2.3 and 2.4.

Table 2.9 Tests for Conditional Heteroscedasticity

Panel A of this table shows the tests for conditional heteroscedasticity for individual shares. The number of shares that has ARCH error are reported based on the Ljung-Box Q^2-test (LBQ) and Engle ARCH test. Panel B also shows the test statistics and critical value (CV) for the A-shares and B-shares indexes on both exchanges. Panel C shows the number of shares that have asymmetric effect in volatility based on the Engle and Ng's (1993) test.

Panel A Tests for conditional heteroscedasticity

	LBQ^2 (20)[a]			LBQ^2 (8)[b]			Engle		
SSE 40	5%	1%	0.1%	5%	1%	0.1%	5%	1%	0.1%
A	21	12	5	24	14	8	21	20	19
B	21	15	11	28	24	13	26	25	25
SZSE 38									
A	23	15	12	22	16	9	21	19	16
B	24	20	15	24	19	16	24	21	20

Panel B Tests for conditional heteroscedasticity for indexes

SSE	LBQ^2 (20)[a]	LBQ^2 (8)[b]	Engle	**SZSE**	LBQ^2 (20)	LBQ^2 (8)	Engle
A	559.97	286.53	42.50	A	573.21	329.04	52.21
B	949.57	630.47	128.39	B	325.42	221.29	48.92
CV (5%)	31.41	15.51	3.84	CV (5%)	31.41	15.51	3.84
CV (1%)	37.57	20.09	6.63	CV (1%)	37.57	20.09	6.63
CV (0.1%)	45.31	26.12	10.83	CV (0.1%)	45.31	26.12	10.83

Panel C Tests for asymmetries in volatility

SSE 40	5%	1%	0.1%	SZSE 38	5%	1%	0.1%
A	1	1	0	A	3	0	0
B	10	0	0	B	3	0	0

[a] A 20-lags LBQ^2 test is adopted by Box, Jenkins and Reinsel (2008).

[b] A Log(T)-lags LBQ^2 test is suggested by Tsay (2010). T is the number of observations, then Log(2187)≈8.

Table 2.10 Log-likelihood Ratio Statistics I[a]

This table summarises the log-likelihood (LL) ratio statistics among the OLS, modified-GARCH-M (MGM) and truncated-GARCH-M (TGM). The log-likelihood (LL) ratio statistics are equal to $LL1=2*(LL_{MGM}-LL_{OLS})$, $LL2=2*(LL_{TGM}-LL_{OLS})$ and $LL3=2*(LL_{TGM}-LL_{MGM})$ which follow chi-squared distributions.

	A-shares			B-shares		
SSE	LL1	LL2	LL3	LL1	LL2	LL3
Mean	242.71	753.37	510.66	437.65	761.07	323.43
SD	140.49	507.93	569.96	133.30	316.74	378.69
Min	1.87	327.89	48.59	3.74	399.83	5.40
Q1	159.13	446.28	174.88	376.64	514.80	77.49
Median	218.14	582.35	292.55	449.97	679.65	165.89
Q3	322.67	902.04	587.67	528.07	945.29	391.74
Max	708.57	2864.82	2843.06	680.92	1716.39	1712.65
SZSE	LL1	LL2	LL3	LL1	LL2	LL3
Mean	234.78	752.84	518.07	278.37	619.31	340.94
SD	144.01	478.54	512.61	183.58	324.65	328.13
Min	-4.14	178.80	10.56	10.99	143.61	-12.75
Q1	124.21	441.23	175.57	177.73	378.14	48.48
Median	219.13	641.73	397.42	249.98	548.93	250.09
Q3	332.91	920.66	677.16	341.32	886.41	606.90
Max	639.34	2351.29	2278.20	988.92	1385.33	1246.49

[a] Detailed results are shown in Appendix 2.6.

Table 2.11 Log-likelihood Ratio Statistics II[a]

This table summarises the log-likelihood (LL) ratio statistics for the truncated-GARCH-M presented in equation (2.9) and (2.8). The log-likelihood (LL) ratio statistics are equal to $2*(LL_{eq9}-LL_{eq8})$ which follows a chi-squared distribution.

	SSE A	SSE B	SZSE A	SZSE B
	$2*(LL_{eq9}-LL_{eq8})$	$2*(LL_{eq9}-LL_{eq8})$	$2*(LL_{eq9}-LL_{eq8})$	$2*(LL_{eq9}-LL_{eq8})$
Mean	12.18	8.78	22.76	18.03
SD	26.54	28.00	124.08	71.17
Min	-84.16	-149.27	-126.55	-21.25
Q1	4.05	4.44	2.79	2.55
Median	9.54	8.43	5.45	5.09
Q3	16.79	21.20	13.26	10.46
Max	73.82	41.86	747.51	442.12
Critical Values for 0.001, 0.01 and 0.05 are 16.27, 11.34 and 7.81, respectively				

[a] Detailed results are shown in Appendix 2.7.

Table 2.12 Models Estimation for AB-shares on the SSE[a]

This table reports the number of stocks that show price continuation (PC), price reversal (PR), volatility increase (VI) and volatility decrease (VD) after price limits. There are 40 AB-shares on the SSE. For upper price limit (PC): $\beta_2+\beta_5>0$ and $\beta_2+\beta_5>\beta_2+\beta_7$; (PR): $\beta_2+\beta_5<0$ and $\beta_2+\beta_5<\beta_2+\beta_7$; (VI): $\beta_{12}>0$ and $\beta_{12}>\beta_{14}$; (VD): $\beta_{12}<0$ and $\beta_{12}<\beta_{14}$. For lower price limit (PC): $\beta_2+\beta_6<0$ and $\beta_2+\beta_6<\beta_2+\beta_8$; (PR): $\beta_2+\beta_6>0$ and $\beta_2+\beta_6>\beta_2+\beta_8$; (VI): $\beta_{13}>0$ and $\beta_{13}>\beta_{15}$; (VD): $\beta_{13}<0$ and $\beta_{13}<\beta_{15}$. The signs '>' and '<' imply significant 'larger than' and 'smaller than'.

$$R_t = \mu_t + \varepsilon_t \qquad \varepsilon_t\,|\Omega_t \sim N(0,\sigma_t^2) \text{ or } \varepsilon_t\,|\Omega_t \sim TN(0,\sigma_t^2)$$

$$\mu_t = \beta_1 + (\beta_2 + \beta_3 Tor_{t-1} + \beta_4\sigma_{t-1} + \beta_5 Up_{t-1} + \beta_6 Lo_{t-1} + \beta_7 Up9_{t-1} + \beta_8 Lo9_{t-1})R_{t-1},$$
$$\sigma_t^2 = \beta_9 + \beta_{10}\varepsilon_{t-1}^2 + \beta_{11}\sigma_{t-1}^2 + \beta_{12}Up_{t-1} + \beta_{13}Lo_{t-1} + \beta_{14}Up9_{t-1} + \beta_{15}Lo9_{t-1},$$

where R_t is the daily stock return on day *t*. Tor_{t-1} is the daily negotiable turnover ratio on day *t-1*, which is measured by daily negotiable turnover divided by daily negotiable market value. Up_{t-1} ($Up9_{t-1}$) and Lo_{t-1} ($Lo9_{t-1}$) are upper (90% upper) and lower (90% lower) price limit hits dummy variables taking value of one on day *t* if a share hits the limit on day *t-1*.

	Modified-GARCH-M				Truncated-GARCH-M			
5% significant results								
SSE A (40)	PC	PR	VI	VD	PC	PR	VI	VD
Upper	23	0	4	5	22	0	17	3
Lower	12	0	7	3	9	0	15	0
SSE B (40)	PC	PR	VI	VD	PC	PR	VI	VD
Upper	23	0	7	10	21	0	15	2
Lower	9	2	4	7	4	0	7	3
1% significant results								
SSE A (40)	PC	PR	VI	VD	PC	PR	VI	VD
Upper	20	0	4	4	14	0	13	1
Lower	9	0	6	3	2	0	9	0
SSE B (40)	PC	PR	VI	VD	PC	PR	VI	VD
Upper	14	0	6	6	15	0	3	2
Lower	7	0	3	6	1	0	0	3
0.1% significant results								
SSE A (40)	PC	PR	VI	VD	PC	PR	VI	VD
Upper	12	0	4	3	6	0	1	0
Lower	4	0	4	1	0	0	3	0
SSE B (40)	PC	PR	VI	VD	PC	PR	VI	VD
Upper	9	0	6	6	5	0	0	1
Lower	5	0	1	4	0	0	0	2

[a] Detailed estimation results are shown in Appendix 2.8a, 2.8b, 2.8c and 2.8d

Note: The conditional standard deviation σ_{t-1} is replaced by the daily standard deviation $\sqrt{R_{t-1}^2}$ in the mean equation in order to make a comparison between results. In addition, the turnover ratio is added into variance equation. The results are similar and presented in Appendix 2.10 and 2.11.

Table 2.13 Models Estimation for AB-shares on the SZSE[a]

This table reports the number of stocks that show price continuation (PC), price reversal (PR), volatility increase (VI) and volatility decrease (VD) after price limits. There are 38 AB-shares on the SZSE. For upper price limit (PC): $\beta_2+\beta_5>0$ and $\beta_2+\beta_5>\beta_2+\beta_7$; (PR):$\beta_2+\beta_5<0$ and $\beta_2+\beta_5<\beta_2+\beta_7$; (VI): $\beta_{12}>0$ and $\beta_{12}>\beta_{14}$; (VD): $\beta_{12}<0$ and $\beta_{12}<\beta_{14}$. For lower price limit (PC): $\beta_2+\beta_6<0$ and $\beta_2+\beta_6<\beta_2+\beta_8$; (PR):$\beta_2+\beta_6>0$ and $\beta_2+\beta_6>\beta_2+\beta_8$; (VI): $\beta_{13}>0$ and $\beta_{13}>\beta_{15}$; (VD): $\beta_{13}<0$ and $\beta_{13}<\beta_{15}$. The signs '>' and '<' imply significant 'larger than' and 'smaller than'.

$$R_t=\mu_t+\varepsilon_t \quad \varepsilon_t\,|\Omega_t \sim N(0,\sigma_t^2) \text{ or } \varepsilon_t\,|\Omega_t \sim TN(0,\sigma_t^2)$$

$$\mu_t=\beta_1+(\beta_2+\beta_3 Tor_{t-1}+\beta_4\sigma_{t-1}+\beta_5 Up_{t-1}+\beta_6 Lo_{t-1}+\beta_7 Up9_{t-1}+\beta_8 Lo9_{t-1})R_{t-1}\,,$$
$$\sigma_t^2=\beta_9+\beta_{10}\varepsilon_{t-1}^2+\beta_{11}\sigma_{t-1}^2+\beta_{12}Up_{t-1}+\beta_{13}Lo_{t-1}+\beta_{14}Up9_{t-1}+\beta_{15}Lo9_{t-1}\,,$$

where R_t is the daily stock return on day *t*. Tor_{t-1} is the daily negotiable turnover ratio on day *t-1*, which is measured by daily negotiable turnover divided by daily negotiable market value. Up_{t-1} ($Up9_{t-1}$) and Lo_{t-1} ($Lo9_{t-1}$) are upper (90% upper) and lower (90% lower) price limit hits dummy variables taking value of one on day *t* if a share hits the limit on day *t-1*.

	Modified-GARCH-M				Truncated-GARCH-M			
5% significant results								
SZSE A (38)	PC	PR	VI	VD	PC	PR	VI	VD
Upper	20	0	10	2	17	0	15	1
Lower	12	1	4	1	7	1	11	0
SZSE B (38)	PC	PR	VI	VD	PC	PR	VI	VD
Upper	20	1	5	0	19	1	16	1
Lower	12	0	3	4	9	2	6	3
1% significant results								
SZSE A (38)	PC	PR	VI	VD	PC	PR	VI	VD
Upper	12	0	11	1	12	0	8	1
Lower	8	1	2	1	4	0	7	1
SZSE B (38)	PC	PR	VI	VD	PC	PR	VI	VD
Upper	14	1	3	0	10	0	4	1
Lower	9	0	2	3	6	2	2	2
0.1% significant results								
SZSE A (38)	PC	PR	VI	VD	PC	PR	VI	VD
Upper	7	0	10	1	7	0	2	0
Lower	6	0	2	1	1	0	1	1
SZSE B (38)	PC	PR	VI	VD	PC	PR	VI	VD
Upper	9	0	3	0	7	0	1	0
Lower	6	0	1	2	3	1	2	3

[a] Detailed estimation results are shown in Appendix 2.9a, 2.9b, 2.9c and 2.9d.

Note: The conditional standard deviation σ_{t-1} is replaced by the daily standard deviation $\sqrt{R_{t-1}^2}$ in the mean equation in order to make a comparison between results. In addition, the turnover ratio is added into variance equation. The results are similar and presented in Appendix 2.12 and 2.13.

Table 2.14 Summary of Tail Probability

This table summarises the computed tail probabilities on the days of upper (U) and lower (L) price-limit-hits. The vigintiles are reported. The explanation of the table entries is as follows. There are about 2000 upper price-limit-hits (details in the Appendix 2.1) in A-shares on the SSE and the tail probabilities are computed for each price-limit-hit. For the Truncated-GARCH model for upper price limits in SSE A, about 20% of the tail probabilities are greater than 0.52. That is, given 2000 upper price-limit-hits, there are about 400 times that the price has a probability of 0.52 of exceeding the restricted level.

	Modified-GARCH								Truncated-GARCH							
	SSEA		SSEB		SZSEA		SZSEB		SSEA		SSEB		SZSEA		SZSEB	
Vigintiles	U	L	U	L	U	L	U	L	U	L	U	L	U	L	U	L
5%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00
20%	0.00	0.00	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.01	0.01	0.00
25%	0.01	0.01	0.01	0.00	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.01	0.01	0.03	0.01	0.01
30%	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.03	0.03	0.02	0.02	0.06	0.03	0.03
35%	0.01	0.01	0.02	0.01	0.01	0.02	0.02	0.01	0.04	0.05	0.06	0.05	0.04	0.14	0.07	0.07
40%	0.02	0.02	0.02	0.01	0.02	0.02	0.02	0.02	0.06	0.09	0.10	0.10	0.06	0.22	0.15	0.12
45%	0.02	0.02	0.03	0.02	0.02	0.03	0.03	0.02	0.10	0.15	0.17	0.14	0.10	0.28	0.23	0.20
50%	0.03	0.02	0.04	0.03	0.03	0.03	0.04	0.03	0.14	0.24	0.24	0.20	0.18	0.35	0.30	0.26
55%	0.03	0.03	0.05	0.03	0.03	0.04	0.04	0.03	0.23	0.33	0.32	0.28	0.27	0.39	0.37	0.34
60%	0.04	0.03	0.06	0.04	0.04	0.05	0.05	0.04	0.31	0.40	0.38	0.34	0.36	0.43	0.43	0.41
65%	0.04	0.04	0.08	0.05	0.05	0.05	0.06	0.04	0.38	0.45	0.43	0.39	0.40	0.47	0.48	0.45
70%	0.05	0.05	0.10	0.06	0.06	0.06	0.08	0.05	***0.44***	***0.48***	***0.49***	***0.43***	***0.45***	***0.51***	***0.50***	***0.50***
75%	0.07	0.06	0.12	0.08	0.07	0.07	0.09	0.06	0.48	0.52	0.64	0.47	0.49	0.57	0.61	0.59
80%	0.09	0.09	0.15	0.09	0.09	0.10	0.11	0.07	**0.52**	0.59	0.77	0.53	0.53	0.62	0.74	0.68
85%	0.11	0.13	0.18	0.11	0.11	0.12	0.14	0.09	0.63	0.73	0.81	0.67	0.59	0.73	0.80	0.79
90%	0.17	0.16	0.21	0.14	0.16	0.14	0.15	0.12	0.80	0.84	0.86	0.76	0.69	0.84	0.92	0.89
95%	***0.27***	***0.22***	***0.26***	***0.17***	***0.24***	***0.17***	***0.18***	***0.15***	0.89	0.91	0.91	0.80	0.78	0.90	0.995	0.996

Note: Values are shown rounded to two decimal places.

Table 2.15 Goodness of Fit

This table reports the adjusted R-squared (R^2) and p-value of the overall F-test (PF) for the models. A small p-value of the F-test (PF) suggests that at least one of the coefficients' values is significantly different from 0. A summary statistics of R-squared values are reported at the end. Due to a large F-statistics, the respective p-value is approximately to equal to 0. In order to save space values are rounded to two decimal places only.

Modified GARCH-M								Truncated-GARCH-M							
SSE A (40)		SSE B (40)		SZSE A (38)		SZSE B (38)		SSE A (40)		SSE B (40)		SZSE A (38)		SZSE B (38)	
R^2	PF	R^2	PF	R^2	PF	R^2	PF	R^2	PF	R^2	PF	R^2	PF	R^2	PF
0.15	0.00	0.01	*0.07*	0.37	0.00	0.16	0.00	0.05	0.00	0.08	0.00	0.01	0.00	0.02	0.00
0.04	0.00	0.02	0.00	0.02	0.00	0.06	0.00	0.46	0.00	0.27	0.00	0.50	0.00	0.50	0.00
0.01	0.00	0.08	0.00	0.04	0.00	0.37	0.00	0.31	0.00	0.18	0.00	0.36	0.00	0.05	0.00
0.50	0.00	0.12	0.00	0.16	0.00	0.03	0.00	0.50	0.00	0.45	0.00	0.36	0.00	0.08	0.00
0.02	0.00	0.01	*0.01*	0.06	0.00	0.14	0.00	0.01	0.00	0.30	0.00	0.50	0.00	0.46	0.00
0.49	0.00	0.36	0.00	0.19	0.00	0.19	0.00	0.02	0.00	0.43	0.00	0.42	0.00	0.49	0.00
0.03	0.00	0.11	0.00	0.25	0.00	0.04	0.00	0.08	0.00	0.04	0.00	0.50	0.00	0.50	0.00
0.14	0.00	0.28	0.00	0.18	0.00	0.02	0.00	0.30	0.00	0.29	0.00	0.22	0.00	0.03	0.00
0.12	0.00	0.17	0.00	0.07	0.00	0.02	0.00	0.50	0.00	0.50	0.00	0.50	0.00	0.50	0.00
0.07	0.00	0.08	0.00	0.06	0.00	0.29	0.00	0.34	0.00	0.11	0.00	0.20	0.00	0.23	0.00
0.07	0.00	0.15	0.00	0.01	*0.01*	0.05	0.00	0.03	0.00	0.14	0.00	0.02	0.00	0.14	0.00
0.12	0.00	0.03	0.00	0.04	0.00	0.03	0.00	0.46	0.00	0.50	0.00	0.03	0.00	0.23	0.00
0.07	0.00	0.25	0.00	0.02	0.00	0.01	0.00	0.50	0.00	0.50	0.00	0.20	0.00	0.11	0.00
0.15	0.00	0.14	0.00	0.49	0.00	0.05	0.00	0.42	0.00	0.51	0.00	0.28	0.00	0.39	0.00
0.15	0.00	0.12	0.00	0.03	0.00	0.01	0.00	0.31	0.00	0.28	0.00	0.40	0.00	0.13	0.00
0.27	0.00	0.06	0.00	0.09	0.00	0.11	0.00	0.50	0.00	0.51	0.00	0.30	0.00	0.16	0.00
0.12	0.00	0.05	0.00	0.01	*0.02*	0.07	0.00	0.26	0.00	0.20	0.00	0.50	0.00	0.25	0.00
0.27	0.00	0.19	0.00	0.27	0.00	0.12	0.00	0.50	0.00	0.40	0.00	0.46	0.00	0.15	0.00
0.11	0.00	0.17	0.00	0.13	0.00	0.03	0.00	0.04	0.00	0.01	0.00	0.23	0.00	0.06	0.00
0.08	0.00	0.01	0.00	0.02	0.00	0.23	0.00	0.30	0.00	0.03	0.00	0.13	0.00	0.38	0.00
0.11	0.00	0.11	0.00	0.01	0.00	0.01	*0.06*	0.50	0.00	0.50	0.00	0.14	0.00	0.18	0.00
0.37	0.00	0.19	0.00	0.37	0.00	0.37	0.00	0.13	0.00	0.23	0.00	0.50	0.00	0.50	0.00
0.03	0.00	0.20	0.00	0.05	0.00	0.24	0.00	0.04	0.00	0.19	0.00	0.08	0.00	0.42	0.00
0.18	0.00	0.10	0.00	0.01	0.00	0.02	0.00	0.50	0.00	0.50	0.00	0.03	0.00	0.17	0.00
0.02	0.00	0.30	0.00	0.10	0.00	0.01	*0.11*	0.44	0.00	0.50	0.00	0.10	0.00	0.03	0.00
0.07	0.00	0.05	0.00	0.01	*0.01*	0.15	0.00	0.50	0.00	0.50	0.00	0.04	0.00	0.25	0.00
0.01	0.00	0.02	0.00	0.04	0.00	0.33	0.00	0.03	0.00	0.09	0.00	0.26	0.00	0.14	0.00
0.08	0.00	0.12	0.00	0.32	0.00	0.04	0.00	0.50	0.00	0.47	0.00	0.26	0.00	0.06	0.00
0.40	0.00	0.09	0.00	0.19	0.00	0.34	0.00	0.11	0.00	0.32	0.00	0.50	0.00	0.07	0.00
0.08	0.00	0.02	0.00	0.12	0.00	0.12	0.00	0.50	0.00	0.15	0.00	0.43	0.00	0.22	0.00
0.13	0.00	0.38	0.00	0.01	*0.03*	0.02	0.00	0.47	0.00	0.48	0.00	0.05	0.00	0.06	0.00
0.03	0.00	0.26	0.00	0.33	0.00	0.04	0.00	0.03	0.00	0.18	0.00	0.50	0.00	0.49	0.00
0.05	0.00	0.29	0.00	0.16	0.00	0.09	0.00	0.09	0.00	0.09	0.00	0.50	0.00	0.50	0.00
0.19	0.00	0.03	0.00	0.05	0.00	0.40	0.00	0.22	0.00	0.40	0.00	0.08	0.00	0.28	0.00
0.28	0.00	0.03	0.00	0.08	0.00	0.12	0.00	0.50	0.00	0.47	0.00	0.45	0.00	0.21	0.00
0.33	0.00	0.17	0.00	0.11	0.00	0.44	0.00	0.10	0.00	0.23	0.00	0.05	0.00	0.48	0.00
0.04	0.00	0.43	0.00	0.27	0.00	0.06	0.00	0.50	0.00	0.50	0.00	0.25	0.00	0.09	0.00
0.08	0.00	0.06	0.00	0.02	0.00	0.28	0.00	0.18	0.00	0.24	0.00	0.01	*0.13*	0.11	0.00
0.25	0.00	0.06	0.00					0.50	0.00	0.50	0.00				
0.03	0.00	0.26	0.00					0.50	0.00	0.50	0.00				

	Modified GARCH-M				Truncated-GARCH-M			
	SSE A	SSE B	SZSE A	SZSE B	SSE A	SSE B	SZSE A	SZSE B
Mean	0.14	0.14	0.13	0.13	0.31	0.32	0.27	0.24
SD	0.13	0.11	0.13	0.13	0.19	0.17	0.18	0.17
Min	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02
Q1	0.05	0.05	0.02	0.03	0.10	0.18	0.09	0.10
Median	0.11	0.12	0.08	0.08	0.33	0.31	0.26	0.20
Q3	0.18	0.19	0.19	0.22	0.50	0.50	0.46	0.41
Max	0.50	0.43	0.49	0.44	0.50	0.51	0.50	0.50

Table 2.16 Summary of Truncated-GARCH-M Model' Parameters

This table summarises the number of estimated parameters which are significant at 0.1%, 1% and 5% from the truncated-GARCH-M mode.

SSE (N=40)	β_1	β_2	β_3	β_4	β_5	β_6	β_7	β_8	β_9	β_{10}	β_{11}	β_{12}	β_{13}	β_{14}	β_{15}
5% significance results															
SSE A Total	1	5	19	10	22	10	1	9	39	39	39	20	15	12	10
Positive	1	1	0	9	22	10	0	8	39	39	39	17	15	2	3
Negative	0	4	19	1	0	0	1	1	0	0	0	3	0	10	7
SSE B Total	2	8	7	5	22	5	3	4	39	39	40	17	10	11	6
Positive	1	5	1	5	22	4	3	3	39	39	40	15	7	4	3
Negative	1	3	6	0	0	1	0	1	0	0	0	2	3	7	3
1% significance results															
SSE A Total	1	5	15	6	14	2	1	4	38	37	39	14	9	8	7
Positive	1	1	0	6	14	2	0	3	38	37	39	13	9	1	0
Negative	0	4	15	0	0	0	1	1	0	0	0	1	0	7	7
SSE B Total	1	2	3	4	15	2	1	3	39	39	40	5	3	7	4
Positive	0	1	0	4	15	1	1	2	39	39	40	3	0	2	1
Negative	1	1	3	0	0	1	0	1	0	0	0	2	3	5	3
0.1% significance results															
SSE A Total	0	4	8	4	6	0	1	2	33	36	39	1	3	6	6
Positive	0	1	0	4	6	0	0	2	33	36	39	1	3	0	0
Negative	0	3	8	0	0	0	1	0	0	0	0	0	0	6	6
SSE B Total	1	1	2	2	5	1	0	1	39	39	40	1	2	5	2
Positive	0	0	0	2	5	0	0	0	39	39	40	0	0	0	0
Negative	1	1	2	0	0	1	0	1	0	0	0	1	2	5	2

SZSE (N=38)	β_1	β_2	β_3	β_4	β_5	β_6	β_7	β_8	β_9	β_{10}	β_{11}	β_{12}	β_{13}	β_{14}	β_{15}
5% significant results															
SZSE A Total	3	3	16	7	18	8	3	4	35	35	38	17	12	5	14
Positive	3	2	0	6	18	7	1	0	35	35	38	16	11	2	4
Negative	0	1	16	1	0	1	2	4	0	0	0	1	1	3	10
SZSE B Total	4	6	6	4	21	11	3	4	37	37	38	17	11	6	14
Positive	4	4	0	3	20	9	1	1	37	37	38	16	6	1	3
Negative	0	2	6	1	1	2	2	3	0	0	0	1	5	5	11
1% significant results															
SZSE A Total	0	2	10	4	12	4	1	2	35	35	38	9	8	2	11
Positive	0	1	0	4	12	4	0	0	35	35	38	8	7	0	2
Negative	0	1	10	0	0	0	1	2	0	0	0	1	1	2	9
SZSE B Total	1	3	5	3	10	8	1	4	37	37	38	5	6	5	13
Positive	1	2	0	2	10	6	0	1	37	37	38	4	2	1	3
Negative	0	1	5	1	0	2	1	3	0	0	0	1	4	4	10
0.1% significance results															
SZSE A Total	0	0	4	1	7	1	1	0	31	35	38	2	2	1	6
Positive	0	0	0	1	7	1	0	0	31	35	38	2	1	0	1
Negative	0	0	4	0	0	0	1	0	0	0	0	0	1	1	5
SZSE B Total	1	2	3	1	7	4	1	2	37	37	38	1	6	3	9
Positive	1	1	0	1	7	3	0	1	37	37	38	1	2	1	1
Negative	0	1	3	0	0	1	1	1	0	0	0	0	4	2	8

Note: Detailed estimated parameters' values are shown in Appendix 2.8c, 2.8d, 2.9c and 2.9d.

Table 2.17 The Return of the Trading Strategy I

This table summarises the returns from the trading strategy when the forecasted tail probabilities are greater than 0.50. The explanation of the table entries, such as -4.22%, is as follows. The forecasted tail probability for stock 600610 at time T+1 is 0.9421, then buying the stock at the closing price at time T and selling it at the closing price at time T+1 generates a loss of 4.22%. The return is calculated as $\ln(P_{T+1}/P_T)$. Detailed results are reported in Appendix 2.14. The symbol '~' means do nothing.

	SSE A		SSE B					SZSE A		SZSE B			
T+1	-4.22	~	~	~	~	~	~	-2.58	~	~	~	~	~
T+2	~	~	~	~	~	~	~	~	~	0.99	~	~	~
T+3	9.55	4.97	3.52	3.29	4.06	4.32	8.35	2.02	6.61	2.54	-1.64	-0.21	9.52
T+4	-1.79	4.34	5.53	-3.77	1.24	3.04	~	~	~	-5.46	~	~	~
T+5	~	~	3.00	~	~	~	~	-1.22	~	-0.06	~	~	~
T+6	-4.94	~	~	~	~	~	~	~	~	~	~	~	~
T+7	~	~	~	~	~	~	~	0.06	~	~	~	~	~
T+8	1.47	-0.43	0.97	-0.20	~	~	~	~	~	~	~	~	~
T+9	-2.68	~	2.07	-1.29	~	~	~	~	~	~	~	~	~
T+10	~	~	-2.39	~	~	~	~	~	~	~	~	~	~
T+11	~	~	~	~	~	~	~	~	~	~	~	~	~
T+12	~	~	4.60	~	~	~	~	~	~	~	~	~	~
T+13	~	~	-2.12	-0.08	~	~	~	~	~	~	~	~	~
T+14	1.24	~	~	~	~	~	~	~	~	-0.85	~	~	~
T+15	~	~	-5.56	~	~	~	~	~	~	~	~	~	~
T+16	~	~	~	~	~	~	~	~	~	~	~	~	~
T+17	~	~	~	~	~	~	~	~	~	~	~	~	~
T+18	~	~	2.66	~	~	~	~	2.74	~	9.58	~	~	~
T+19	~	~	~	~	~	~	~	-0.18	~	-0.28	0	~	~
T+20	~	~	~	~	~	~	~	~	~	~	~	~	~
Total	7.51		31.25					7.46		14.14			

Table 2.18 Daily Values of the Trading Strategy

This table reports the daily values of the trading strategy up to 20 days.

Value on day *T* (V_T)	SSE A	SSE B	SZSE A	SZSE B	Total
V_1	94.44	100.00	96.07	100.00	390.51
V_2	94.44	100.00	96.07	99.58	390.09
V_3	***99.89***	***103.25***	***98.82***	***100.70***	***402.66***
V_4	99.76	103.35	98.82	93.87	395.80
V_5	99.76	104.96	96.24	92.51	393.47
V_6	93.51	104.96	96.24	92.51	387.22
V_7	93.52	104.96	94.96	92.51	385.95
V_8	92.69	103.90	94.96	92.51	384.06
V_9	88.95	102.85	94.96	92.51	379.27
V_{10}	88.96	98.98	94.96	92.51	375.41
V_{11}	88.96	98.98	94.96	92.51	375.41
V_{12}	88.97	102.09	94.96	92.51	378.53
V_{13}	88.97	99.56	94.96	92.51	376.00
V_{14}	88.82	99.56	94.96	90.44	373.78
V_{15}	88.82	92.72	94.96	90.44	366.94
V_{16}	88.83	92.72	94.96	90.44	366.95
V_{17}	88.84	92.72	94.96	90.44	366.96
V_{18}	88.84	93.86	96.21	97.72	376.63
V_{19}	88.85	93.86	94.69	96.23	373.63
V_{20}	88.85	93.86	94.69	96.23	373.63

Table 2.19 Values with Different Forecasted Tail Probabilities

This table repots the values for a 20-days investment with different forecasted tail probabilities, *P>0.6, P>0.7, P>0.8* and *P>0.9.*

	P>0.6					*P>0.7*					*P>0.8*					*P>0.9*				
	SSE A	SSE B	SZSE A	SZSE B	Total	SSE A	SSE B	SZSE A	SZSE B	Total	SSE A	SSE B	SZSE A	SZSE B	Total	SSE A	SSE B	SZSE A	SZSE B	Total
V_1	94.44	100.00	100.00	100.00	394.44	94.44	100.00	100.00	100.00	394.44	94.44	100.00	100.00	100.00	394.44	94.44	100.00	100.00	100.00	394.44
V_2	94.44	100.00	100.00	100.00	394.44	94.44	100.00	100.00	100.00	394.44	94.44	100.00	100.00	100.00	394.44	94.44	100.00	100.00	100.00	394.44
V_3	***94.44***	***103.93***	***105.13***	***101.12***	***404.62***	***94.44***	***103.93***	***105.13***	***104.55***	***408.05***	***94.44***	***104.85***	***100.00***	***107.99***	***407.29***	***94.44***	***106.84***	***100.00***	***107.99***	***409.28***
V_4	97.17	104.12	105.13	94.27	400.68	94.44	102.10	105.13	97.46	399.14	94.44	103.01	100.00	100.67	398.13	94.44	106.84	100.00	107.99	409.28
V_5	97.17	104.12	105.13	94.27	400.68	94.44	102.10	105.13	97.46	399.14	94.44	103.01	100.00	100.67	398.13	94.44	106.84	100.00	107.99	409.28
V_6	97.17	104.12	105.13	94.27	400.68	94.44	102.10	105.13	97.46	399.14	94.44	103.01	100.00	100.67	398.13	94.44	106.84	100.00	107.99	409.28
V_7	97.17	104.12	105.13	94.27	400.68	94.44	102.10	105.13	97.46	399.14	94.44	103.01	100.00	100.67	398.13	94.44	106.84	100.00	107.99	409.28
V_8	97.17	103.66	105.13	94.27	400.23	94.44	101.66	105.13	97.46	398.69	94.44	102.56	100.00	100.67	397.67	94.44	106.37	100.00	107.99	408.81
V_9	97.17	100.89	105.13	94.27	397.46	94.44	98.94	105.13	97.46	395.98	94.44	99.82	100.00	100.67	394.94	94.44	103.53	100.00	107.99	405.97
V_{10}	97.17	100.89	105.13	94.27	397.46	94.44	98.94	105.13	97.46	395.98	94.44	99.82	100.00	100.67	394.94	94.44	103.53	100.00	107.99	405.97
V_{11}	97.17	100.89	105.13	94.27	397.46	94.44	98.94	105.13	97.46	395.98	94.44	99.82	100.00	100.67	394.94	94.44	103.53	100.00	107.99	405.97
V_{12}	97.17	100.89	105.13	94.27	397.46	94.44	98.94	105.13	97.46	395.98	94.44	99.82	100.00	100.67	394.94	94.44	103.53	100.00	107.99	405.97
V_{13}	97.17	99.41	105.13	94.27	395.97	94.44	97.49	105.13	97.46	394.52	94.44	98.35	100.00	100.67	393.47	94.44	102.01	100.00	107.99	404.44
V_{14}	97.00	99.41	105.13	92.16	393.70	94.44	97.49	105.13	95.28	392.34	94.44	98.35	100.00	100.67	393.47	94.44	102.01	100.00	107.99	404.44
V_{15}	97.00	99.41	105.13	92.16	393.70	94.44	97.49	105.13	95.28	392.34	94.44	98.35	100.00	100.67	393.47	94.44	102.01	100.00	107.99	404.44
V_{16}	97.00	99.41	105.13	92.16	393.70	94.44	97.49	105.13	95.28	392.34	94.44	98.35	100.00	100.67	393.47	94.44	102.01	100.00	107.99	404.44
V_{17}	97.00	99.41	105.13	92.16	393.70	94.44	97.49	105.13	95.28	392.34	94.44	98.35	100.00	100.67	393.47	94.44	102.01	100.00	107.99	404.44
V_{18}	97.00	99.41	106.51	99.58	402.50	94.44	97.49	105.13	102.96	400.02	94.44	98.35	100.00	108.78	401.58	94.44	102.01	100.00	116.69	413.14
V_{19}	97.00	99.41	106.51	98.06	400.97	94.44	97.49	105.13	101.52	398.58	94.44	98.35	100.00	107.26	400.06	94.44	102.01	100.00	116.69	413.14
V_{20}	97.00	99.41	106.51	98.06	400.97	94.44	97.49	105.13	101.52	398.58	94.44	98.35	100.00	107.26	400.06	94.44	102.01	100.00	116.69	413.14

Figure 2.3 Autocorrelation Function

This figure plots the autocorrelation function for AB-shares on the SSE and SZSE. The numbers inside the figures denote the number of shares whose autocorrelation is beyond the 99% confidence interval.

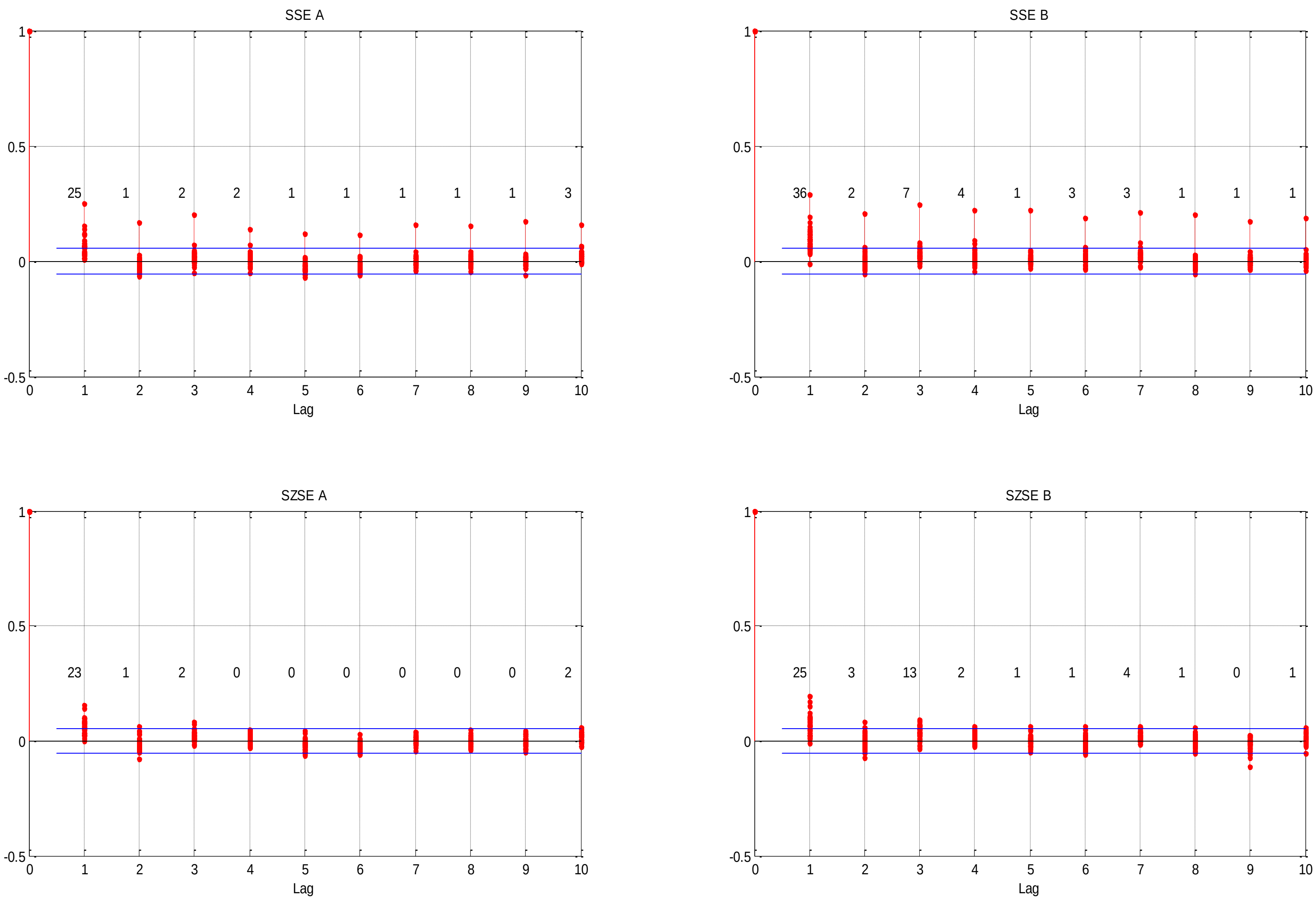


Table 2.20 The Return of the Trading Strategy II

Panel A summarises the returns from the trading strategy when the forecasted tail probabilities are greater than 0.50 and holding the shares for 3-days. The explanation of the table entries, such as 3.52%, is as follows. The forecasted tail probability for stock 900905 at time T+3 is 0.758, then buying the stock at the closing price ($Clsp_T$) at time T and generates a return of 3.52% (=ln(P_{T+1}/ P_T) at time T+1, 1.80% (= ln(P_{T+2}/ P_{T+1})) at time T+2 and -0.17% (= ln(P_{T+3}/ P_{T+2})) at time T+3. Detailed results are reported in Appendix 2.14. The symbol '~' means do nothing. Panel B summarises the returns from the trading strategy when the forecasted tail probabilities are greater than 0.90.

Panel A

SSE B	T+1	T+2	T+3	SZSE B	T+1	T+2	T+3
T=0	~	~	~	T=0	~	~	~
T=1	~	~	~	T=1	0.99	1.45	-3.36
T=2	3.52	1.80	-0.17	T=2	2.54	-1.90	1.27
T=2	3.29	-2.51	1.65	T=2	-1.64	0.07	3.54
T=2	4.06	-1.54	0.93	T=2	-0.21	0.62	2.55
T=2	4.32	-1.69	0.22	T=2	9.52	-5.46	-0.06
T=2	8.35	1.24	-2.63	T=3	~	~	~
T=3	5.53	3.00	-2.82	T=4	~	~	~
T=3	-3.77	0.00	-3.08	T=5	~	~	~
T=3	3.04	3.67	-4.04	T=6	~	~	~
T=4	~	~	~	T=7	~	~	~
T=5	~	~	~	T=8	~	~	~
T=6	~	~	~	T=9	~	~	~
T=7	0.97	2.07	-2.39	T=10	~	~	~
T=7	-0.20	0.00	-1.20	T=11	~	~	~
T=8	-1.29	-2.07	2.44	T=12	~	~	~
T=9	~	~	~	T=13	-0.85	-2.60	0.87
T=10	~	~	~	T=14	~	~	~
T=11	~	~	~	T=15	~	~	~
T=12	-0.08	6.25	-5.56	T=16	~	~	~
T=13	~	~	~	T=17	9.58	0.00	-1.82
T=14	~	~	~				
T=15	~	~	~				
T=16	~	~	~				
T=17	2.66	-1.66	-0.92				

Panel B

SSE B	T+1	T+2	T+3	SZSE B	T+1	T+2	T+3
T=0	~	~	~	T=0	~	~	~
T=1	~	~	~	T=1	~	~	~
T=2	8.35	1.24	-2.63	T=2	9.52	-5.46	-0.06
T=3	~	~	~	T=3	~	~	~
T=4	~	~	~	T=4	~	~	~
T=5	~	~	~	T=5	~	~	~
T=6	~	~	~	T=6	~	~	~
T=7	0.97	2.07	-2.39	T=7	~	~	~
T=8	-1.29	-2.07	2.44	T=8	~	~	~
T=9	~	~	~	T=9	~	~	~
T=10	~	~	~	T=10	~	~	~
T=11	~	~	~	T=11	~	~	~
T=12	-0.08	6.25	-5.56	T=12	~	~	~
T=13	~	~	~	T=13	~	~	~
T=14	~	~	~	T=14	~	~	~
T=15	~	~	~	T=15	~	~	~
T=16	~	~	~	T=16	~	~	~
T=17	~	~	~	T=17	9.58	0.00	-1.82

Appendix 2.1 The Number of Missing Values and Price-Limit-Hits of AB-Shares on the SSE

This table reports the numbers of missing values and price-limits-hits for AB-shares during the sample period 2004-2012 on the SSE. A percentage of missing value based on the total 2187 observations is calculated. The number of days between adjacent limit-hits is also reported.

SSE 44 A-Shares						SSE 44 B-Shares					
Company Code	Missing value	Percentage	Upper	Lower	Days Between[b]	Company Code	Missing value	Percentage	Upper	Lower	Days Between[b]
600054	48	2%	4	3	197	900942	19	1%	5	5	151
600094[a]	*916*	*42%*	*83*	*60*	3	*900940*[a]	*869*	*40%*	*58*	*54*	2
600190	73	3%	18	14	35	900952	45	2%	12	9	79
600221	110	5%	30	17	20	900945	47	2%	26	14	43
600272	89	4%	57	32	13	900943	30	1%	28	25	2
600295	72	3%	20	16	38	900936	44	2%	12	9	29
600320	65	3%	12	2	68	900947	37	2%	18	6	72
600555	88	4%	27	22	43	900955	58	3%	26	14	36
600602	170	8%	30	14	5	900901	134	6%	22	19	5
600604[a]	*109*	*5%*	*103*	*78*	6	*900902*[a]	*71*	*3%*	*73*	*82*	7
600610	201	9%	127	111	5	900906	29	1%	96	84	3
600611	51	2%	27	12	13	900903	10	0%	18	7	20
600612	82	4%	31	7	29	900905	41	2%	16	7	56
600613	295	13%	89	40	8	900904	246	11%	64	27	3
600614	105	5%	121	49	2	900907	51	2%	84	40	1
600617[a]	*391*	*18%*	*89*	*76*	9	*900913*[a]	*242*	*11%*	*97*	*57*	4
600618	53	2%	56	26	11	900908	21	1%	20	18	5
600619	57	3%	36	24	28	900910	23	1%	14	12	11
600623	68	3%	52	22	10	900909	27	1%	23	18	5
600639	45	2%	15	11	90	900911	15	1%	12	8	117
600648	141	6%	50	16	18	900912	105	5%	18	12	26
600650	71	3%	10	8	89	900914	47	2%	8	3	157
600663	43	2%	24	10	27	900932	12	1%	12	11	100
600679	56	3%	60	35	13	900916	22	1%	34	19	5
600680	76	3%	43	23	21	900930	24	1%	16	13	13
600689	76	3%	49	27	21	900922	28	1%	26	26	33
600695	242	11%	133	77	3	900919	54	2%	94	72	3
600698[a]	*436*	*20%*	*175*	*135*	4	*900946*[a]	*374*	*17%*	*130*	*130*	6
600726	66	3%	20	6	37	900937	25	1%	15	6	23
600751	220	10%	177	153	4	900938	198	9%	133	141	3
600754	73	3%	8	12	114	900934	33	2%	9	5	56
600776	46	2%	45	30	8	900941	23	1%	28	24	18
600801	62	3%	35	7	29	900933	35	2%	24	15	28
600818	46	2%	54	26	10	900915	14	1%	34	15	23
600819	56	3%	37	22	14	900918	14	1%	18	15	0
600822	60	3%	26	17	42	900927	17	1%	13	6	50
600827	126	6%	12	10	100	900923	89	4%	16	3	69
600835	52	2%	14	10	40	900925	19	1%	14	7	30
600841	150	7%	48	24	14	900920	115	5%	21	14	6
600843	58	3%	36	28	33	900924	25	1%	24	23	5
600844	271	12%	120	74	3	900921	219	10%	108	75	2
600845	46	2%	34	8	28	900926	14	1%	16	10	6
600848	135	6%	107	52	4	900928	36	2%	89	45	3
600851	49	2%	44	25	10	900917	12	1%	30	24	3
	Total		2388	1471			Total		1654	1229	

[a] 600094 (900940), 600604 (900902), 600617 (900913) and 600698 (900946) are deleted

[b] Median value is reported.

Appendix 2.2 The Number of Missing Values and Price-Limit-Hits of AB-Shares on the SZSE

This table reports the numbers of missing values and price-limits-hits for AB-shares during the sample period 2004-2012 on the SZSE. A percentage of missing value based on the total 2187 observations is calculated. The number of days between adjacent limit-hits is also reported.

SZSE 42 A-Shares						SZSE 42 B-Shares					
Company Code	Missing value	Percentage	Upper	Lower	Days Between[b]	Company Code	Missing value	Percentage	Upper	Lower	Days Between[b]
000002	55	3%	15	8	27	200002	25	1%	17	11	23
000011	204	9%	82	63	2	200011	54	2%	77	53	5
000012	81	4%	25	14	45	200012	42	2%	12	10	58
000016	61	3%	8	7	99	200016	25	1%	8	9	30
000017[a]	*840*	*38%*	*121*	*113*	4	*200017*[a]	*75*	*3%*	*231*	*187*	3
000018	95	4%	90	77	13	200018	30	1%	68	65	11
000019	209	10%	39	30	23	200019	189	9%	13	10	0
000020	219	10%	110	116	5	200020	81	4%	106	98	4
000022[a]	*75*	*3%*	*9*	*2*	113	*200022*[a]	*20*	*1%*	*2*	*2*	335
000024	74	3%	17	14	26	200024	44	2%	6	5	72
000025	86	4%	94	57	9	200025	60	3%	71	49	9
000026	85	4%	17	11	76	200026	17	1%	20	10	45
000028	57	3%	11	5	204	200028	28	1%	8	3	74
000029	62	3%	44	20	32	200029	29	1%	23	13	30
000030[a]	*832*	*38%*	*184*	*145*	2	*200030*[a]	*341*	*16%*	*235*	*176*	2
000037	89	4%	31	14	42	200037	55	3%	14	8	56
000039	88	4%	14	7	70	200039	70	3%	5	3	87
000045	73	3%	40	18	21	200045	30	1%	15	9	41
000055	57	3%	37	29	25	200055	32	1%	18	14	91
000056	132	6%	58	43	13	200056	95	4%	44	33	15
000058[a]	*419*	*19%*	*90*	*80*	6	*200058*[a]	*398*	*18%*	*48*	*64*	6
000413	137	6%	82	42	7	200413	102	5%	55	32	7
000418	114	5%	30	11	41	200418	91	4%	16	10	8
000429	185	8%	4	7	43	200429	137	6%	5	4	8
000488	78	4%	11	9	83	200488	44	2%	11	5	74
000505	189	9%	163	130	4	200505	162	7%	122	88	6
000513	202	9%	17	11	31	200513	73	3%	11	4	8
000521	75	3%	21	11	28	200521	38	2%	22	13	14
000530	91	4%	28	10	25	200530	70	3%	7	7	81
000539	157	7%	11	8	101	200539	115	5%	6	1	17
000541	84	4%	13	10	48	200541	31	1%	5	6	163
000550	56	3%	19	8	75	200550	27	1%	8	3	276
000553	109	5%	42	24	11	200553	83	4%	17	14	15
000570	49	2%	36	22	19	200570	20	1%	17	12	26
000581	47	2%	22	16	43	200581	19	1%	11	8	159
000596	200	9%	97	45	2	200596	169	8%	67	26	3
000613	156	7%	162	170	2	200613	62	3%	195	177	2
000625	179	8%	26	10	15	200625	157	7%	21	9	4
000725	106	5%	75	57	3	200725	80	4%	56	49	4
000726	92	4%	19	13	14	200726	54	2%	8	8	23
000761	70	3%	25	12	51	200761	37	2%	6	3	30
000869	53	2%	8	4	123	200869	27	1%	5	3	125
	Total		2047	1503			Total		1712	1314	

[a] 000017 (200017), 000022(200022), 000030 (200030) and 000058 (200058) are deleted.
[b] Median value is reported.

Appendix 2.3 Tests for the Imputation for AB-shares on the SSE

This table reports the p-values of the two-sample Kolmogorov-Smirnov (KS) test and two-sample t-test (Ttest). The null hypothesis of KS test is that the newly generated data (return) and original data are from the same continuous distribution. The null hypothesis of Ttest is that mean and variance of the newly generated data are not significantly different from those of original data. As the newly generated data are repeated for 100 times, the mean and median values are shown. The number of p-values which is greater than 0.10 is also reported.

		KS			Ttest				KS			Ttest	
A-shares	Mean	Median	P>0.10	Mean	Median	P>0.10	B-Shares	Mean	Median	P>0.10	Mean	Median	P>0.10
600054	1.00	1.00	100	0.94	0.95	100	900942	1.00	1.00	100	0.95	0.96	100
600190	1.00	1.00	100	0.93	0.94	100	900952	1.00	1.00	100	0.93	0.94	100
600221	1.00	1.00	100	0.91	0.93	100	900945	1.00	1.00	100	0.93	0.94	100
600272	1.00	1.00	100	0.93	0.94	100	900943	1.00	1.00	100	0.95	0.96	100
600295	1.00	1.00	100	0.92	0.93	100	900936	1.00	1.00	100	0.94	0.96	100
600320	1.00	1.00	100	0.89	0.90	100	900947	1.00	1.00	100	0.93	0.94	100
600555	1.00	1.00	100	0.92	0.92	100	900955	1.00	1.00	100	0.92	0.94	100
600602	1.00	1.00	100	0.86	0.88	100	900901	1.00	1.00	100	0.89	0.90	100
600610	1.00	1.00	100	0.82	0.85	100	900906	1.00	1.00	100	0.94	0.95	100
600611	1.00	1.00	100	0.95	0.96	100	900903	1.00	1.00	100	0.98	0.98	100
600612	1.00	1.00	100	0.92	0.93	100	900905	1.00	1.00	100	0.94	0.95	100
600613	*0.00*	*0.00*	*0*	*0.17*	*0.12*	*55*	*900904*	*0.00*	*0.00*	*0*	*0.16*	*0.09*	*44*
600614	1.00	1.00	100	0.90	0.91	100	900907	1.00	1.00	100	0.94	0.95	100
600618	1.00	1.00	100	0.93	0.94	100	900908	1.00	1.00	100	0.96	0.97	100
600619	1.00	1.00	100	0.94	0.94	100	900910	1.00	1.00	100	0.95	0.96	100
600623	1.00	1.00	100	0.93	0.93	100	900909	1.00	1.00	100	0.95	0.96	100
600639	1.00	1.00	100	0.94	0.95	100	900911	1.00	1.00	100	0.96	0.97	100
600648	1.00	1.00	100	0.89	0.90	100	900912	1.00	1.00	100	0.89	0.91	100
600650	1.00	1.00	100	0.91	0.92	100	900914	1.00	1.00	100	0.92	0.92	100
600663	1.00	1.00	100	0.94	0.95	100	900932	1.00	1.00	100	0.97	0.97	100
600679	1.00	1.00	100	0.92	0.93	100	900916	1.00	1.00	100	0.95	0.96	100
600680	1.00	1.00	100	0.93	0.95	100	900930	1.00	1.00	100	0.95	0.96	100
600689	1.00	1.00	100	0.93	0.95	100	900922	1.00	1.00	100	0.95	0.96	100
600695	1.00	1.00	100	0.86	0.87	100	900919	1.00	1.00	100	0.94	0.95	100
600726	1.00	1.00	100	0.92	0.93	100	900937	1.00	1.00	100	0.95	0.95	100
600751	1.00	1.00	100	0.80	0.83	100	900938	0.99	1.00	100	0.75	0.77	100
600754	1.00	1.00	100	0.92	0.92	100	900934	1.00	1.00	100	0.94	0.95	100
600776	1.00	1.00	100	0.94	0.94	100	900941	1.00	1.00	100	0.95	0.96	100
600801	1.00	1.00	100	0.95	0.96	100	900933	1.00	1.00	100	0.95	0.95	100
600818	1.00	1.00	100	0.94	0.96	100	900915	1.00	1.00	100	0.97	0.97	100
600819	1.00	1.00	100	0.92	0.93	100	900918	1.00	1.00	100	0.96	0.96	100
600822	1.00	1.00	100	0.93	0.95	100	900927	1.00	1.00	100	0.96	0.96	100
600827	1.00	1.00	100	0.90	0.91	100	900923	1.00	1.00	100	0.92	0.93	100
600835	1.00	1.00	100	0.94	0.95	100	900925	1.00	1.00	100	0.96	0.97	100
600841	1.00	1.00	100	0.90	0.90	100	900920	1.00	1.00	100	0.89	0.91	100
600843	1.00	1.00	100	0.93	0.94	100	900924	1.00	1.00	100	0.95	0.96	100
600844	0.97	1.00	100	0.70	0.70	100	900921	0.98	1.00	100	0.71	0.71	100
600845	1.00	1.00	100	0.94	0.96	100	900926	1.00	1.00	100	0.97	0.97	100
600848	1.00	1.00	100	0.91	0.92	100	900928	1.00	1.00	100	0.94	0.95	100
600851	1.00	1.00	100	0.93	0.94	100	900917	1.00	1.00	100	0.96	0.97	100

Appendix 2.4 Tests for the Imputation for AB-shares on the SZSE

This table reports the p-values of the two-sample Kolmogorov-Smirnov (KS) test and two-sample t-test (Ttest). The null hypothesis of KS test is that the newly generated data (return) and original data are from the same continuous distribution. The null hypothesis of Ttest is that mean and variance of the newly generated data are not significantly different from those of original data. As the newly generated data are repeated for 100 times, the mean and median values are shown. The number of p-values which is greater than 0.10 is also reported.

	KS			Ttest				KS			Ttest		
A-shares	Mean	Median	P>0.10	Mean	Median	P>0.10	B-shares	Mean	Median	P>0.10	Mean	Median	P>0.10
000002	1.00	1.00	100	0.92	0.94	100	200002	1.00	1.00	100	0.95	0.96	100
000011	1.00	1.00	100	0.87	0.88	100	200011	1.00	1.00	100	0.93	0.93	100
000012	1.00	1.00	100	0.92	0.93	100	200012	1.00	1.00	100	0.94	0.95	100
000016	1.00	1.00	100	0.95	0.95	100	200016	1.00	1.00	100	0.95	0.96	100
000018	1.00	1.00	100	0.90	0.92	100	200018	1.00	1.00	100	0.95	0.96	100
000019	*0.00*	*0.00*	*0*	*0.73*	*0.73*	*100*	*200019*	*0.00*	*0.00*	*0*	*0.64*	*0.65*	*100*
000020	1.00	1.00	100	0.88	0.90	100	200020	1.00	1.00	100	0.90	0.91	100
000024	1.00	1.00	100	0.92	0.93	100	200024	1.00	1.00	100	0.92	0.93	100
000025	1.00	1.00	100	0.91	0.93	100	200025	1.00	1.00	100	0.92	0.93	100
000026	1.00	1.00	100	0.92	0.94	100	200026	1.00	1.00	100	0.96	0.96	100
000028	1.00	1.00	100	0.93	0.94	100	200028	1.00	1.00	100	0.94	0.95	100
000029	1.00	1.00	100	0.93	0.93	100	200029	1.00	1.00	100	0.94	0.95	100
000037	1.00	1.00	100	0.91	0.92	100	200037	1.00	1.00	100	0.92	0.93	100
000039	1.00	1.00	100	0.89	0.91	100	200039	1.00	1.00	100	0.91	0.92	100
000045	1.00	1.00	100	0.91	0.92	100	200045	1.00	1.00	100	0.94	0.95	100
000055	1.00	1.00	100	0.94	0.95	100	200055	1.00	1.00	100	0.95	0.97	100
000056	1.00	1.00	100	0.89	0.91	100	200056	1.00	1.00	100	0.92	0.93	100
000413	1.00	1.00	100	0.91	0.93	100	200413	1.00	1.00	100	0.90	0.91	100
000418	1.00	1.00	100	0.90	0.92	100	200418	1.00	1.00	100	0.90	0.92	100
000429	1.00	1.00	100	0.86	0.87	100	200429	1.00	1.00	100	0.88	0.91	100
000488	1.00	1.00	100	0.91	0.92	100	200488	1.00	1.00	100	0.93	0.94	100
000505	1.00	1.00	100	0.86	0.88	100	200505	1.00	1.00	100	0.88	0.91	100
000513	1.00	1.00	100	0.86	0.88	100	200513	1.00	1.00	100	0.90	0.91	100
000521	1.00	1.00	100	0.93	0.93	100	200521	1.00	1.00	100	0.94	0.95	100
000530	1.00	1.00	100	0.92	0.93	100	200530	1.00	1.00	100	0.92	0.94	100
000539	1.00	1.00	100	0.88	0.89	100	200539	1.00	1.00	100	0.90	0.92	100
000541	1.00	1.00	100	0.93	0.94	100	200541	1.00	1.00	100	0.95	0.96	100
000550	1.00	1.00	100	0.92	0.93	100	200550	1.00	1.00	100	0.94	0.95	100
000553	1.00	1.00	100	0.90	0.91	100	200553	1.00	1.00	100	0.91	0.93	100
000570	1.00	1.00	100	0.95	0.96	100	200570	1.00	1.00	100	0.96	0.96	100
000581	1.00	1.00	100	0.94	0.96	100	200581	1.00	1.00	100	0.96	0.96	100
000596	1.00	1.00	100	0.86	0.87	100	200596	1.00	1.00	100	0.88	0.90	100
000613	1.00	1.00	100	0.88	0.89	100	200613	1.00	1.00	100	0.92	0.93	100
000625	1.00	1.00	100	0.88	0.91	100	200625	1.00	1.00	100	0.87	0.90	100
000725	1.00	1.00	100	0.88	0.89	100	200725	1.00	1.00	100	0.89	0.90	100
000726	1.00	1.00	100	0.91	0.92	100	200726	1.00	1.00	100	0.93	0.94	100
000761	1.00	1.00	100	0.93	0.94	100	200761	1.00	1.00	100	0.94	0.95	100
000869	1.00	1.00	100	0.93	0.94	100	200869	1.00	1.00	100	0.94	0.95	100

Appendix 2.5 Derivation of the Log-Likelihood Function

Truncated Normal Distributions

The return r is truncated at the lower (L) and upper limits (U) so that $L \leq r \leq U$. The probability density function (pdf) of return is now

$$\frac{1}{\sqrt{2\pi\sigma^2}} exp\left\{-\frac{1}{2\sigma^2}(r-\mu)^2\right\}\left[\frac{1}{\sqrt{2\pi\sigma^2}}\int_L^U exp\left\{-\frac{1}{2\sigma^2}(r-\mu)^2\right\}dr\right]^{-1} \qquad (A)$$

Equation (A) in a simple form is:

$$\frac{f(r)}{\{F(U)-F(L)\}} \qquad (B)$$

where $f(r)$ is probability density function. $F(r)$ is cumulative distribution function.

Then the log-likelihood function ($logL$) is

$$logL = \sum_{t=1}^{n} logf(r_t) - nlog\{F(U)-F(L)\} \qquad (C)$$

Now, there are nl values which are truncated at the lower limit and nu at the upper limit. In this case the log-likelihood function is

$$logL = \sum_{t=1}^{n'} logf(r_t) - n' \, log\{F(U)-F(L)\} + nl \cdot logF(L) + nu \cdot log\{1-F(U)\} \qquad (D)$$

$$n' + nl + nu = T$$

$$\Pr(r_i = L) = \Pr(r_i \leq L) = F(L)$$

The contribution to the log-likelihood of the values truncated below L is $nl \cdot logF(L)$

$$\Pr(r_i = U) = \Pr(r_i \geq U) = 1 - F(U)$$

The contribution to the log-likelihood of the values truncated above U is $nu \cdot log\{1-F(U)\}$

Equation (D) in an obvious notation is

$$logL = \sum_{t=1}^{n'} log\{\emptyset(r_t, \mu, \sigma^2)\} - n'\log\{\Phi\left(\frac{U-\mu}{\sigma}\right) - \Phi\left(\frac{L-\mu}{\sigma}\right)\} + nl \cdot log\{\Phi\left(\frac{L-\mu}{\sigma}\right)\}$$

$$+ nu \cdot log\{1 - \Phi\left(\frac{U-\mu}{\sigma}\right)\} \qquad (E)$$

Equation (E) assumes lower, truncated and upper parts of data have a constant mean and variance. However, according to the Equation (2), mean and variance are time-varying.

$$\mu_t = \beta_1 + (\beta_2 + \beta_3 Tor_{t-1} + \beta_4 \sigma_{t-1} + \beta_5 Up_{t-1} + \beta_6 Lo_{t-1} + \beta_7 Up9_{t-1} + \beta_8 Lo9_{t-1})R_{t-1} \,,$$

$$\sigma_t^2 = \beta_9 + \beta_{10}\varepsilon_{t-1}^2 + \beta_{11}\sigma_{t-1}^2 + \beta_{12} Up_{t-1} + \beta_{13} Lo_{t-1} + \beta_{14} Up9_{t-1} + \beta_{15} Lo9_{t-1}$$

In this case the log-likelihood function is

$$logL = \sum_{t'=1}^{n'} \log\{\emptyset(r_{t'}, \mu_{t'}, \sigma_{t'}^2)\} - \sum_{t'=1}^{n'} \log\{\Phi\left(\frac{U_{t'}-\mu_{t'}}{\sigma_{t'}}\right) - \Phi\left(\frac{L_{t'}-\mu_{t'}}{\sigma_{t'}}\right)\} + \sum_{tl=1}^{nl} \log\{\Phi\left(\frac{L_{tl}-\mu_{tl}}{\sigma_{tl}}\right)\}$$

$$+ \sum_{tu=1}^{nu} \log\{1 - \Phi\left(\frac{U_{tu}-\mu_{tu}}{\sigma_{tu}}\right)\}$$

Appendix 2.6 Log-likelihood Ratio Statistics I

This table reports the log-likelihood (LL) ratio statistics among the OLS, modified-GARCH-M (MGM) and truncated-GARCH-M (TGM). The log-likelihood (LL) ratio statistics are equal to $LL1=2*(LL_{MGM}-LL_{OLS})$, $LL2=2*(LL_{TGM}-LL_{OLS})$ and $LL3=2*(LL_{TGM}-LL_{MGM})$ which follow chi-squared distributions.

A-shares	LL1	LL2	LL3	B-Shares	LL1	LL2	LL3
600054	220.10	608.61	388.50	900942	412.99	741.39	328.40
600190	528.42	712.30	183.88	900952	465.40	559.74	94.35
600221	346.31	471.02	124.70	900945	366.83	417.85	51.01
600272	33.38	1405.07	1371.69	900943	624.70	741.50	116.79
600295	351.07	412.08	61.01	900936	355.01	399.83	44.82
600320	173.31	1363.19	1189.88	900947	257.20	1419.07	1161.88
600555	311.47	895.87	584.40	900955	586.10	1235.91	649.81
600602	212.91	327.89	114.98	900901	530.96	714.54	183.58
600610	178.94	848.28	669.34	900906	321.76	725.34	403.58
600611	708.57	1000.91	292.35	900903	680.92	1068.72	387.80
600612	167.19	355.80	188.62	900905	310.35	511.05	200.70
600613	162.47	872.07	709.60	*900904*	395.52	1061.70	666.18
600614	248.53	1295.37	1046.84	900907	458.83	1111.70	652.87
600618	205.26	354.25	148.99	900908	435.19	503.16	67.96
600619	176.43	414.06	237.63	900910	451.11	599.30	148.19
600623	343.30	565.27	221.97	900909	537.19	617.85	80.66
600639	398.06	518.35	120.30	900911	429.96	496.08	66.12
600648	276.19	453.43	177.24	900912	622.93	670.40	47.48
600650	315.37	431.97	116.60	900914	442.01	465.60	23.59
600663	410.62	459.20	48.59	900932	448.84	470.57	21.74
600679	116.60	453.83	337.24	900916	459.41	554.02	94.61
600680	219.92	478.61	258.69	900930	491.41	532.09	40.68
600689	187.77	355.57	167.80	900922	379.90	462.13	82.23
600695	131.65	1101.68	970.03	900919	325.32	707.68	382.36
600726	307.69	442.60	134.91	900937	576.47	607.19	30.72
600751	21.77	2864.82	2843.06	900938	117.43	1402.30	1284.87
600754	356.43	447.50	91.08	900934	461.01	466.41	5.40
600776	478.49	976.65	498.17	900941	582.75	1157.41	574.66
600801	86.50	620.60	534.10	900933	527.11	1018.92	491.81
600818	322.54	615.28	292.75	900915	567.66	688.90	121.25
600819	149.12	674.19	525.07	900918	497.64	877.66	380.03
600822	168.54	394.93	226.39	900927	335.04	630.58	295.54
600827	239.22	462.16	222.94	900923	393.19	514.58	121.39
600835	224.50	495.41	270.92	900925	417.83	531.44	113.61
600841	144.27	634.86	490.59	900920	588.55	920.74	332.19
600843	216.36	599.44	383.07	900924	383.07	514.88	131.81
600844	1.87	2051.12	2049.25	900921	3.74	1716.39	1712.65
600845	134.84	436.57	301.74	900926	505.37	711.61	206.24
600848	323.08	920.56	597.48	900928	469.99	756.04	286.05
600851	109.43	1343.29	1233.87	900917	289.20	1140.66	851.46

A-shares	LL1	LL2	LL3	B-Shares	LL1	LL2	LL3
000002	334.15	1016.21	682.06	200002	287.12	1006.32	719.20
000011	68.57	1445.15	1376.58	200011	231.36	515.00	283.64
000012	57.62	720.08	662.46	200012	78.24	876.70	798.46
000016	372.23	927.70	555.47	200016	342.45	1039.46	697.00
000018	232.84	757.53	524.69	200018	392.37	692.40	300.04
000019	153.98	430.06	276.08	*200019*	250.82	290.73	39.92
000020	-4.14	2220.57	2224.71	200020	122.66	582.84	460.18
000024	338.78	626.23	287.45	200024	337.91	536.61	198.70
000025	259.77	746.35	486.58	200025	367.89	596.29	228.41
000026	130.09	521.06	390.97	200026	196.98	482.49	285.51
000028	168.24	178.80	10.56	200028	178.37	180.18	1.81
000029	122.24	239.07	116.83	200029	256.71	297.46	40.75
000037	174.98	305.12	130.13	200037	206.66	205.59	-1.06
000039	5.24	899.54	894.30	200039	10.99	1028.87	1017.88
000045	84.85	584.23	499.37	200045	134.44	538.68	404.24
000055	121.00	569.34	448.34	200055	140.09	494.82	354.73
000056	162.53	456.85	294.32	200056	270.89	429.10	158.21
000413	199.14	611.93	412.78	200413	249.14	413.99	164.85
000418	220.20	595.56	375.37	200418	288.86	560.64	271.78
000429	425.41	561.26	135.85	200429	393.97	397.85	3.88
000488	356.98	723.87	366.89	200488	160.53	578.58	418.05
000505	377.67	1163.03	785.36	200505	367.53	1023.34	655.81
000513	271.56	305.51	33.95	200513	426.32	444.10	17.78
000521	117.26	288.45	171.19	200521	234.99	360.77	125.79
000530	212.61	328.12	115.51	200530	212.54	199.79	-12.75
000539	375.84	482.38	106.54	200539	319.26	322.43	3.18
000541	301.07	1083.90	782.84	200541	395.87	1163.39	767.52
000550	167.85	213.05	45.20	200550	148.78	143.61	-5.16
000553	539.89	1066.82	526.94	200553	830.38	1034.17	203.79
000570	444.81	689.73	244.92	200570	403.07	559.18	156.11
000581	247.32	436.02	188.70	200581	177.52	249.19	71.67
000596	329.18	1236.73	907.55	200596	183.48	1048.45	864.97
000613	73.09	2351.29	2278.20	200613	138.84	1385.33	1246.49
000625	83.77	771.20	687.43	200625	68.40	727.25	658.85
000725	218.06	1132.13	914.07	200725	180.01	889.64	709.64
000726	639.34	861.46	222.12	200726	988.92	1147.28	158.36
000761	284.14	404.51	120.37	200761	334.35	371.56	37.21
000869	253.37	657.23	403.86	200869	269.41	719.73	450.32

Appendix 2.7 Log-likelihood Ratio Statistics II

This table reports the log-likelihood (LL) ratio statistics for the truncated-GARCH-M presented in equation (2.9) and (2.8). The log-likelihood (LL) ratio statistics are equal to $LLs=2*(LL_{eq9}-LL_{eq8})$ which follows a chi-squared distribution.

A-shares	LLs	B-Shares	LLs	A-shares	LLs	B-Shares	LLs
600054	11.71	900942	-1.12	000002	17.80	200002	4.43
600190	4.11	900952	14.83	000011	5.88	200011	11.86
600221	12.94	900945	3.39	000012	7.32	200012	6.42
600272	41.34	900943	9.99	000016	1.76	200016	3.31
600295	16.72	900936	9.95	000018	3.19	200018	23.98
600320	1.11	900947	2.61	*000019*	13.43	*200019*	2.41
600555	10.56	900955	3.68	000020	-89.49	200020	34.97
600602	1.91	900901	6.22	000024	21.86	200024	1.01
600610	-84.16	900906	35.64	000025	36.14	200025	18.49
600611	25.59	900903	8.41	000026	4.20	200026	3.14
600612	6.39	900905	10.97	000028	2.68	200028	7.40
600613	17.00	*900904*	13.34	000029	3.35	200029	5.58
600614	7.33	900907	4.68	000037	2.94	200037	2.45
600618	6.48	900908	12.82	000039	2.39	200039	3.40
600619	4.41	900910	9.44	000045	3.55	200045	3.29
600623	16.13	900909	24.88	000055	3.17	200055	7.18
600639	8.37	900911	6.84	000056	14.94	200056	3.48
600648	3.87	900912	23.97	000413	11.03	200413	7.60
600650	11.21	900914	18.19	000418	11.63	200418	1.02
600663	17.31	900932	0.66	000429	1.71	200429	13.68
600679	10.48	900916	20.81	000488	2.74	200488	5.47
600680	7.82	900930	4.53	000505	747.51	200505	-21.25
600689	60.94	900922	23.78	000513	19.30	200513	11.15
600695	8.61	900919	27.70	000521	2.26	200521	5.23
600726	4.35	900937	1.94	000530	7.40	200530	5.72
600751	-54.76	900938	-149.27	000539	8.47	200539	-0.04
600754	8.24	900934	2.64	000541	9.52	200541	17.45
600776	11.18	900941	8.45	000550	5.02	200550	2.83
600801	1.57	900933	4.17	000553	46.33	200553	14.40
600818	18.48	900915	6.09	000570	1.39	200570	14.69
600819	34.69	900918	4.62	000581	12.76	200581	0.92
600822	2.87	900927	-0.87	000596	3.08	200596	1.89
600827	1.48	900923	6.35	000613	-126.55	200613	442.12
600835	16.52	900925	5.48	000625	-0.23	200625	0.18
600841	52.06	900920	30.79	000725	10.01	200725	4.95
600843	2.75	900924	22.39	000726	14.60	200726	8.40
600844	15.64	900921	41.86	000761	17.79	200761	3.80
600845	2.19	900926	6.85	000869	3.92	200869	2.06
600848	67.98	900928	39.34				
600851	73.82	900917	24.01				

Appendix 2.8a Detailed Estimation Results for Modified-GARCH-M on the SSE A-shares

β_1	β_2	β_3	β_4	β_5	β_6	β_7	β_8	β_9	β_{10}	β_{11}	β_{12}	β_{13}	β_{14}	β_{15}
-0.01	0.11	0.31	-0.04	0.15	0.36	-0.24	0.14	0.11***	0.09***	0.91***	-5.5	-3.76	-11.53***	-1.75
-0.06	-0.03	-1.45	0.02	0.19	0.18	-0.31	-0.08	0.02**	0.05***	0.95***	1.32	-0.02	-4.50**	-1.92
-0.05	-0.02	1.5	0	-0.03	0.16	-0.27	-0.16	0.08***	0.05***	0.94***	0.23	2.97	-2.01	-2.09
-0.26**	-0.45***	0.16	0.11***	0	0.04	-0.04	0.06	1.09***	0.11***	0.89***	-7.22***	-11.58***	-16.01***	-15.92***
-0.03	0.11	-0.31	-0.01	0.14	-0.02	0.04	0.15	0.13***	0.07***	0.92***	2.64	-0.94	-8.80***	-2.23
-0.18***	0.42***	2.84**	-0.04**	0.21	-0.27	-0.22	-0.42	3.98***	0.70***	0.30***	-32.27***	-3.71	-9.26	-10.73
-0.07	0.13	-2.77***	0	0.20**	-0.01	-0.2	-0.25	0.81***	0.11***	0.83***	-1.04	43.79***	-8.18	-10.10***
-0.09	-0.09	-2.10***	0.04	0.20***	0.33***	-0.17	-0.07	0.18***	0.05***	0.93***	-0.06	2.45	-1.73	0.07
-0.03	-0.02	-1.17***	0.03	0.28***	0.33***	-0.05	0.03	0.20***	0.05***	0.93***	-0.28	-0.1	-0.89	-1.5
-0.06	0.03	-1.26	0.01	0.13	0.15	0.15	0.08	0.02***	0.04***	0.96***	0.64	6.61***	-1.27	-2.65**
-0.01	0.09	-0.25	-0.02	0.15	-0.2	-0.12	0.42***	0.73***	0.08***	0.85***	2.76	4.4	-13.12***	0.83
0.09	0.13	-1.35***	-0.03	0.33***	0.36***	0	0.1	0.40***	0.06***	0.92***	0.01	-2.70***	0.52	-1.08
0.05	0.12	-1.75**	0	0.31***	0.28***	-0.45**	0.01	1.44***	0.15***	0.71***	24.91***	-1.37	-4.9	-9.04***
-0.05	-0.04	-1.35	0.03	0.22***	0.11	0.03	-0.16	0.54***	0.10***	0.86***	-0.67	-3.77	-1.58	-2.79
-0.03	0.18	-1.78***	-0.04	0.20***	0.22**	-0.12	0.05	0.53***	0.07***	0.88***	0.5	3.77	0.12	-2.2
-0.04	-0.11	-1.26**	0.04	0.22***	0.09	0.1	0.03	0.27***	0.10***	0.89***	-0.71	2.29	-7.51***	-5.80**
-0.05	-0.1	-0.54	0.03	0.1	0.05	0.06	-0.08	0.11***	0.07***	0.92***	-0.38	-1.05	-5.49**	1.68
-0.04	-0.12	-1.03	0.05	0.23***	-0.01	0.21	-0.05	0.35***	0.09***	0.89***	-0.54	-4.84	-2.51	3.1
-0.01	0.12	0.53	-0.04	0.09	-0.17	0.09	-0.25	0.22***	0.10***	0.88***	-7.70***	-4.88	0.91	5.72
-0.06	-0.05	-0.66	0.02	0.29***	0.04	0.02	-0.09	0.11***	0.04***	0.94***	2.45	2.13	2.11	-1.74
-0.05	0.24	-1.32**	-0.03	0.29***	0.12	0.02	-0.09	0.58***	0.07***	0.90***	0.37	-1.92	-2.96	-1.37
-0.02	0.30***	-0.28	-0.07***	0.22***	0.05	-0.06	0.01	0.26***	0.10***	0.90***	-4.08***	-3.76	-2.92	-5.84**
0.01	0.07	-1.67***	-0.01	0.20***	0.09	-0.04	0.19	0.41***	0.06***	0.91***	-1.47	2.64	-5.88	-4.22
0.01	0.23	-1.14**	-0.05	0.14***	0.37***	0.06	-0.08	0.16***	0.03***	0.96***	-0.2	0.57	-1.52	-1.81***
-0.03	0.04	0.61	-0.01	0.14	0.27	-0.28	-0.51**	0.76***	0.20***	0.71***	-9.15***	6.55	-20.45***	-2.55
0.08	0.06	-1.59	0	0.34	0.32***	-0.48***	0.09	6.74***	0.13***	0.04	45.36***	1.69	-1.8	-0.76
0	0.05	-1.15	0	0.03	0.23***	0.3	0.34**	0.04***	0.05***	0.95***	-5.15***	-1.12	-3.45	-5.13**
-0.04	0.05	-1.84***	0.01	0.27***	0.21**	-0.53	0.02	0.43***	0.13***	0.84***	0.68	-1.26	73.26***	-3.14
0.04	0.33**	-5.50***	-0.03	0.26**	0.15	0.25	0.18	1.15***	0.23***	0.75***	-13.94***	-17.17**	-18.59***	-13.58**
-0.05	0.01	-1.11	0.01	0.28***	0.19	-0.13	0.19	0.26***	0.11***	0.88***	-2.48**	-3.62***	-1.53	0.91
-0.07	0.04	-1.13	0.03	0.09	-0.08	-0.38**	0.03	0.69***	0.03***	0.90***	3.44	7.91**	-0.56	2.14
-0.06	0.09	-1.85***	-0.01	0.1	0.14	0.17	0.31***	0.19***	0.05***	0.93***	-3.72***	0.12	-10.41***	7.07***
-0.04	0.11	-1.69**	-0.02	0.38***	-0.02	0.14	-0.07	0.11***	0.07***	0.93***	-2.1	0.86	-8.93***	-5.08
-0.04	-0.1	-2.54***	0.05	0.25	-0.12	0.17	-0.1	0.03**	0.01***	0.99***	-0.53	3.50***	0.35	-3.13***
-0.04	-0.15	-0.78**	0.05	0.28***	0.21**	0.06	0.18	0.31***	0.02***	0.96***	-0.23	7.70***	-3.05	-2
-0.02	0.21**	-0.33	-0.05**	0.1	0.23***	-0.44***	-0.11	5.26***	0.46***	0.26***	-17.22**	-19.78***	-24.79***	-43.41***
-0.15	0.04	-0.51	0	0.34***	0.25	0.02	-0.14	13.49***	0.06**	0	-2.53	96.87***	-9.58**	-5.47
0.05	0.01	-3.61***	0.03	0.24**	-0.16	0.03	-0.22	0.72***	0.05***	0.86***	10.42***	6.97	-2.43	1.6
0	-0.05	-1.67**	0.03	0.36***	0.21***	-0.29	0.16	0.29***	0.09***	0.89***	-0.26	-2.34***	1.24	-2.71**
-0.08	0.11	-0.48	-0.01	0.30***	0.21**	-0.23	-0.04	0.48***	0	0.95***	4.77***	8.63***	3.35	1.2

Note: ***(**) means the coefficients are significant at 1% (5%) level.

Appendix 2.8b Detailed Estimation Results for Modified-GARCH-M on the SSE B-shares

β_1	β_2	β_3	β_4	β_5	β_6	β_7	β_8	β_9	β_{10}	β_{11}	β_{12}	β_{13}	β_{14}	β_{15}
0.04	0.01	-1.17	0	0.11	-0.3	0.14	-0.24**	0.05***	0.03***	0.96***	32.26***	-9.77***	1.3	7.49***
-0.02	0.01	-0.83	0.01	0.15	-0.07	-0.07	-0.15	0.22***	0.16***	0.83***	-3.63**	-11.37***	4.68	-9.10**
0.03	0.14	-0.29	-0.03	0.05	0.11	-0.05	-0.1	0.35***	0.12***	0.85***	-7.25***	-3.83	0.43	-3.84
-0.01	0.1	-1.09	-0.02	0.48***	0.18**	0.1	-0.08	0.21***	0.08***	0.89***	5.71	2.57	1.03	-2.23
0.05	0.06	-2.95	0	0.2	0.09	0.26	-0.18	0.42***	0.14***	0.81***	8.34	-1.01	2.46	-7.34
-0.06	0.05	3.55	-0.02	0.01	-0.36**	-0.03	-0.01	0.76***	0.14***	0.86***	-10.72***	-15.51***	-9.81***	-16.84***
0.06	0.08	-3.75	-0.01	-0.06	0.64	0.08	-0.18	0.96***	0.31***	0.68***	-20.46***	119.18***	-4	-24.84***
-0.02	0	-12.96***	0.03	0.44***	0.28***	0.4	0.15	0.32***	0.18***	0.80***	-5.92***	-7.59**	3.49	-12.79***
-0.04	0.20**	0.7	-0.06	0.33***	0.30***	0.16	0.07	0.38***	0.12***	0.83***	0.48	0.1	-0.03	-0.13
-0.08**	0.08	-0.04	-0.01	0.06	-0.04	-0.07	-0.1	0.29***	0.12***	0.84***	5.43	0.72	1.63	8.32
-0.01	0.21**	-3.51	-0.05	0.37***	-0.23	0.15	-0.22	0.38***	0.14***	0.82***	1.76	-2.88	-5.03	-2.63
0.11	0.08	-0.41	0	0.24**	0.07	0.14	-0.11	1.09***	0.18***	0.72***	8.21***	1.38	-9.15***	0.76
-0.02	0.08	-2.27	0.02	0.31**	0.14	0.11	-0.24	0.55***	0.15***	0.79***	12.59***	-2.24	-4.08**	0.79
-0.01	0.09**	2.85	-0.03***	0.70***	0.05	0	-0.04	0.70***	0.13***	0.77***	-1.87***	1.81	14.16**	17.79
0	0.04	2.59	-0.03	0.2	-0.13	-0.03	0.12	0.31***	0.11***	0.84***	1.13	-6.19**	-8.02**	15.64**
0	0.05	1.73	-0.02	0.46***	0.07	0.19	-0.05	0.35***	0.13***	0.82***	3.1	-5.13	9.32	-2.48
0.05	0.04	-7.77	0.02	0.24	-0.12	-0.16	-0.16	0.38***	0.18***	0.78***	-6.63**	-11.01***	-7.85	-13.15***
-0.02	-0.04	-2.77	0.03	0.42***	0.11	0.04	-0.22	0.18***	0.08***	0.89***	3.62	2.13	-3.6	-0.61
0.03	0.17**	-5.68	-0.05	0.2	-0.32	0.17	0.1	0.22***	0.12***	0.84***	-2.65	-4.31	1.2	8.55
0.02	0.11	0.27	-0.01	0.14	-0.05	-0.02	-0.08	0.38***	0.19***	0.78***	-0.38	-10.99***	-14.16***	-9.06
-0.01	0.12	3.29	-0.03	0.29**	-0.05	-0.03	-0.14	0.51***	0.11***	0.83***	4.37	3.21	-1.8	-3.39
0	0.11	2.36	-0.04	0.3	0.19**	0.13	0.14	0.30***	0.11***	0.85***	6.29	-2.1	-3.16	6.76
0.01	0.15	-0.54	-0.04	0.28***	0.22***	0.05	0.08	0.39***	0.09***	0.87***	-2.95	1.59	9.68**	-2.43
-0.01	0.11	-2.98	-0.05	0.49***	0.27***	-0.08	-0.07	0.31***	0.08***	0.86***	0.48	0.63	-0.13	1.32
-0.05	0.17**	0.23	-0.08**	0.24**	0.31	0.94	0.04	0.31***	0.18***	0.78***	-6.84**	-8.86	-6.1	-2.84
0.01	0.04	0.05	0	0.34***	0.26***	-0.1	0.13	1.61***	0.05	0.62***	7.72***	3.93***	-0.57	0.34
0.09**	0.12	-5.15	-0.01	0.18	0.12	0.02	-0.02	0.18***	0.16***	0.82***	1.05	-11.10***	1.07	-2.36
-0.08	-0.03	-4.08	0.01	0.30***	0.14***	0.18	-0.01	0.36***	0.20***	0.80***	-7.86***	-3.74***	0.53	1.21
0.1	0.24***	-8.03***	0	0.12	0.04	-0.1	-0.23	1.03***	0.35***	0.65***	-14.22**	-8.77	-9.24	-23.29***
0	0.07	-0.59	0	0.19**	-0.1	-0.02	-0.03	0.25***	0.12***	0.86***	-1.66	-1.24	-1.06	-4.55**
0.07	0.16**	0.11	-0.04	0.48**	0.11	-0.22	-0.02	0.66***	0.33***	0.67***	0.88	-15.95	2.69	-14.96***
0.04	0.11	0.62	-0.04	0.35**	-0.02	0.1	0.14	0.52***	0.21***	0.77***	-4.54	-17.87***	-6.36	-0.1
0.01	0.17**	-2.66	-0.04	0.24**	0.59	-0.07	-0.02	0.31***	0.13***	0.83***	0.65	100.74**	-17.27***	-4.2
-0.01	0.08	-5.03	0.01	0.33***	-0.36**	0.22	-0.26	0.06***	0.04***	0.95***	0.79	-2.52	1.8	2.73
0.03	0.09	3.06	0	0.32**	-0.05	0	-0.35***	0.25***	0.15***	0.84***	4.34	-7.56	8.12	-7.44**
-0.02	0.06	4.79	-0.03	0.15	0.04	0	-0.01	0.54***	0.15***	0.79***	13.08**	-1.5	-17.03***	-8.80***
-0.05	-0.40**	-1.95**	0.14***	0.39***	0.31***	0.14	0.11	0.25***	0	0.98***	0.71***	-0.34	-4.01***	-3.09***
0.02	0.1	1.66	-0.02	0.33	0.21	-0.03	-0.35	0.27***	0.20***	0.80***	1.18	-1.45	-14.94**	-10.32**
0.01	0.06	-2.96**	0.01	0.30***	0.15**	0.2	0.12	0.23***	0.08***	0.89***	1.11	-0.03	-2.82**	-1.39
-0.01	0.1	0.48	-0.02	0.21**	-0.01	-0.02	0.34***	0.23***	0	0.95***	6.13***	29.61***	5.78***	3.75

Note: ***(**) means the coefficients are significant at 1% (5%) level.

Appendix 2.8c Detailed Estimation Results for Truncated-GARCH-M on the SSE A-shares

β_1	β_2	β_3	β_4	β_5	β_6	β_7	β_8	β_9	β_{10}	β_{11}	β_{12}	β_{13}	β_{14}	β_{15}
0.01	0.09	-0.32	-0.03	0.21	0.39**	-0.3	0.17	0.05***	0.03***	0.96***	1.08	1.38	-4.54***	4.53
-0.04	-0.08	-2.2	0.04	0.31***	0.29	-0.34	-0.23	0.05***	0.08***	0.92***	-2.11	73.24***	-3.65	-9.76***
-0.02	-0.1	1.47	0.03	-0.07	0.24	-0.32	-0.36	0.10***	0.07***	0.92***	5.43	36.83***	-1.01	9.51
0.1	0.07	-1.13	0.01	0.14	0.03	487.09	0.25**	0.95***	0.13***	0.80***	17.86***	-9.11	44225	-11.13***
-0.02	0.07	-0.24	0	0.28	-0.1	0.04	0.23	0.13***	0.08***	0.91***	12.97***	9.71	-10.93***	2.95
-0.01	0.04	-0.44	0	0.32**	0.42	-0.06	-0.49	0.22***	0.10***	0.88***	-6.62**	36.25	3.15	18.29**
-0.08	0.1	-3.68***	0.01	0.22***	0.23	-0.2	-0.21	0.09***	0.06***	0.94***	0.83	4.4	-1.81	-6.94***
-0.04	-0.08	-2.63***	0.04	0.28***	0.62**	-0.19	-0.2	0.25***	0.06***	0.91***	5.52***	28.44***	-2.01	3.19
-0.09	-0.25	-0.87	0.09**	8.31***	6.62**	-2.64	-0.11	1.87***	0.04**	0.77***	613.23***	910.70**	203.08	-15.85***
-0.04	-0.02	-1.91***	0.04	0.34***	0.18	0.2	0.05	0.03***	0.06***	0.94***	3.8	2.11	-0.64	3.87
0.03	0.04	-0.6	0	0.28**	-0.38	-0.14	0.61***	0.59***	0.10***	0.84***	12.24***	1.6	-14.46***	7.72
0.29***	0.09	-2.14**	0	4.23***	1.57**	0.01	0.03	2.72***	0.16***	0.65***	558.18**	119.17	52.54	111.66
0.08	0.03	-0.6	0.02	11.86***	12.38***	-1.37	0.31***	2.97***	0.27***	0.48***	1406.56	1091.89	93.37	-29.77***
-0.01	-0.09	-1.92	0.05	0.40**	0.09	0.07	-0.41	0.73***	0.17***	0.80***	18.88**	1.23	0.64	26.41
0.01	0.12	-1.91**	-0.02	0.65	1.04**	-0.04	0.12	1.49***	0.14***	0.72***	79.66***	102.35**	-18.85***	2.48
0.04	-0.13	-1.89**	0.04**	0.36**	0.18	0.11	0.18	0.39***	0.16***	0.83***	18.61***	289.69**	-9.84**	-8.47
-0.04	-0.11	-0.83	0.03	0.1	-0.27	0.08	-0.21	0.12***	0.08***	0.91***	2.88	34.03**	-5.42	12.10**
0	-0.24***	-1.91	0.08***	0.31	-0.26	0.17	-8.2	1.15***	0.20***	0.72***	20.93**	13.24	8.84	2959.7
0.01	0.05	0.2	-0.01	0.11	-0.3	0.28	-0.35	0.17***	0.06***	0.92***	-3.43**	-2.47	59.29***	15.42**
-0.06	-0.08	-2.14	0.04	0.43**	-0.08	-0.02	-0.13	0.12***	0.05***	0.93***	9.05***	22.38***	4.19	-1.72
0.07	0.36***	-3.01***	-0.04**	1242.49	8.75	13.92	42.11	9.68***	0.51***	0.02	110417.7	36653.51	12210.78	12591.03
0.01	0.15	-1.13***	-0.02	0.36***	0.1	0.03	-0.01	0.38***	0.14***	0.85***	-2.86	29.30**	-4.14	3.98
0.05	0.02	-2.07***	0.01	0.27***	0.12	-0.15	0.19	0.12***	0.01**	0.97***	3.55***	7.51***	2.95	1.44
0.03	-0.15	-3.26***	0.07***	0.2	21.7	1.69	0.04	0.90***	0.05***	0.85***	4.83	15737.5	340.15	1.48
-0.06	-0.04	-0.67	0.03	0.25***	1.37	-0.28	-1.08***	0.53***	0.15***	0.78***	-4.15	220.21	-16.55***	15.94
-9.67	32.64	-1135.37	0.05	68.08	63.71	-99	-12.95	257.29	0	1.00***	-376.43	-271.19	-63.04	-8.53
0.01	0.02	-1.52	0.01	0.02	0.30***	0.31	0.38**	0.03***	0.06***	0.94***	-5.28***	0.69	-2.75	-4.72
-0.01	-0.02	-3.16***	0.04	0.72**	0.75	-0.49	-0.02	0.65***	0.23***	0.75***	74.73***	616.18	6.7	-5.26
0.09	0.12	-4.67***	0.01	0.36***	0.12	0.32	0.24	0.20***	0.06***	0.93***	1.58	-2.18	1.45	1.56
-0.01	-0.27***	-4.13***	0.12***	0.12	0.18	-1.67	25.13**	0.42***	0.16***	0.82***	-0.18	-2.35	185.59	3159.67
-0.06	-0.07	-1.68	0.06**	0.09	-0.43	-0.32	0.14	0.24***	0.15***	0.85***	12.19**	67.01***	-8.56**	-5.17
-0.03	0.09	-2.18***	-0.01	0.15	0.18	0.17	0.22**	0.35***	0.10***	0.88***	-2.65	2.8	-17.66***	0.87
-0.04	0.13	-0.13	-0.03	0.45***	0	0.06	-0.1	0.10***	0.06***	0.93***	0.37	8.01**	-7.09**	-1.37
-0.01	-0.08	-2.22**	0.05	0.27	-0.26	0.13	-0.11	0.03**	0.03***	0.96***	1.83	3.47	-1.45	0.48
0.09	-0.33***	-1.40***	0.10***	0.34***	2.97	0.19	0.54***	0.65***	0.09***	0.85***	6.27***	1887.52	-10.14***	-17.79***
0.03	0.12	-0.09	-0.02	0.16	0.38**	-0.16	-0.15	0.25***	0.07***	0.91***	1	15.69***	8.32**	-6.25
0.03	0.15	-2.15	-0.01	23.57	21.91	-2.27	-22.15	2.48***	0.25***	0.56***	5688.05	15781	3107.25	6029.09
0.03	-0.05	-3.27***	0.04	0.35***	-0.33	-0.01	-0.59	0.11***	0.06***	0.93***	1.07	2.83	-2.89	17.43
0.05	-0.43***	-7.26***	0.17***	1.16**	19.04**	0.51	13.82**	1.08***	0.20***	0.72***	61.84***	1543.98***	58.17	557.24
-0.06	-0.02	-3.86***	0.07***	0.44**	1.48**	-56.27***	-0.06	0.02***	0.11***	0.89***	11.99***	126.67***	6013.42	-7.27***

Note: ***(**) means the coefficients are significant at 1% (5%) level.

Appendix 2.8d Detailed Estimation Results for Truncated-GARCH-M on the SSE B-shares

β_1	β_2	β_3	β_4	β_5	β_6	β_7	β_8	β_9	β_{10}	β_{11}	β_{12}	β_{13}	β_{14}	β_{15}
0.07	0.02	0.27	0	-0.12	-1.58	0.11	-0.2	0.23***	0.18***	0.79***	-7.32	54.36	4.36	5.35
0.01	-0.05	-7.44***	0.04	0.13	-0.12	-0.02	-0.24	0.23***	0.17***	0.82***	-1.87	-11.64***	13.31**	-6.84
0.05	0.17**	0.25	-0.03	0.06	0.22	0.02	-0.16	0.38***	0.16***	0.82***	-8.14***	7.74	3.1	-1
0.01	0.08	-4.15	0	4.75***	0.44	0.19	-0.16	0.55***	0.16***	0.77***	286.04	47.20**	8.01	4.62
0.06	0.13	-2.81	-0.03	1.02	0.23	0.73	-0.2	0.52***	0.17***	0.76***	74.67**	13.62	30.22	-7.37
0.02	0.12	7.66	-0.03	-0.01	-1.21	-0.03	-0.14	0.65***	0.13***	0.79***	6.66	75.97**	4.33	-3.88
-0.03	0.05	-7.18	0	-0.02	0.14	0.44	-0.2	0.26***	0.16***	0.84***	-6.27	-4.56	27.37**	-12.86***
0	0.07	-20.31***	0.01	0.63***	0.48**	1.15**	0.33***	0.34***	0.22***	0.78***	-2.66	11.36	51.61	-14.82***
-0.02	-0.05	7.95	0.03	9.56	7.27	4.62	8.4	2.47***	0.33***	0.38***	2423.51	2857.49	2590.16	5443.82
0.02	0.07	-3.02	0.01	0.27	-0.14	0.01	-0.18	0.18***	0.12***	0.85***	0.93	6.5	1.19	65.97***
0.05	0.21**	-5.52	-0.03	0.59***	-0.29	0.26	-0.31	0.30***	0.14***	0.83***	9.39	2.53	-0.66	2.19
0.08	-0.08	0.91	0.03**	5.82***	0.2	-0.01	-0.37	1.93***	0.28***	0.54***	287.82**	136.89	-15.14***	90.71
0.01	0.05	-3.55	0.04	14.62**	7.5	16.61	-8.79	2.04***	0.33***	0.43***	1020.11	1962.17	2020.12	3566.09
0.02	-0.09	-7.56	0.05	1.77**	-0.02	0.03	-0.09	0.67***	0.16***	0.76***	75	-1.27	15.25	19
0.02	-0.08	0.87	0.03	0.38	-0.23	-0.03	-0.19	0.49***	0.17***	0.77***	30.11**	-6.81	-10.91**	30.15
0.02	-0.08	-4.06	0.04	2.45***	0	0.47	-0.16	0.50***	0.20***	0.76***	97.98	-11.3	40.52	10.42
0.06	-0.03	-11.27**	0.05	0.32	-0.19	-0.19	-0.16	0.35***	0.19***	0.78***	3.51	0.52	-3.77	-13.33***
-0.03	-0.16**	0.17	0.06***	0.64***	-0.12	-0.06	-0.25	0.30***	0.14***	0.81***	3.18	2.41	0.55	0.41
0.03	0.07	-7.85**	0	0.22	-0.45	0.22	0	0.17***	0.11***	0.86***	-2.31	-3.65	7.14	-0.1
0.06	0.12**	-2.78	-0.01	0.27	0.02	-0.01	0.81***	0.48***	0.21***	0.73***	2.86	1.02	0.55	0.4
0	-0.07	-0.65	0.04	1.82***	-0.5	-0.05	-0.21	1.01***	0.20***	0.69***	140.25**	78.56**	1.3	-11.27
0.01	0.05	2.74	-0.02	1.14**	0.24	0.15	0.31	0.37***	0.14***	0.81***	55.27**	-0.2	-3.07	34.93
0.02	0.01	-1.74	0.01	0.38***	0.32**	0.42	0.13	0.55***	0.14***	0.81***	-5.16	12.72**	130.22***	-5.03
0.02	-0.06	-8.74	0.04	9.73**	12.78**	-0.07	-0.85	1.08***	0.17***	0.63***	1284.11	2132.88	-5.19	292.34
-0.03	-0.22***	0.89	0.07***	0.25	-0.29	4.93***	0.18	0.45***	0.28***	0.70***	0.04	6.5	7.39	3.1
-3.79	1.87	-321.46	0.11	38.42	9.61	-3.65	7.92	62.81	0	1.00***	-161.48	-69.9	162.39	-99.96
0.09**	0.08	-8.18**	0.02	0.24	0.14	0.07	-0.21	0.19***	0.18***	0.81***	10.35**	-12.57***	5.67	3.73
-0.02	-0.04	-3.53	0.04	0.15	-0.09	0.58	-0.3	0.30***	0.19***	0.80***	-7.02***	12.79**	106.54	52.08
0.08	0.01	0.22	0.02	0.64***	0.80***	0.2	-0.13	0.24***	0.09***	0.88***	15.25***	26.01**	-1.77	-1.59
-0.20***	0.13***	2.56	0.01	0.09	-0.54***	0.26	-1.26***	0.33***	0.16***	0.80***	1.64	0.51	0.33	0.55
0.04	0.13	-6.37	-0.01	6.75**	0.08	-0.12	-0.01	0.61***	0.18***	0.72***	436.1	6.63	28.74***	3.53
0.03	0.09	-0.4	-0.03	1.01***	-0.07	0.2	0.2	0.64***	0.15***	0.76***	29.66**	-3.87	4.2	12.91**
0.03	0.15**	-6.11	-0.02	0.63**	0.05	-0.17	-0.04	0.47***	0.18***	0.76***	32.97**	-26.53***	-20.84***	-3.85
0.03	0.08	-4.06	0.01	0.80***	-5.64	0.35	-0.48	0.46***	0.11***	0.81***	18.73**	463	13.61	20.56**
0.03	0.01	1.87	0.01	1.61***	0.19	4.08	-0.42	0.41***	0.14***	0.80***	34.46**	13.34	467.22	-0.08
-0.04	-0.05	8.67**	0	1.22***	0.01	-0.16	0.01	0.54***	0.17***	0.78***	59.70***	11.98	-19.75***	-8.92
-0.02	-0.15**	-17.66***	0.12***	2.41**	1.81	0.62**	-0.17	0.57***	0.14***	0.79***	305.32**	157.89**	-9.39	2.12
0.03	0.06	-1.14	0.01	0.97***	0.45	-0.07	-0.55	0.23***	0.14***	0.84***	22.71***	30.87	-14.05**	5.97
0.05	-0.12	-4.72	0.08***	2.03***	1.26	0.13	0.24	1.13***	0.32***	0.62***	239.60**	248.52	-9.56***	5.35
-0.02	-0.05	-2.72	0.03	1.78	-0.08	-0.11	2.73**	0.88***	0.28***	0.65***	459.91	13.86	-21.29***	264.2

Note: ***(**) means the coefficients are significant at 1% (5%) level.

Appendix 2.9a Detailed Estimation Results for Modified-GARCH-M on the SZSE A-Shares

β_1	β_2	β_3	β_4	β_5	β_6	β_7	β_8	β_9	β_{10}	β_{11}	β_{12}	β_{13}	β_{14}	β_{15}
0.04	-0.09	-3.39	0.05	0.14	-0.54***	0.05	0.04	0.19***	0.09***	0.91***	6.43***	10.12**	-9.14***	-8.97***
0.03	0.07	-0.75**	0	0.19***	0.25***	0	-0.16	0.93***	0.07***	0.84***	0.58	-0.06	2.05	-1.7
0	0.06	-1.23**	0.01	0.25	0.1	0.15	-0.14	0.37***	0	0.95***	6.62***	20.06***	4.34**	21.29***
-0.01	-0.02	-1.75**	0.03	0.08	-0.36	-0.04	0.06	0.17***	0.01***	0.96***	23.67***	3.58	5.96	-3.32***
0.04	0.14	-1.26	-0.03	0.15**	0.31***	0.15	0.18**	0.04**	0.04***	0.96***	0.1	-0.37	-0.89	-0.38
0.06	0.01	-2.96***	0.03	0.20**	0.08	0.3	0	0.30***	0.04***	0.93***	4.38***	-1.55	-2.77	3.1
0.06	-0.15	-0.26	0.06	0.08	0.31***	-0.2	-0.03	0.25***	0	0.99***	-0.86***	-0.23	0.39	-1.77***
0.08	-0.07	-0.95	0.03	0.07	0.1	-0.02	0.17	0.08***	0.02***	0.97***	1.4	6.89***	1.28	0.29
0.01	0.15	-0.52	-0.02	0.13**	0.16**	0.02	-0.04	0.39***	0.09***	0.88***	0.61	-1.3	-0.84	-2.51**
-0.03	0.15	-1.39	0.01	0.03	-0.16	-0.72	-0.15	0.53***	0.14***	0.84***	-5.93	-5.89	-14.57***	-7.04
0.07	0.11	-0.52	-0.01	0.11	0	-0.27**	-0.39	0.23***	0.06***	0.91***	-2.17	1.42	-0.23	-1.96
-0.06	0.03	-0.93	-0.02	0.28***	0.1	-0.45	0.18	0.15***	0.04***	0.95***	-0.85	1.53	-6.64	-0.61
-0.03	0.07	-2.03**	0.01	0.13**	0.14	-0.23	0.05	0.72***	0.14***	0.80***	-7.09***	-6.55	-15.60***	-2.88
-0.05	2.13	1.86	-0.61	0.3	0.01	-0.32**	-0.36	5.71***	0	0.54***	6.43	0.34	-7.94***	-0.68
-0.06	-0.01	-1.32**	0.01	0.23***	0.21	-0.13	0.17	1.00***	0.08***	0.85***	-1.55	4.56	-6.96	-3.7
0.02	0.05	-0.56	-0.02	0.44***	0.23**	0.01	0.12	2.77***	0.23***	0.61***	-2.42	-1.06	-20.01***	-20.63***
0.06	0.11	-1.40**	0	0.17**	0.14**	-0.11	-0.09	0.34***	0.07***	0.92***	-1.72	-1.83	9.66	-6.58***
0	0.30***	-1.77***	-0.07**	0.41***	0.18	0.02	-0.04	0.40***	0.08***	0.88***	-0.58	-0.43	1.32	1.18
-0.01	-0.03	1.09	0.02	0.21***	0.33***	-0.3	-0.22	0.09***	0.02***	0.97***	0.64	1.4	-1.85***	9.25***
-0.02	0.01	-3.1	0.01	0.35	0.2	-0.09	-0.3	0.24***	0.16***	0.81***	-5.35	1.95	-14.69**	-18.34***
-0.07	0.04	-1.51	0	0.43***	-0.03	-0.14	-0.04	0.15***	0.11***	0.89***	-5.25**	-0.63	-0.04	-4.38
0.01	-0.1	-2.97***	0.06**	0.26***	0.23***	0.05	0.12	0.08**	0.05***	0.95***	0.28	-0.69	-1.39	-0.34
0.06	0.16	-2.15**	-0.03	0.28**	0.18	-0.03	0.23	0.09***	0.04***	0.95***	-0.38	-0.28	-0.8	2.26
-0.05	0.04	-0.29	0	0.29***	-0.02	-0.18	0.05	0.10***	0.01***	0.97***	0.08	2.65**	0.26	0.66
-0.05	0.14	-1.03	-0.04	0.26***	0.32**	0.4	-0.19	0.20***	0.04***	0.94***	2.06	2.05	5.25	-0.58
-0.08	0.08	-0.76	-0.01	0.13	0.09	0.06	-0.1	0.14***	0.10***	0.89***	-1.61	3.72	-10.23**	-10.53**
-0.03	0.01	0.09	0.01	0.17	-0.24	-0.02	0.37	0.10***	0.01***	0.98***	9.54***	-0.66	-2.37***	42.65***
-0.01	0.37***	0.13	-0.11***	-0.04	-0.13	-0.05	-0.22	0.21***	0.08***	0.91***	-1.72	-4.66	-11.72***	-6.83
-0.04	-0.02	-0.68	0.02	0.28**	0.05	0.36	0.15	0.31***	0.01***	0.95***	7.21***	11.35***	14.59**	3.63
-0.04	0.06	-1.77**	0.02	-0.03	-0.01	-0.24	-0.29**	0.13***	0.06***	0.93***	4.38***	1.62	-1.01	-1.21
0.02	0.07	-0.02	0	0.13	-0.08	-0.33	-0.18***	0.09***	0.03***	0.96***	1.52	2.16	8.83***	-3.68***
-0.08	-0.02	-0.64	0.01	0.25**	0.15***	0.22	-0.13	5.13***	0.55***	0.21***	8.48***	-5.25	-13.19***	-16.32***
-0.02	-0.04	-0.37	0.02	0.35	0.29***	-0.07	0.08	6.30***	0	0.08	31.77***	3.43	2.56	1.29
-0.20***	0	-0.72	0.01	0.23	-0.05	0.07	-0.04	1.21***	0.18***	0.77***	-1.9	-19.86***	-11.33	-3.76
-0.09	0.12	-1.33	-0.02	0.38***	0.35***	0.16	-0.07	0.96***	0.10***	0.84***	1.6	-0.31	-6.11	2.56
-0.02	0.05	-0.69	-0.01	0.22	0.11	0.2	0.09	0.16***	0.05***	0.92***	13.49***	1.92	0.59	0.17
-0.03	-0.16	-1.85**	0.08**	0.26***	-0.02	-0.55***	-0.29	0.06***	0.02***	0.97***	3.04***	-1.31	-0.5	2.73
0.08	0.05	2.19	-0.01	-0.45	0.05	0.12	-0.23	1.35***	0.14***	0.66***	22.17	-8.28	25.36	-18.89***

Note: ***(**) means the coefficients are significant at 1% (5%) level.

Appendix 2.9b Detailed Estimation Results for Modified-GARCH-M on the SZSE B-Shares

β_1	β_2	β_3	β_4	β_5	β_6	β_7	β_8	β_9	β_{10}	β_{11}	β_{12}	β_{13}	β_{14}	β_{15}
0.09	-0.01	5.81	0.02	-0.19	-0.75	-0.29**	-0.24	0.24***	0.09***	0.89***	11.88***	61.34***	-3.27	-10.52**
0	-0.04	-0.84	0.02	0.24***	0.27***	0.13	-0.08	0.68***	0.11***	0.81***	-0.6	-0.06	0.91	0
0.01	-0.02	-2.22	0.01	0.29**	-0.02	0.15	-0.41	6.84***	0.61***	0	-34.10***	-65.50***	-50.58***	-30.7
-0.04	0.02	-2.43	0	0.58	-0.26	1.12***	0.29	0.08***	0.01***	0.96***	29.91***	2.48**	-7.24***	0.38
-0.01	0.13	-0.73	-0.04	0.33***	0.31***	0.03	-0.08	0.18***	0.12***	0.87***	0.19	-0.83	-2.40**	-1.14
0.03	-0.06	-0.78	0.04	0.41***	-0.1	0.12	-0.53***	0.61***	0.13***	0.80***	9.84	-9.48***	-1.36	-13.47***
-0.04	0.02	-3.41	0	0.32***	0.33***	0.04	-0.21	0.29***	0.05***	0.90***	0.95	0.43	-0.65	-0.33
0.08	0.04	-0.72	0	0.41	-0.04	-0.49	-0.61	0.19***	0.08***	0.89***	-2.99	-0.49	-3.07	57.73***
0.01	0.04	-1.57***	0	0.19***	0.25***	-0.05	-0.13	0.51***	0.15***	0.80***	0.88	-1.26	-0.6	-1.28
-0.02	0.28**	3.34	-0.07	0.23	-0.12	0	-0.11	0.96***	0.11***	0.77***	2.93	4.92	6.65	-7.98
0.07	0.13	2.34	-0.04	0.14	-0.22	0.14	0.05	0.31***	0.07***	0.88***	4.61	0.62	-1.53	1.78
-0.03	0.05	-4.67**	-0.01	0.50***	0.16	-0.1	-0.23	0.36***	0.10***	0.87***	1.35	-1.12	-5.91**	-7.19***
-0.04	0.02	3.03	-0.01	0.04	0.31***	-0.23	0.13	0.46***	0.08***	0.84***	-1.28	1.37	-6.73	6.17
-0.01	0.18	-7.55	-0.03	0.08	-0.23	-0.1	-0.12	0.63***	0	0.93***	15.88***	-8.05***	42.42***	-5.14***
-0.04	0.04	-0.07	0	0.34**	0.02	0.08	-0.15	1.26***	0.06***	0.78***	6.55	9.94	10.49	1.44
0.03	0.07	-4.36	-0.02	0.3	0.1	0.1	-0.08	2.78***	0.21***	0.52***	-0.72	4.75	-18.30***	2.68
0.05	-0.03	-2.88	0.02	0.22***	0.15**	0.14	-0.03	0.42***	0.10***	0.87***	-0.29	-1.99	-7.54***	-4.84**
0.08	0.23**	-2.21	-0.04	0.09	0.16	0.04	-0.22	0.95***	0.18***	0.73***	0.75	-0.62	-4.08	-1.02
0.04	0.12	-9.01***	0	0.43***	0.03	0.09	-0.32	0.09***	0.03***	0.96***	1.84**	0.65	-0.82	10.30***
0.01	-0.16**	-4.59	0.07	0.56**	0.78***	-0.59	-0.25**	0.13***	0.08***	0.88***	5	2.6	-1.44	-9.12***
-0.02	0.09	-3.86	0	0.21**	0.14	-0.34	-0.16	0.57***	0.09***	0.83***	-4.49	15.12	-18.87	1.3
0	-0.12	-1.66	0.05**	0.19***	0.20***	0.09	0.02	0.15***	0.09***	0.91***	-0.05	-0.93**	-1.02	-1.36**
0.06	0.24***	-4.83	-0.07**	0.53***	0.04	-0.06	0.17	0.18***	0.09***	0.88***	2.01	-8.92**	1.52	5.51
-0.05	0	1.78	0	0.23**	-0.19	0.3	-0.35	0.51***	0.10***	0.84***	-0.11	4.12	-4.03	-7.72
-0.02	0.02	-4.22	0	0.27	0.05	0.42	0.25	0.38***	0.06***	0.86***	8.09	1.35	9.2	-8.50***
-0.01	0.16	-2.18	-0.06	0.19	0.44	-0.38	-0.22	0.26***	0.15***	0.81***	-1.97	4.34	-7.12	-9.31***
-0.15***	-0.04	-11.51***	0.02	0.61	0.35**	0.51**	0.12	0.58***	0.25***	0.75***	5.9	-3.96	-16.73**	-19.05**
0.04	0.21	-8.87	-0.04	-0.27***	0.13	0.19	-0.24	0.53***	0.11***	0.81***	-2.71	-2.21	-10.93**	-10.69
0	0.07	0.39	-0.02	0.21	-0.37	0.11	0.12	0.47***	0.17***	0.78***	1.43	36.07***	-6.02	-1.06
-0.02	0.15	-1.19	-0.03	0.19	0.09	0.01	-0.26	0.15***	0.07***	0.92***	3.69	-4.41***	-2.17	-2.8
0.07	0.17	-2.83	-0.02	0.42***	-0.19	-0.11	-0.2	0.50***	0.12***	0.83***	-2.31	-4.28	-5.35	-10.56***
-0.18***	0.02	-1.84	0	0.39***	0.24**	0.19	-0.06	4.94***	0.61***	0.14***	-0.88	-3.16	-6.32	-9.92
0	0.15	0.55	-0.06	0.31***	0.28***	-0.11	0.24**	0.68***	0.05	0.81***	2.36**	1.16	0.9	0.66
-0.13	0.41***	-0.3	-0.10**	0.40**	0.04	0.01	-0.26***	2.78***	0.14***	0.63***	10.39	-17.11***	0.09	-21.63***
-0.09	0	-4.61	0.02	0.30***	0.28***	-0.1	-0.94***	0.14***	0.05***	0.93***	-0.16	-0.16	-1.53	22.38***
0.01	-0.07	-1.67	0.03	-0.14	-0.38	-0.24	-0.35	0.15***	0.08***	0.89***	46.14***	-4.25	-0.08	-3.52
-0.02	0.02	-2.42	0.03	0.21	-0.35	-0.35	-0.43***	0.04***	0.04***	0.96***	2.64	0.73	-0.4	-3.09***
0.12**	0.28***	-11.01	-0.06	0.1	0.02	-0.28	0.17	0.57***	0.16***	0.79***	-7.45	-11.52	-9.57	-6.09

Note: ***(**) means the coefficients are significant at 1% (5%) level.

Appendix 2.9c Detailed Estimation Results for Truncated-GARCH-M on the SZSE A-Shares

β_1	β_2	β_3	β_4	β_5	β_6	β_7	β_8	β_9	β_{10}	β_{11}	β_{12}	β_{13}	β_{14}	β_{15}
0.09	-0.02	-1.44	0.01	0.24**	-0.04	0.12	-0.03	0.03***	0.00***	0.99***	3.82***	1.77	2.33**	-0.32
0.16	0.03	-1.47	0.01	19.35	20.36	24.08	0.04	3.65***	0.07	0.52***	16391.27	13781.18	4948.41	-7.57***
0.06	-0.03	-0.07	0.03	0.21	0.06	0.16	-0.68***	0.53***	0.17***	0.82***	5.02	-7.75	-10.69	13.69
-0.01	-0.02	-2.67***	0.04	0.14	-0.57**	-0.07	0.02	0.23***	0.07***	0.90***	0.89	11.09	9.99	-5.69***
0.05	-0.11	-3.12***	0.07**	0.50**	18.55**	0.27	-0.22	0.30***	0.11***	0.87***	17.53***	4129.39	-2.11	-7.84***
0.1	0.02	-3.00***	0.03	0.35	0.17	0.15	0.05	1.14***	0.18***	0.75***	51.38***	20.64	-21.15***	23.22
0.06	0.28**	-1.13***	-0.05	2.65**	12.44***	-2.22	0.33	2.82***	0.22***	0.58***	354.17	525.43	270.86	120.1
0.12	-0.01	-3.06	0.03	0.15	0.17	0.03	0.16	0.04***	0.02***	0.98***	6.03***	7.27***	-0.57	0.24
0.17	0.05	-6.30***	0.03	1.02	7.53***	3.51	-0.22	2.22***	0.37***	0.57***	450.09**	2813.78	977.86	629.37
0.05	0.09	-2.25***	0.02	0.17	-0.18	-0.72	-0.13	0.35***	0.10***	0.88***	7.92	6.78	-8.48	-0.64
0.08	0.08	-0.93	0.01	0.14	-0.03	-0.27	-0.51	0.30***	0.08***	0.89***	-1.82	11.37	0.62	-0.86
-0.04	-0.04	-1.81**	0.01	0.35***	0.08	-0.68	0.15	0.20***	0.08***	0.92***	-0.07	8.42**	-18.77	2.52
-0.02	-0.03	-2.54**	0.04	0.15**	0.12	-0.19	0	0.63***	0.15***	0.81***	-5.89***	-2.07	-14.86**	9.4
0.07	-0.08	0.74	0.03	0.32	0.12	-0.28	-0.39**	0.45***	0.10***	0.86***	-2.38	-4.99	-8.18	-14.50***
0.03	-0.06	-2.55***	0.04	0.45	0.46	-0.33	0.27	1.40***	0.26***	0.67***	34.61**	50.62	-6.3	4.76
0.01	-0.06	-1.59**	0.03	0.57***	0.37	0.06	0.11	0.49***	0.08***	0.88***	7.55**	32.16***	-8.16	-7.07**
0.23**	-0.13	-2.18***	0.06***	0.47	0.51	-1.55**	0.11	2.15***	0.21***	0.69***	87.35***	144.50***	146.2	-31.58***
0.09	0.1	-1.96**	0	0.82***	2.23	0.25	-1.34	1.05***	0.22***	0.72***	21.21**	810.82	379.9	540.25
0.07	-0.05	0.35	0.03	0.22***	0.56***	-0.33	-0.21	0.10***	0.03***	0.96***	-0.93	5.40**	0.71	5.72
-0.02	-0.04	-2.56	0.01	0.49	0.49	-0.05	-0.27	0.21***	0.13***	0.84***	2.57	43.74	-11.63	-14.96***
-0.06	-0.05	-1.18	0.02	0.52***	-0.23	-0.27	-0.07	0.14***	0.08***	0.90***	2.54	30.90**	14.32	0.68
-6.84	-1.12	-452.97	0.14***	21.49	31.86	0.4	50.46	156.06	0	1.00***	-79.31	-1.8	36.97	28.35
0.07	0.15	-2.38**	-0.03	0.34**	0.32**	-0.01	0.41	0.10***	0.05***	0.94***	1.03	4.84	-1.24	11.39**
-0.03	0.02	-0.32	0.01	0.32***	-0.01	-0.2	0.05	0.01	0.01***	0.98***	-0.77	3.43***	-0.65	0.77
-0.03	0.1	-1.01	-0.03	0.37***	0.41**	0.75**	-0.23	0.12***	0.05***	0.93***	4.20***	5.36	17.36**	-1.06
-0.06	0.02	-0.99	0.01	0.16	0.16	0.01	-0.19	0.10***	0.08***	0.91***	0.77	26.06***	-7.29	-9.96***
0.02	-0.02	-0.78	0.02	0.31	-0.34	-0.18	1.22	0.14***	0.09***	0.89***	15.57**	-1.19	0.23	41.32
0.01	0.29***	0.37	-0.07**	-0.05	-0.14	-0.19	-0.32	0.18***	0.10***	0.90***	-1.73	-2.82	-14.52	-4.95
-0.03	-0.17***	-2.85***	0.08***	0.34***	-0.19	144.74	0.12	0.45***	0.09***	0.86***	3.46	13.21**	22308.28	30.06
-0.03	-0.04	-2.42***	0.06**	0.15	-0.13	-0.09	-0.48**	0.13***	0.08***	0.91***	2.67	19.36***	-6.86***	12.16
0.04	0.04	-0.24	0.01	0.18	-0.1	-0.44	-0.22***	0.10***	0.05***	0.94***	8.14***	11.87***	1.74	-5.56***
0.16**	0.01	-1.94	0.05	2.43***	2.58	-0.27	-2.24	1.87***	0.23***	0.60***	286.94**	992.22	-1.01	577.33
4.37	-3.98	-825.52	0.17***	29.85	40.5	-67.01	-102.21	443.36	0	1.00***	-453.83	-597.02	-133.48	71.5
0	0.07	-1.68**	0.01	0.51***	-0.09	0.2	-0.12	0.29***	0.07***	0.90***	9.19**	0.07	-3.65	33.45***
-0.04	0.03	-0.38	-0.01	2.10***	2.83***	2.96	0.22	0.76***	0.22***	0.73***	113.29**	365.56	279.64	46.47
-0.01	0.05	-0.84	-0.01	0.41***	0.21	0.32	0.18	0.07***	0.05***	0.95***	1.03	5.3	1.05	11.75**
-0.01	-0.11	-0.63	0.05	0.22**	-0.03	-0.67***	-0.49	0.03***	0.01***	0.98***	2.64***	-1.79***	-0.67	9.69***
0.10**	0.05	0.31	0	-0.18	0.02	0.36	-0.15	0.21***	0.08***	0.89***	7.57	-3.71	1.78	-8.86***

Note: ***(**) means the coefficients are significant at 1% (5%) level.

Appendix 2.9d Detailed Estimation Results for Truncated-GARCH-M on the SZSE B-Shares

β_1	β_2	β_3	β_4	β_5	β_6	β_7	β_8	β_9	β_{10}	β_{11}	β_{12}	β_{13}	β_{14}	β_{15}
0.15**	0.04	5.62	0	-0.07	-0.49***	-0.33	-0.26	0.20***	0.10***	0.89***	7.06	-3.21	-0.85	-6.32
0	0.05	1.07	-0.02	15.92***	31.45***	7.04	0.01	3.82***	0.21***	0.36***	1888.76	2284.35***	975.47	1047.06
0.08	0.09	-6.61**	0	0.45**	0.03	0.05	-0.67	0.68***	0.18***	0.75***	7.85	-15.13***	-21.58***	6.22
0.02	0.01	-3.61	-0.01	0.75***	-0.40***	0.80**	0.38	0.29***	0.12***	0.84***	1.54	-8.13**	14.01	-1.24
0.03	-0.01	-7.18	0.02	1.67***	1.38***	0.07	-0.12	0.48***	0.26***	0.74***	81.87***	24.96**	-1.38	3.89
0.04	-0.07	-0.7	0.04	0.93	-0.15	0.23	-0.58***	0.74***	0.17***	0.75***	99.54**	-14.97***	4.35	-17.31***
-0.02	-0.03	-14.15***	0.06	17.56	17.63	2.08	-28.75	2.58***	0.14***	0.45***	19273.91	17532.79	2158.39	2320.29
0.10**	0.07	-1.11	-0.01	0.54	-0.06	-0.82	-0.39	0.18***	0.09***	0.88***	-2.37	2.1	17.51	12.18
0.06	0.05	-4.67***	0.02	0.74**	7.70***	-1.05	-0.89	1.18***	0.44***	0.56***	78.12	1482.87	712.13	490.16
0	0.14	4.03	-0.03	0.62***	-0.03	0.52	-0.04	0.70***	0.16***	0.76***	13.07	46.14	51.98	-8.95
0.07	0.2	3.44	-0.06	0.31	-0.22	0.16	0.12	0.32***	0.07***	0.88***	7.99	2.04	-1.95	1.72
-0.01	-0.02	-9.84***	0.03	0.88***	0.1	-0.04	-0.21	0.45***	0.13***	0.83***	16.36**	6.8	-9.28***	-10.51***
-0.04	-0.09	2.26	0.03	0.02	0.36**	-0.31	0.01	0.54***	0.10***	0.82***	-0.99	7.86	-9.26	17.56***
0.04	0.27***	-2.32	-0.06	0.39	-0.13	-0.02	-0.1	0.85***	0.15***	0.75***	11.99	-13.3	-9.66	-11.43***
0	0.02	0.14	0.01	0.77**	-0.02	0.67	-0.18	0.97***	0.14***	0.73***	32.63**	42.57	83.98	1.06
0.02	-0.05	-4.51	0.02	0.46	0	0.07	-0.28	1.31***	0.14***	0.70***	19.83**	46.00**	-10.33***	23.33
0.12	0.09	-3.07	-0.01	1.06***	0.88***	0.04	-0.08	1.50***	0.21***	0.69***	77.92**	68.78**	-3.05	-14.70***
0	0.12	-1.67	0	0.91	0.88	-0.04	-0.85	1.25***	0.33***	0.61***	148.41**	108.93	-16.90***	59.14
0.06	0.13	-6.27	0	0.84**	-0.11	0.12	-0.32	0.65***	0.16***	0.76***	30.19**	10.69	1.86	-11.28**
0.01	-0.05	-7.67	0.02	1.44**	1.54***	-7.76**	-0.2	0.23***	0.11***	0.82***	43.14	2.38	16.84	-11.80***
-0.03	0.01	-4.03	0.02	0.23**	0.42	-0.35	-0.2	0.33***	0.15***	0.81***	-8.56***	133.19	-101.97	1.64
13.42	13.23	-958.6	0.18***	-5.71	-58.17	27.9	-118.34	515.29	0	1.00***	-377.6	-158.3	-32.11	87.23
0.07	0.27***	-6.96	-0.07***	1.30***	0.28**	0	0.58	0.20***	0.10***	0.87***	25.33**	-16.50***	1	30.15***
-0.03	-0.07	2.92	0.02	0.4	-0.34	0.4	-0.4	0.78***	0.14***	0.77***	14.05**	11.21	0.26	-8.92
-0.02	0.04	-2.27	-0.01	0.53	0.12	0.45	0.2	0.43***	0.06***	0.86***	24.40**	7.66	8.4	-8.68***
0	0.15	-3.12	-0.05	0.32	1.43	-0.34	-0.26	0.27***	0.16***	0.80***	11.84	52.74	-7.69	-10.34***
0.04	0.03	-9.25***	0.01	1.11**	0.11	0.51	0.03	0.41***	0.15***	0.77***	13.12	10.15	0.84	-4.34
0.04	0.23**	-5.35	-0.05	-0.27**	0.22	0.15	-0.26	0.54***	0.12***	0.80***	-3.23	-1.75	-12.53**	-12.34
0	0.01	-0.19	0	0.52**	-0.09	0.18	0.18	0.43***	0.19***	0.78***	17.98	20.48	-0.37	3.39
0	0.14	1.5	-0.03	0.56	0.24	0.02	-0.27	0.44***	0.10***	0.84***	31.74***	5.63	3.31	-3.41
0.06	0.1	-2.84	0.01	0.67***	-0.27	-0.14	-0.19	0.44***	0.11***	0.85***	3.63	1.35	-3.28	-9.83***
0.08	0.14	-0.1	-0.01	6.40**	3.06	0.12	0.45	1.04***	0.19***	0.68***	507.99	1134.49	0.78	-3.92
0.04***	-0.04***	-0.74***	0.56***	0.53***	0.42***	-0.11***	0.30***	2.91***	0.05***	0.90***	0.40***	0.27***	0.06***	0.06***
0.01	0.2	-0.48	-0.03	1.38***	0.03	0.12	-0.33***	1.24***	0.18***	0.69***	46.91***	-18.28***	-0.37	-22.73***
-0.03	0.04	-0.24	0	0.92**	1.44**	-0.25	-1	0.78***	0.19***	0.73***	64.67**	167.89**	9.16	25.99
0.01	-0.12**	-0.3	0.05**	0.09	-0.71	-0.3	-0.42	0.08***	0.07***	0.92***	8.47	4.94	-1.58	-2.25
-0.01	0.01	-2.41	0.03	0.23	-0.46	-0.36	-0.46***	0.06***	0.04***	0.95***	6.41**	4.06	-0.36	-3.30***
0.10**	0.20**	-10.22	-0.02	0.12	0	-0.41	0.19	0.51***	0.20***	0.74***	-0.57	-8.38	-5.74	4.28

Note: ***(**) means the coefficients are significant at 1% (5%) level.

Appendix 2.10 Models Estimation for AB-shares on the SSE

This table reports the number of stocks that show price continuation (PC), price reversal (PR), volatility increase (VI) and volatility decrease (VD) after price limits. There are 40 AB-shares on the SSE. For upper price limit (PC): β_2+β_5 >0 and β_2+β_5 > β_2+β_7; (PR):β_2+β_5 <0 and β_2+β_5 < β_2+β_7; (VI): β_{12}>0 and $\beta_{12} > \beta_{14}$; (VD): β_{12}<0 and $\beta_{12} < \beta_{14}$. For lower price limit (PC): β_2+β_6 <0 and β_2+β_6 < β_2+β_8; (PR):β_2+β_6>0 and β_2+β_6 > β_2+β_8; (VI): β_{13}>0 and $\beta_{13} > \beta_{15}$; (VD): β_{13}<0 and $\beta_{13} < \beta_{15}$. The signs '>' and '<' imply significant 'larger than' and 'smaller than'.

$$R_t = \mu_t + \varepsilon_t \quad \varepsilon_t\,|\Omega_t \sim N(0, \sigma_t^2) \text{ or } \varepsilon_t\,|\Omega_t \sim TN(0, \sigma_t^2)$$

$$\mu_t = \beta_1 + (\beta_2 + \beta_3 Tor_{t-1} + \beta_4\sigma_{t-1} + \beta_5 Up_{t-1} + \beta_6 Lo_{t-1} + \beta_7 Up9_{t-1} + \beta_8 Lo9_{t-1})R_{t-1}\ ,$$
$$\sigma_t^2 = \beta_9 + \beta_{10}\varepsilon_{t-1}^2 + \beta_{11}\sigma_{t-1}^2 + \beta_{12}Up_{t-1} + \beta_{13}Lo_{t-1} + \beta_{14}Up9_{t-1} + \beta_{15}Lo9_{t-1} + \beta_{16}Tor_{t-1}\ ,$$

where R_t is the daily stock return on day *t*. Tor_{t-1} is the daily negotiable turnover ratio on day *t-1*, which is measured by daily negotiable turnover divided by daily negotiable market value. Up_{t-1} ($Up9_{t-1}$) and Lo_{t-1} ($Lo9_{t-1}$) are upper (90% upper) and lower (90% lower) price limit hits dummy variables taking value of one on day *t* if a share hits the limit on day *t-1*.

	Modified-GARCH-M				Truncated-GARCH-M			
5% significant results								
SSE A (40)	PC	PR	VI	VD	PC	PR	VI	VD
Upper	21	0	5	5	22	0	12	2
Lower	11	0	7	6	10	0	13	1
SSE B (40)	PC	PR	VI	VD	PC	PR	VI	VD
Upper	21	0	6	9	26	0	16	5
Lower	8	2	4	10	5	1	8	3
1% significant results								
SSE A (40)	PC	PR	VI	VD	PC	PR	VI	VD
Upper	17	0	5	4	11	0	3	1
Lower	8	0	7	5	6	0	6	0
SSE B (40)	PC	PR	VI	VD	PC	PR	VI	VD
Upper	12	0	6	5	18	0	5	3
Lower	5	0	3	8	1	0	1	3
0.1% significant results								
SSE A (40)	PC	PR	VI	VD	PC	PR	VI	VD
Upper	10	0	5	4	5	0	0	1
Lower	4	0	4	3	2	0	2	0
SSE B (40)	PC	PR	VI	VD	PC	PR	VI	VD
Upper	9	0	6	4	2	0	0	2
Lower	4	0	1	5	0	0	0	3

Appendix 2.11 Models Estimation for AB-shares on the SSE

This table reports the number of stocks that show price continuation (PC), price reversal (PR), volatility increase (VI) and volatility decrease (VD) after price limits. There are 40 AB-shares on the SSE. For upper price limit (PC): β_2+β_5 >0 and β_2+β_5 > β_2+β_7; (PR):β_2+β_5 <0 and β_2+β_5 < β_2+β_7; (VI): β_{12}>0 and $\beta_{12} > \beta_{14}$; (VD): β_{12}<0 and $\beta_{12} < \beta_{14}$. For lower price limit (PC): β_2+β_6 <0 and β_2+β_6 < β_2+β_8; (PR):β_2+β_6>0 and β_2+β_6 > β_2+β_8; (VI): β_{13}>0 and $\beta_{13} > \beta_{15}$; (VD): β_{13}<0 and $\beta_{13} < \beta_{15}$. The signs '>' and '<' imply significant 'larger than' and 'smaller than'.

$$R_t = \mu_t + \varepsilon_t \quad \varepsilon_t\,|\Omega_t \sim N(0,\sigma_t^2) \text{ or } \varepsilon_t\,|\Omega_t \sim TN(0,\sigma_t^2)$$

$$\mu_t = \beta_1 + \left(\beta_2 + \beta_3 Tor_{t-1} + \beta_4\sqrt{R_{t-1}^2} + \beta_5 Up_{t-1} + \beta_6 Lo_{t-1} + \beta_7 Up9_{t-1} + \beta_8 Lo9_{t-1}\right) R_{t-1}\,,$$
$$\sigma_t^2 = \beta_9 + \beta_{10}\varepsilon_{t-1}^2 + \beta_{11}\sigma_{t-1}^2 + \beta_{12} Up_{t-1} + \beta_{13} Lo_{t-1} + \beta_{14} Up9_{t-1} + \beta_{15} Lo9_{t-1}\,,$$

where R_t is the daily stock return on day *t*. Tor_{t-1} is the daily negotiable turnover ratio on day *t-1*, which is measured by daily negotiable turnover divided by daily negotiable market value. Up_{t-1} ($Up9_{t-1}$) and Lo_{t-1} ($Lo9_{t-1}$) are upper (90% upper) and lower (90% lower) price limit hits dummy variables taking value of one on day *t* if a share hits the limit on day *t-1*.

	Modified-GARCH-M				Truncated-GARCH-M			
5% significant results								
SSE A (40)	PC	PR	VI	VD	PC	PR	VI	VD
Upper	21	0	6	6	28	0	17	3
Lower	10	0	7	4	8	0	14	0
SSE B (40)	PC	PR	VI	VD	PC	PR	VI	VD
Upper	24	0	8	8	26	0	15	2
Lower	8	1	4	8	9	0	6	3
1% significant results								
SSE A (40)	PC	PR	VI	VD	PC	PR	VI	VD
Upper	16	0	4	5	20	0	10	1
Lower	6	0	6	2	7	0	9	0
SSE B (40)	PC	PR	VI	VD	PC	PR	VI	VD
Upper	13	0	6	6	19	0	4	2
Lower	6	0	4	6	4	0	0	2
0.1% significant results								
SSE A (40)	PC	PR	VI	VD	PC	PR	VI	VD
Upper	10	0	4	4	7	0	3	0
Lower	4	0	4	1	2	0	2	0
SSE B (40)	PC	PR	VI	VD	PC	PR	VI	VD
Upper	13	0	6	6	11	0	0	1
Lower	6	0	4	6	2	0	0	1

Appendix 2.12 Models Estimation for AB-shares on the SZSE

This table reports the number of stocks that show price continuation (PC), price reversal (PR), volatility increase (VI) and volatility decrease (VD) after price limits. There are 38 AB-shares on the SZSE. For upper price limit (PC): β_2+β_5 >0 and β_2+β_5 > β_2+β_7; (PR):β_2+β_5 <0 and β_2+β_5 < β_2+β_7; (VI): β_{12}>0 and $\beta_{12} > \beta_{14}$; (VD): β_{12}<0 and $\beta_{12} < \beta_{14}$. For lower price limit (PC): β_2+β_6 <0 and β_2+β_6 < β_2+β_8; (PR):β_2+β_6>0 and β_2+β_6 > β_2+β_8; (VI): β_{13}>0 and $\beta_{13} > \beta_{15}$; (VD): β_{13}<0 and $\beta_{13} < \beta_{15}$. The signs '>' and '<' imply significant 'larger than' and 'smaller than'.

$$R_t = \mu_t + \varepsilon_t \quad \varepsilon_t\,|\Omega_t \sim N(0, \sigma_t^2) \text{ or } \varepsilon_t\,|\Omega_t \sim TN(0, \sigma_t^2)$$

$$\mu_t = \beta_1 + (\beta_2 + \beta_3 Tor_{t-1} + \beta_4 \sigma_{t-1} + \beta_5 Up_{t-1} + \beta_6 Lo_{t-1} + \beta_7 Up9_{t-1} + \beta_8 Lo9_{t-1})R_{t-1}\,,$$
$$\sigma_t^2 = \beta_9 + \beta_{10}\varepsilon_{t-1}^2 + \beta_{11}\sigma_{t-1}^2 + \beta_{12} Up_{t-1} + \beta_{13} Lo_{t-1} + \beta_{14} Up9_{t-1} + \beta_{15} Lo9_{t-1} + \beta_{16} Tor_{t-1}\,,$$

where R_t is the daily stock return on day *t*. Tor_{t-1} is the daily negotiable turnover ratio on day *t-1*, which is measured by daily negotiable turnover divided by daily negotiable market value. Up_{t-1} ($Up9_{t-1}$) and Lo_{t-1} ($Lo9_{t-1}$) are upper (90% upper) and lower (90% lower) price limit hits dummy variables taking value of one on day *t* if a share hits the limit on day *t-1*.

	Modified-GARCH-M				Truncated-GARCH-M			
5% significant results								
SZSE A (38)	PC	PR	VI	VD	PC	PR	VI	VD
Upper	20	0	9	2	15	0	12	0
Lower	11	1	5	2	7	0	12	0
SZSE B (38)	PC	PR	VI	VD	PC	PR	VI	VD
Upper	18	1	5	0	19	0	12	1
Lower	12	0	1	5	7	2	6	3
1% significant results								
SZSE A (38)	PC	PR	VI	VD	PC	PR	VI	VD
Upper	12	0	10	1	11	0	5	0
Lower	7	1	3	1	4	0	8	0
SZSE B (38)	PC	PR	VI	VD	PC	PR	VI	VD
Upper	14	1	3	0	12	0	1	1
Lower	9	0	1	3	6	1	1	2
0.1% significant results								
SZSE A (38)	PC	PR	VI	VD	PC	PR	VI	VD
Upper	7	0	9	1	5	0	1	0
Lower	5	0	3	1	1	0	3	0
SZSE B (38)	PC	PR	VI	VD	PC	PR	VI	VD
Upper	9	0	3	0	5	0	1	0
Lower	6	0	1	1	4	1	1	2

Appendix 2.13 Models Estimation for AB-shares on the SZSE

This table reports the number of stocks that show price continuation (PC), price reversal (PR), volatility increase (VI) and volatility decrease (VD) after price limits. There are 38 AB-shares on the SZSE. For upper price limit (PC): β_2+β_5 >0 and β_2+β_5 > β_2+β_7; (PR):β_2+β_5 <0 and β_2+β_5 < β_2+β_7; (VI): β_{12}>0 and $\beta_{12} > \beta_{14}$; (VD): β_{12}<0 and $\beta_{12} < \beta_{14}$. For lower price limit (PC): β_2+β_6 <0 and β_2+β_6 < β_2+β_8; (PR):β_2+β_6>0 and β_2+β_6 > β_2+β_8; (VI): β_{13}>0 and $\beta_{13} > \beta_{15}$; (VD): β_{13}<0 and $\beta_{13} < \beta_{15}$. The signs '>' and '<' imply significant 'larger than' and 'smaller than'.

$$R_t = \mu_t + \varepsilon_t \quad \varepsilon_t\,|\Omega_t \sim N(0, \sigma_t^2) \text{ or } \varepsilon_t\,|\Omega_t \sim TN(0, \sigma_t^2)$$

$$\mu_t = \beta_1 + \left(\beta_2 + \beta_3 Tor_{t-1} + \beta_4\sqrt{R_{t-1}^2} + \beta_5 Up_{t-1} + \beta_6 Lo_{t-1} + \beta_7 Up9_{t-1} + \beta_8 Lo9_{t-1}\right) R_{t-1}\,,$$
$$\sigma_t^2 = \beta_9 + \beta_{10}\varepsilon_{t-1}^2 + \beta_{11}\sigma_{t-1}^2 + \beta_{12} Up_{t-1} + \beta_{13} Lo_{t-1} + \beta_{14} Up9_{t-1} + \beta_{15} Lo9_{t-1}\,,$$

where R_t is the daily stock return on day *t*. Tor_{t-1} is the daily negotiable turnover ratio on day *t-1*, which is measured by daily negotiable turnover divided by daily negotiable market value. Up_{t-1} ($Up9_{t-1}$) and Lo_{t-1} ($Lo9_{t-1}$) are upper (90% upper) and lower (90% lower) price limit hits dummy variables taking value of one on day *t* if a share hits the limit on day *t-1*.

	Modified-GARCH-M				Truncated-GARCH-M			
5% significant results								
SZSE A (38)	PC	PR	VI	VD	PC	PR	VI	VD
Upper	21	0	11	1	22	0	14	1
Lower	10	1	3	2	10	0	12	1
SZSE B (38)	PC	PR	VI	VD	PC	PR	VI	VD
Upper	18	0	5	1	22	0	16	1
Lower	10	0	3	4	7	2	4	3
1% significant results								
SZSE A (38)	PC	PR	VI	VD	PC	PR	VI	VD
Upper	11	0	11	1	17	0	8	0
Lower	6	0	2	2	3	0	7	1
SZSE B (38)	PC	PR	VI	VD	PC	PR	VI	VD
Upper	14	0	3	1	11	0	4	1
Lower	8	0	2	2	5	2	0	2
0.1% significant results								
SZSE A (38)	PC	PR	VI	VD	PC	PR	VI	VD
Upper	5	0	10	1	8	0	3	0
Lower	5	0	2	2	1	0	1	1
SZSE B (38)	PC	PR	VI	VD	PC	PR	VI	VD
Upper	9	0	3	1	6	0	0	0
Lower	5	0	2	1	2	0	0	2

Appendix 2.14 Returns and the Tail Probabilities

This table reports the returns before the costs (%). The forecasted tail probabilities are also reported inside the bracket under the returns.

Stock	T+1	T+2	T+3	T+4	T+5
600054	-2.0884	0.4858	2.9449	-0.5505	0.2363
	(0.1908)	(0.1758)	(0.1888)	(0.2097)	(0.189)
600190	-2.2039	-0.8392	0.5602	-0.2797	0.8368
	(0.0894)	(0.1328)	(0.119)	(0.1048)	(0.1038)
600221	-0.9501	0	0	1.1863	1.4052
	(0.1803)	(0.1883)	(0.1769)	(0.1718)	(0.1638)
600272	-1.5873	1.2916	-0.2966	2.927	-1.7459
	(0.3732)	(0.3691)	(0.3737)	(0.3542)	(0.3623)
600295	-1.1312	0.2273	2.5772	-1.0006	0.3346
	(0.2456)	(0.2195)	(0.2261)	(0.2584)	(0.2186)
600320	0.5882	1.1662	-0.5814	-0.292	1.1628
	(0.2066)	(0.203)	(0.2055)	(0.1885)	(0.1847)
600555	-1.2121	0	1.5129	0.8969	-1.1976
	(0.3045)	(0.2987)	(0.3075)	(0.3217)	(0.3092)
600602	-0.8633	1.4347	1.4145	0.2805	1.1142
	(0.2377)	(0.2376)	(0.233)	(0.2305)	(0.2314)
600610	***-4.22***	-1.1825	2.506	***-1.7948***	0.8624
	(0.9421)	(0.3435)	(0.4301)	***(0.5503)***	(0.4038)
600611	1.2346	-1.0278	0.4124	-0.6192	0
	(0.1916)	(0.1935)	(0.1783)	(0.1808)	(0.1706)
600612	0.2317	2.2432	-1.2756	-1.9913	0.5132
	(0.2696)	(0.2623)	(0.2733)	(0.261)	(0.2612)
600613	-1.4702	4.4606	-0.7393	-1.9015	0.8688
	(0.4698)	(0.4639)	(0.4372)	(0.4477)	(0.437)
600614	0.3419	0.5955	0.592	-1.017	0.1702
	(0.2864)	(0.2849)	(0.2852)	(0.284)	(0.2753)
600618	-0.6161	0.3701	1.224	0.4854	0.3625
	(0.2647)	(0.2576)	(0.252)	(0.2507)	(0.2463)
600619	-0.9259	2.6015	2.3882	-0.5917	1.0332
	(0.2855)	(0.2704)	(0.304)	(0.3004)	(0.2825)
600623	0.9513	0.2364	0.5886	-0.7067	0.5893
	(0.2414)	(0.2268)	(0.2238)	(0.2154)	(0.2217)
600639	0	-0.1112	-2.2498	-1.0292	3.279
	(0.3773)	(0.3696)	(0.3638)	(0.3549)	(0.3519)
600648	0.2079	0.2075	-2.0943	-0.8502	1.9028
	(0.4525)	(0.4801)	(0.4751)	(0.3939)	(0.429)
600650	0.1467	0.2928	0.292	-0.1459	-0.2924
	(0.2269)	(0.2216)	(0.2182)	(0.2143)	(0.2078)
600663	-0.0841	-0.8446	0.8446	-0.2526	0.756
	(0.3499)	(0.3518)	(0.343)	(0.3484)	(0.3378)
600679	-2.1317	2.5033	4.9437	-2.3811	0.4808
	(0.3423)	(0.2999)	(0.3966)	(0.3984)	(0.3215)
600680	0.8172	0.4061	1.6081	-1.4056	-1.1185
	(0.2892)	(0.2909)	(0.2769)	(0.2914)	(0.2463)
600689	-0.6662	0.6662	1.1881	2.078	-0.5155
	(0.2989)	(0.2953)	(0.2997)	(0.2999)	(0.2981)
600695	-0.9756	0.7326	2.1661	0.2378	-0.2378
	(0.2844)	(0.28)	(0.2853)	(0.2851)	(0.2834)
600726	1.4493	0	-1.085	-1.0969	0
	(0.2038)	(0.2042)	(0.197)	(0.1961)	(0.1947)
600754	-2.5028	0.5776	0.431	0.6431	1.9747
	(0.222)	(0.2091)	(0.2199)	(0.2136)	(0.2098)
600776	-1.3921	2.081	1.5891	0	0.4494
	(0.2591)	(0.237)	(0.2776)	(0.2682)	(0.2409)
600801	-2.8077	2.2789	0.1986	-1.0638	0.0668
	(0.3457)	(0.2866)	(0.3411)	(0.3157)	(0.2949)

600818	0.1695	0.3381	-0.1689	-1.0196	-0.7715
	(0.2523)	(0.2465)	(0.2361)	(0.229)	(0.2327)
600819	4.66	-0.8467	0.678	-0.8482	0.6791
	(0.2324)	(0.3016)	(0.2652)	(0.2684)	(0.2458)
600822	-0.9009	2.2372	2.8355	-2.174	0
	(0.2532)	(0.2478)	(0.2731)	(0.2697)	(0.2603)
600827	0.2328	3.5412	0.7826	-1.6845	-0.454
	(0.2422)	(0.24)	(0.2801)	(0.2507)	(0.2287)
600835	-0.6223	1.487	0.8573	-0.8573	0
	(0.2127)	(0.2098)	(0.2079)	(0.2062)	(0.205)
600841	-2.1622	9.5476	***9.5461***	***4.3437***	-4.419
	(0.2724)	(0.3111)	***(0.5842)***	***(0.6834)***	(0.4431)
600843	-0.7358	9.5713	***4.9748***	-5.3783	-0.2699
	(0.2744)	(0.2555)	***(0.5921)***	(0.3684)	(0.3163)
600844	4.9349	-0.8636	1.6344	4.7489	-0.817
	(0.266)	(0.3766)	(0.3094)	(0.3246)	(0.3699)
600845	-1.7404	0.8015	2.6496	-0.4959	1.76
	(0.2073)	(0.2161)	(0.209)	(0.2088)	(0.2158)
600848	1.565	-1.8809	0	-1.1138	1.1138
	(0.344)	(0.3391)	(0.3129)	(0.303)	(0.293)
600851	-2.0619	2.2473	1.4706	-0.3656	2.8883
	(0.2259)	(0.2032)	(0.2537)	(0.2414)	(0.2101)
900942	3.0185	4.5132	0.5966	-1.6492	1.4259
	(0.2071)	(0.2552)	(0.3112)	(0.2795)	(0.2632)
900952	-0.2677	3.9427	3.0459	-2.2757	0
	(0.2443)	(0.2258)	(0.2316)	(0.2466)	(0.2893)
900945	-0.6329	3.1253	4.8057	-1.4771	0.5935
	(0.2398)	(0.2064)	(0.3044)	(0.3585)	(0.2798)
900943	0.271	3.196	3.097	-0.7653	0.5109
	(0.2554)	(0.2429)	(0.2687)	(0.256)	(0.2637)
900936	1.1539	1.2352	4.0709	-1.9223	-1.9599
	(0.2262)	(0.2339)	(0.2297)	(0.3092)	(0.2608)
900947	4.5078	8.7011	1.005	-1.2579	-0.5076
	(0.2439)	(0.3668)	(0.4294)	(0.3624)	(0.3378)
900955	-1.387	3.5669	2.1334	1.5707	-0.5208
	(0.3187)	(0.3031)	(0.3268)	(0.311)	(0.2978)
900901	-0.2954	5.7487	2.755	-2.1979	1.105
	(0.1996)	(0.1837)	(0.2773)	(0.2771)	(0.3172)
900906	-2.6202	6.2185	9.3229	***5.5263***	***3.0011***
	(0.3937)	(0.2712)	(0.4456)	***(0.6006)***	***(0.5885)***
900903	0.7547	4.2325	2.6668	-1.2357	-1.6115
	(0.1552)	(0.1554)	(0.2651)	(0.2574)	(0.2148)
900905	5.9454	9.5445	***3.5246***	1.8019	-0.1702
	(0.229)	(0.2943)	***(0.758)***	(0.3608)	(0.3679)
900904	1.0582	6.6182	***3.2949***	-2.5098	1.6481
	(0.4736)	(0.4506)	***(0.5111)***	(0.4451)	(0.3522)
900907	0.9231	3.3136	3.6368	-2.7518	0.7315
	(0.2397)	(0.2517)	(0.3327)	(0.3304)	(0.2715)
900908	-0.2172	5.4982	5.4067	0.7767	-0.9718
	(0.2287)	(0.2218)	(0.2679)	(0.2874)	(0.3171)
900910	-1.1494	3.9665	3.458	-1.6231	0.1817
	(0.1944)	(0.2017)	(0.2502)	(0.2841)	(0.2731)
900909	0	8.6433	***4.0567***	-1.5409	0.9274
	(0.2138)	(0.197)	***(0.5943)***	(0.4445)	(0.3867)
900911	2.2765	1.0661	4.3575	-3.7233	0.5255
	(0.3826)	(0.3691)	(0.3675)	(0.2806)	(0.3507)
900912	1.105	1.2136	2.5016	-3.9597	0.1223
	(0.3377)	(0.3559)	(0.3425)	(0.3417)	(0.3066)
900914	-0.5326	3.9272	2.6601	-2.1479	0.1276
	(0.1662)	(0.1581)	(0.2295)	(0.2252)	(0.2277)

900932	3.5201	2.5049	1.3403	-3.999	-0.3857
	(0.3803)	(0.3897)	(0.373)	(0.3467)	(0.3126)
900916	-0.883	3.4862	9.5894	***-3.7666***	0
	(0.2483)	(0.2358)	(0.2893)	***(0.8972)***	(0.4085)
900930	-0.1837	4.3172	4.3073	-1.3583	0.5115
	(0.2026)	(0.1891)	(0.2857)	(0.3201)	(0.2748)
900922	-0.6636	3.5321	1.9097	-2.1671	0.1288
	(0.2599)	(0.2418)	(0.2855)	(0.2764)	(0.266)
900919	-1.0695	5.5764	2.6757	-2.0001	0.3361
	(0.2366)	(0.238)	(0.2721)	(0.2831)	(0.2874)
900937	1.4815	5.7158	2.4015	0.3384	-2.0479
	(0.1944)	(0.1756)	(0.2827)	(0.3358)	(0.301)
900934	2.1551	4.1757	-0.3966	-1.8717	-0.4735
	(0.192)	(0.2234)	(0.3051)	(0.2568)	(0.2485)
900941	0.2608	3.8319	2.7196	-2.4693	0.4988
	(0.2198)	(0.2028)	(0.2672)	(0.2754)	(0.2674)
900933	-1.3606	9.5537	***4.3196***	-1.6945	0.2203
	(0.2426)	(0.2342)	***(0.836)***	(0.4226)	(0.3707)
900915	-1.0182	3.1657	3.3429	-0.6873	0.5502
	(0.2132)	(0.1569)	(0.2963)	(0.3247)	(0.2119)
900918	4.1995	3.4046	3.0898	-2.4642	0.6218
	(0.2274)	(0.3073)	(0.3162)	(0.3078)	(0.2658)
900927	-0.8197	2.8399	2.9559	-1.3685	0.3929
	(0.2392)	(0.2266)	(0.2657)	(0.2754)	(0.255)
900923	4.2489	2.9733	3.1179	-1.5468	-0.9397
	(0.1918)	(0.2729)	(0.2986)	(0.2789)	(0.2719)
900925	0.285	2.9909	0.551	-1.6621	-0.1864
	(0.2018)	(0.2003)	(0.2568)	(0.2222)	(0.2066)
900920	-0.8942	9.5582	***8.349***	***1.2438***	-2.6301
	(0.2762)	(0.2602)	***(0.9765)***	***(0.5273)***	(0.4197)
900924	0.9091	6.5669	9.4925	***3.0363***	3.6701
	(0.2541)	(0.2474)	(0.3845)	***(0.8583)***	(0.4965)
900921	3.3152	3.6756	2.7556	3.6691	-0.6572
	(0.2071)	(0.1714)	(0.2705)	(0.2697)	(0.2878)
900926	-0.1739	4.0926	6.7823	-1.7323	1.9662
	(0.1683)	(0.1556)	(0.2823)	(0.3674)	(0.2937)
900928	-0.3945	3.1131	3.7598	-2.8065	1.8798
	(0.3036)	(0.2599)	(0.311)	(0.3398)	(0.2921)
900917	-0.489	4.0822	3.013	-1.6111	1.1534
	(0.2179)	(0.2056)	(0.2827)	(0.3044)	(0.2823)
000002	-0.597	2.1998	-2.1142	3.0305	1.2361
	(0.1797)	(0.236)	(0.2236)	(0.2383)	(0.2256)
000011	-0.6978	-0.7027	0.7027	-1.1268	0.2829
	(0.3405)	(0.3455)	(0.331)	(0.325)	(0.3198)
000012	-0.6079	-0.3665	3.3698	-0.237	5.2005
	(0.28)	(0.2617)	(0.2548)	(0.2969)	(0.2731)
000016	-0.9539	0.6369	0.6329	0.6289	2.1706
	(0.2348)	(0.2299)	(0.2318)	(0.2266)	(0.2218)
000018	-2.5739	4.9374	***2.0232***	0.7128	-1.4306
	(0.3033)	(0.2716)	***(0.5976)***	(0.4142)	(0.3896)
000019	0.117	1.7392	-3.1526	0.7092	0.5872
	(0.3677)	(0.3548)	(0.3417)	(0.3515)	(0.3369)
000020	-0.9693	1.2903	1.2739	0	-0.1584
	(0.3107)	(0.2856)	(0.3226)	(0.3173)	(0.2956)
000024	5.2146	-2.6385	-2.2421	0.1999	0.4979
	(0.2695)	(0.2761)	(0.2942)	(0.2991)	(0.2872)
000025	-0.489	0.6515	1.9293	0.318	1.105
	(0.2971)	(0.2889)	(0.3007)	(0.3213)	(0.2961)
000026	-1.888	0.8855	4.3137	-0.2415	-0.6064
	(0.3395)	(0.2979)	(0.321)	(0.331)	(0.3096)

000028	-2.8446	-1.2612	0.3536	-0.5308	-0.2072
	(0.3225)	(0.2668)	(0.277)	(0.2893)	(0.2727)
000029	-1.9657	-0.2484	0.2484	-0.7472	0.4988
	(0.3322)	(0.3363)	(0.3266)	(0.3201)	(0.3167)
000037	-0.2378	0.4751	0.7084	0.4695	1.1642
	(0.2318)	(0.2245)	(0.2257)	(0.2252)	(0.2213)
000045	-1.2403	3.3746	7.4108	0	6.8993
	(0.2676)	(0.2689)	(0.2868)	(0.3161)	(0.3565)
000055	-1.373	0.9174	1.5855	-0.9029	-0.4545
	(0.2685)	(0.2744)	(0.2664)	(0.2618)	(0.2707)
000056	***-2.5752***	2.0797	-0.071	0.5666	4.0822
	(0.5056)	(0.3854)	(0.4688)	(0.4155)	(0.4137)
000413	1.1618	2.4451	-0.0805	-1.7067	0.6536
	(0.2865)	(0.291)	(0.3108)	(0.2745)	(0.2589)
000418	-1.4974	-1.5201	0.2186	-0.7671	-1.6639
	(0.2952)	(0.2754)	(0.2739)	(0.2806)	(0.2738)
000429	-0.317	0	0.6329	0.315	-0.6309
	(0.1653)	(0.1739)	(0.1617)	(0.152)	(0.1448)
000488	-1.2063	-0.7308	-0.4902	0.2454	0.2448
	(0.1911)	(0.2004)	(0.1936)	(0.1869)	(0.1788)
000513	-2.6202	9.531	***6.6146***	-4.6496	1.1503
	(0.2908)	(0.2686)	***(0.7791)***	(0.3285)	(0.3279)
000521	-1.5958	0.5348	0.7968	1.0526	0.7823
	(0.2534)	(0.2371)	(0.2464)	(0.2463)	(0.246)
000530	0.2937	3.4586	-0.7107	0.427	0.5666
	(0.3044)	(0.2981)	(0.2776)	(0.2979)	(0.2894)
000539	-1.0187	-1.0292	1.7094	-0.6803	-0.8569
	(0.1963)	(0.1762)	(0.1718)	(0.1911)	(0.1723)
000541	-1.214	0	1.063	0.9023	0
	(0.2257)	(0.2153)	(0.2092)	(0.2066)	(0.2003)
000550	-0.167	-0.8392	0	0.9505	-1.627
	(0.3308)	(0.2821)	(0.2669)	(0.2698)	(0.2783)
000553	-0.3868	1.3475	0	9.4789	***-1.2249***
	(0.2278)	(0.2433)	(0.2345)	(0.2358)	***(0.5562)***
000570	-0.3604	1.9661	-0.5324	1.4135	0.6993
	(0.2672)	(0.2498)	(0.2739)	(0.2421)	(0.2562)
000581	-2.6685	-1.8194	1.9481	1.5949	-1.2419
	(0.2542)	(0.2367)	(0.2419)	(0.2724)	(0.2678)
000596	-2.9005	1.6972	6.3763	3.27	-0.5376
	(0.3521)	(0.2966)	(0.3556)	(0.4416)	(0.4106)
000625	-2.2815	-0.3082	-2.0266	0.7843	-0.7843
	(0.3985)	(0.3259)	(0.3371)	(0.3162)	(0.3373)
000725	-1.3304	0.8889	3.0503	-1.2959	0
	(0.2386)	(0.2347)	(0.2289)	(0.2654)	(0.2553)
000726	-0.7616	0.6098	2.4025	-0.7446	3.2356
	(0.186)	(0.1787)	(0.1821)	(0.1948)	(0.181)
000761	4.3172	-1.4185	0.5698	-1.1429	1.4266
	(0.2153)	(0.2152)	(0.2197)	(0.2181)	(0.2184)
000869	0.0638	0.657	1.8003	0.5999	-0.0619
	(0.2485)	(0.2492)	(0.247)	(0.2551)	(0.2389)
200002	6.6478	0	-0.0619	0.2472	4.2302
	(0.3086)	(0.4416)	(0.3504)	(0.3427)	(0.3366)
200011	2.2264	3.4268	-3.6105	-3.3648	2.2557
	(0.3287)	(0.3078)	(0.3194)	(0.3035)	(0.301)
200016	1.7316	5.022	-0.8197	-2.0791	0.8368
	(0.2024)	(0.2026)	(0.2464)	(0.2714)	(0.276)
200018	0.3384	4.9433	***2.5398***	-1.8988	1.2699
	(0.2364)	(0.2202)	***(0.7508)***	(0.4381)	(0.4142)
200019	3.331	2.1606	0.7605	3.7179	2.1661
	(0.2393)	(0.2616)	(0.2765)	(0.2633)	(0.2871)

200020	3.4006 (0.2644)	6.4728 (0.2336)	-0.8584 (0.2752)	-3.212 (0.3052)	1.4728 (0.3142)
200024	4.1553 (0.3961)	-2.1277 (0.3618)	-2.5042 (0.351)	-2.644 (0.3441)	3.1572 (0.3398)
200025	3.2595 (0.3179)	4.5592 (0.3211)	-0.2789 (0.3371)	-3.4094 (0.3285)	2.2858 (0.3608)
200026	4.7939 (0.2642)	2.9352 (0.3971)	6.4022 (0.3364)	-3.6846 (0.4772)	1.3316 (0.3086)
200028	4.8698 (0.3403)	8.609 (0.392)	***-1.636*** ***(0.6492)***	0.0687 (0.3099)	3.5423 (0.3128)
200029	1.062 (0.2826)	4.8119 (0.2802)	-2.034 (0.2547)	-3.8399 (0.3352)	2.8072 (0.3338)
200037	1.6394 (0.2111)	4.7628 (0.2156)	0.7722 (0.2575)	-1.5504 (0.2592)	0.7782 (0.2557)
200045	1.7544 (0.2705)	5.2922 (0.2671)	5.8074 (0.3269)	-1.5687 (0.3563)	2.1506 (0.3091)
200055	0.7874 (0.2608)	6.0855 (0.2615)	0.7353 (0.2845)	-2.2223 (0.304)	1.1173 (0.3134)
200056	-1.5135 (0.3339)	4.8894 (0.3136)	***-0.2077*** ***(0.6597)***	0.6218 (0.435)	2.5499 (0.4211)
200413	4.8865 (0.2859)	6.2114 (0.3853)	2.6263 (0.4032)	-0.5472 (0.3636)	0.6835 (0.3173)
200418	0.5984 (0.3054)	3.5174 (0.2784)	-1.509 (0.3259)	-1.651 (0.2679)	0 (0.2572)
200429	2.1979 (0.1601)	4.256 (0.1656)	-2.1053 (0.1838)	-2.5136 (0.2875)	1.8019 (0.2871)
200488	2.3811 (0.1732)	3.7522 (0.1931)	-2.0029 (0.2478)	-2.9328 (0.2551)	0.8889 (0.2574)
200513	1.6388 (0.2741)	9.531 (0.2651)	***9.5223*** ***(0.9754)***	***-5.4619*** ***(0.8799)***	***-0.0617*** ***(0.5287)***
200521	2.8411 (0.2432)	5.98 (0.2634)	-2.4033 (0.3309)	-1.6349 (0.2982)	2.9772 (0.2944)
200530	2.4293 (0.2157)	7.6961 (0.2173)	-2.8171 (0.2399)	-2.3122 (0.3037)	1.5474 (0.2922)
200539	1.6807 (0.282)	2.4693 (0.2486)	-0.8163 (0.2554)	-2.2799 (0.2438)	-0.6309 (0.2413)
200541	3.3585 (0.2035)	3.9574 (0.2243)	-1.6 (0.2698)	-1.6261 (0.2772)	0.9066 (0.2622)
200550	5.26 (0.2455)	0.8593 (0.3816)	-1.9984 (0.2909)	-0.1638 (0.252)	0 (0.264)
200553	0.3231 (0.229)	7.157 (0.2104)	-1.5129 (0.3484)	6.7773 (0.3209)	0 (0.37)
200570	0.8392 (0.2575)	5.1572 (0.2396)	1.0526 (0.3442)	-2.9219 (0.2789)	2.3969 (0.2431)
200581	3.4101 (0.3852)	0 (0.3905)	1.3397 (0.3552)	-1.5712 (0.3555)	-0.8144 (0.3258)
200596	5.0745 (0.3361)	7.0727 (0.394)	1.3086 (0.4286)	0.1709 (0.3562)	0.0683 (0.3257)
200625	7.5257 (0.3467)	7.9879 (0.4285)	-2.3906 (0.4214)	-4.3261 (0.3499)	0.8386 (0.3323)
200725	0.6473 (0.3156)	5.6441 (0.2861)	3.0032 (0.3469)	-3.0032 (0.3316)	1.2121 (0.3124)
200726	1.4286 (0.1081)	2.3827 (0.1051)	-0.8345 (0.1192)	-1.9747 (0.1485)	1.4145 (0.1721)
200761	5.2842 (0.1792)	2.541 (0.1916)	0 (0.2207)	-2.9093 (0.2091)	1.1009 (0.1976)
200869	9.535 (0.2475)	***0.9901*** ***(0.5003)***	1.4476 (0.3606)	-3.3573 (0.3551)	-2.8108 (0.3156)

Chapter 3

Price Discovery and Volatility Spillover for AB-shares on the Shanghai and Shenzhen Stock Exchanges: Intraday Study

3.1 Introduction

In the study of daily data reported in Chapter 2, it has been shown that the delayed price discovery hypothesis and the volatility spillover hypothesis cannot be rejected. More specifically, there is no price reversal or systematic reduction of volatility after price-limit-hits. As discussed in Chapter 2, the rationale behind price limits is to see price recovery after a downward movement and to prevent trading from overreaction after an upward movement. The daily results, however, show that prices continue to move in the same direction and volatility is increased after price-limit-hits. The results suggest that investors will trade in a volatile stock market but at a higher cost. On the one hand investors need to pay extra in order to purchase shares on the day after upper price-limit-hits, on the other hand investors have to place an order with a lower price in order to sell shares on the day after lower price-limit-hits. These results are important for investors who can form their trading strategies, as well as for regulators who can evaluate price limit performance. The study of intraday data is also important because there are obvious differences between the daily and intraday data. Any decisions based on the results of daily data may not be feasible or correct in the context of intraday data.

It is important to note that the effects of price limits on price behaviour and volatility may not be the same for the daily and intraday data. First, there is a long overnight period for investors to assimilate information after price-limit-hits on the previous day. The period gives investors plenty of time to react on the signal of extreme price movement sent out by the price-limit-hits. Bikhchandani, Hirshleifer and Welch (1992) put forward the concept of the "*informational cascade*" that describes the existence of correlated behaviour by investors. This correlated behaviour is well known for causing herding behaviour (for example, the arrival of a bid would attract competing bids and drive up the price[16]). Chiang and Zheng (2010) use daily data from 18 countries including China and present strong evidence of herding behaviour in most of them. This explains price continuation after price-limit-hits, as shown in Chapter 2. Secondly, the interday volatility and intraday volatility can be quite different. French and Roll (1986) show that trading hours' volatility is higher than non-trading hours' volatility due to the arrival of information during a trading session. From a practical point of view, the maximum price fluctuation between trading days is 10%, but the fluctuation within a trading day can be greater than that. For example, if a closing price on day *t* is 10 RMB, the possible range of price fluctuation on day *T+1* will be 9 RMB to 11 RMB, that is up to 22%. Lastly, intraday data provides more detail about price-limit-hits. With intraday data, price-limit-hits can be categorised into three types: single price-limit-hit, consecutive price-limit-hit and closing price-limit-hit (Kim and Yang, 2008). As stated by the Brady Commission Report (1988), price limits provide investors with a cooling-off period to re-evaluate market information. Kim and Yang (2008) hypothesise that price limits only work when there are consecutive price-limit-hits. This is because a single price-limit-hit does not provide adequate time for investors to reassess market information. Thus, these three differences motivate further research in the intraday effects of price limits on price behaviour and volatility.

Research on the effects of price limits based on intraday is very limited. Cho, Russell, Tiao and Tsay (2003), Wong, Chang and Tu (2009) and Hsieh, Kim and Yang (2009) study the *ex-ante* effect of price limits in the Taiwan stock market. They all show that there is a "*magnet effect*" which induces the price of near-limit-hit to reach the limits. Lee and Chou (2004) find that in the Taiwan stock market intraday return patterns are determined by the initial direction of the price movement rather than by price limits. As noted above, Kim and Yang (2008) identify three types of price limits: single, consecutive and closing price-limits-hits. They argue that the effects of price limits depend on the types of price-limit-hits. In the Taiwan stock market, they find that volatility decreases only after consecutive

---

[16] In practice, for example, existing bid orders with a price of 10RMB will be driven up by the arrival of new bid orders with prices of 10.01RMB, 10.02RMB *et al.*

price-limit-hits. Seasholes and Wu (2007) conduct the first intraday study of price limits on the Shanghai Stock Exchange (SSE). They point out that there is an obvious order-imbalance caused by upper price-limit-hits. Due to data unavailability, Seasholes and Wu (2007) cannot generate the corresponding results for lower price-limit-hits. Different from Seasholes and Wu (2007), the study reported in this chapter estimates the effects of price limits on returns and volatility on both of the Chinese stock exchanges for both upper and lower limit-hits.

The superiority of the truncated-GARCH-M model has been demonstrated for daily data in Chapter 2. It is obvious that the truncated model takes the fact of truncation into account. In this chapter, the truncated-GARCH-M model is also found to be better than the modified-GARCH-M model empirically; it has a higher value of log-likelihood function and a stable R-squared. According to the results based on the truncated-GARCH-M model using intraday data, the price neither continues to move in the same direction nor the opposite direction after price-limit-hits. The tail probability, however, implies a high probability of price continuation. The inconsistent findings are due to the fact that information is not widely disseminated to most investors. In other words, the tail probability is not a good indicator for intraday data. However, volatility increases significantly. Overall, the delay price discovery hypothesis is rejected but the volatility spillover hypothesis is not rejected. The increase of volatility contradicts the results of Kim and Yang (2008) who show a decrease in volatility. Kim and Yang define volatility from three ways: (1) the standard deviation of returns; (2) the mean of absolute returns; (3) the log of high price to low price. The volatility measures do not consider the time-varying volatility. As discussed in Chapter 2, Chen (1993) find that price limits reduce volatility when it is measured by the standard deviation of returns; however, he also shows that price limits have no effect on volatility when it is estimated is the form of ARCH error.

The rejection of the delayed price discovery hypothesis might be related to the fact that investors do not have enough time to absorb the information and then react on the signal of extreme price movement sent out by price-limit-hits. Busse and Green (2002) show that positive (negative) media coverage for individual stocks will attract buyer (seller) to initiate the trades. In China, there is widespread media coverage for the stocks which hit price limits on the previous day. The study of daily data has shown price continuation after price-limit-hits. Thus, it is hard to say that price limits do not delay price discovery with such a short trading period. If price limits are effective, price reversal should be observed after price-limit-hits, which suggests price recovery after lower price-limit-hits and avoidance of market overreaction after upper price-limit-hits. However, owing to the possibility of more than 10% fluctuation within a trading day, the volatility increase is more substantial in the intraday study. Hence, the volatility spillover hypothesis is not rejected. Last but not least, both daily and intraday studies illustrate that the volatility increase is more prevalent in A-shares on both exchanges. That is to say, domestic investors are more sensitive to price-limit-hits.

As discussed in Chapter 2, studying the effects of price limits is important for both investors and regulators. According to results of daily data, on the one hand a long strategy is suggested to the investor when there is an upper price-limit-hit, on the other hand regulators could consider whether is worthwhile to implement price limits in the Chinese stock market or whether further development of the system of limits and accompanying regulation is indicated. In this chapter, price limits do not provide a clue about the intraday return patterns but suggests a greater volatility. In addition, price continuation after price-limit-hits is consistent with the findings of tail probabilities in the study of daily data, which lays the foundation for the trading rules in daily data. However, this is not the case for the intraday data. Therefore, there is no a well-defined trading strategy but investors should be aware of the high risk brought by price-limit-hits. The intraday volatility is aggravated by price limits. This is not the desired result. So, the regulators need to carefully evaluate whether investors can benefit from price limits.

The reminder of this chapter is organised as follows. Section 3.2 reviews the existing literature. Section 3.3 describes the data. Section 3.4 presents the methodology. Section 3.5 discusses the empirical results. Section 3.6 discusses the results for the study of daily and intraday data. Section 3.7 shows the magnet effect and Section 3.8 concludes.

3.2 Literature Review

The main objective of this section is to review the empirical evidence of the effects of price limits on price behaviour and volatility from the perspective of a high frequency data. The detailed theoretical background and the empirical evidence on low frequency data are discussed in section 2.2 of Chapter 2. Section 3.2.1 reviews the empirical evidence. Section 3.2.2 shows other studies. Section 3.2.3 summarises.

3.2.1 Empirical Evidence

This section reviews the empirical evidence of the effects of price limits on price behavior and volatility from international stock markets.

3.2.1.1 Taiwan

Lee and Chou (2004) conduct an intraday study based on the Taiwan stock market. The minute-by-minute transaction data of 100 stocks from 30th June 1997 to 31st December 1997 are selected. Similar to Kim and Rhee (1997), they compare the price limit performance between price-limit-hit stock and near-price-limit-hit stock, but the comparison is based on an intraday framework, for example 30 minutes before and after the events. Lee and Chou apply variance ratio to test the return autocorrelation before and after the events. They find that price limits do not affect the return dynamics because the results of the groups are not significantly different from each other. The return pattern is determined by the initial direction of the price movement.

Kim and Yang (2008) employ intraday data including detailed price information and transaction records in 2000 on 439 stocks. The intraday data allows them to identify three types of price-limit-hit: closing price-limits-hit, single price-limit-hit and consecutive price-limit-hit. Closing price-limit-hit means that no trades are executed in the following trading hours, while single and consecutive price-limit-hits mean that the current maximum or minimum transaction price is followed by different transaction price and equal transaction price, respectively. They hypothesise that price limits only work when consecutive prices hit the limits. This is because single price-limit-hit does not provide adequate time for investors to reassess market information. Moreover, investors have sufficient time to reappraise the information in an overnight period in terms of closing price-limit-hit. To test their hypothesis, they estimate the volatility before and after the limit-hits. The volatility is measured as the standard deviation of returns, mean of absolute returns and log of high price to low price. They find that price limits moderate volatility only when prices consecutively hit the limits.

3.2.1.2 Spain

The Spanish stock market combines price limits system with trading halts system. More specifically, when a stock reaches its price limits, a tender offer emerges or any shocking news appears, the relative authority has the right to halt the trading temporarily in order to allow the public to be aware of the arrival of the information (Kim, Yagüe and Yang, 2008). Kim, Yagüe and Yang argue that although the function of price limits and trading halts is similar, trading halts are not mechanical. In a sense, trading halts perform better than price limits since trading halts are executed by the authority after careful consideration. They use detailed trade and quote data from 1st January 1998 to 30th April 2001. The data contain 48 firms with 66 events of trading halts and 76 firms with 160 events of price limits. The volatility is measured as log of last middle price to first middle price, log of high price to low price, standard deviation of trade price and standard deviation of middle price. They find that price limits significantly increase volatility. They also conduct an event study in the context of the market model and show that prices continue to move in the same direction after upper price-limits-hits but prices reverse after lower price-limits-hits.

3.2.1.3 Mainland China

Seasholes and Wu (2007) conduct the first intraday study on price limits on the SSE. Detailed transaction data around upper price-limit-hits from 2nd January 2001 to 25th July 2003 are selected. Due to the limitation of the dataset, the transaction data only cover the data which are one day before (*t-1*) and after (*t+1*) the upper price-limit-hits. They study individual trading behaviour by analysing order imbalance. On the day of an upper limit-hit, sell orders dominate buy orders because some investors sell the stocks to capture the immediate profits. On date *t+1* the situation, however, is completely changed that buy orders dominate the sell order. This well explains price continuation after upper limit-hits on day *t+1*.

3.2.2 Other Studies

Most studies emphasise on the *ex-post* effect of price limits, while Cho, Russell, Tiao and Tsay (2003), Wong, Chang and Tu (2009), Wong, Liu and Zeng (2009) and Hsieh, Kim and Yang (2009) study the *ex-ante* effect of price limits. They name the *ex-ante* effect of price limits as the "*magnet effect*" which induces the prices of near-limit-hits to reach the limits: prices are pulled to the limits. Subrahmanyam (1994) attributes this phenomenon to those strategic traders who have a strong desire to secure the trades in advance.

Cho *et al.* (2003), Wong, Chang and Tu (2009) use intraday data in the Taiwan stock market over the period 3 Jan 1998-20 Mar 1999 and 1 Jan 2004-31 Dec 2004, respectively. 5-mins returns are constructed. Cho *et al.* (2003) find that there is a strong tendency for the prices moving toward upper limits when they are close to the upper limits, but a weak tendency for the prices moving toward lower limits. Wong, Chang and Tu (2009) show the magnet effect at both limits. Wong, Liu and Zeng (2009) show similar findings as Wong, Chang and Tu in the Shanghai stock market over the period 4 Jan 2002-31 Dec 2002. Different from the other studies, Hsieh, Kim and Yang (2009) provide a theoretical explanation of the magnet effect based on the intraday data in 2000 in Taiwan stock market. They apply a logit approach and find that the probability of price moving up (down) increases significantly when the price approaches its upper (lower) limits.

3.2.3 Summary

This section reviews the studies on the effect of price limits on price behaviour and volatility from the viewpoint of a high frequency data. Research on the effects of price limits based on intraday data is very limited. Similar to the study of daily data, a comparison of price limit performance between price-limit-hit stock and near-price-limit-hit stock is widely applied. From the existing findings, there is no strong evidence either to support or oppose price limits.

3.3 Data

Different from the daily data which is relatively easy to organise and process, intraday data requires a large amount of time to deal with: the volume is very large and the data structures are much more complex. So, this section starts with introducing the background to the data. Section 3.3.2 describes the data.

3.3.1 Data Background

The intraday data is stored in the txt files (for example 'SHL1_TAQ_600000_201001.txt'). Each file contains the trading data for one stock for one month. There are about 80,500 files whose total size is about 828GB. The files are separated into two categories, the Shanghai Stock Exchange (SSE) and Shenzhen Stock Exchange (SZSE). Each category includes all the A- and B-shares of that exchange. As can be seen from Table 1.3, the codes of A-shares (B-shares) start from 600000 (900901) on the SSE and 000001 (200002) on the SZSE as of December 2012. AB-shares are selected and saved in a folder. As described in Chapter 2, there is no particular order of codes for AB-shares. MATLAB software is used to identify and select the AB-shares. In addition, MATLAB has been used for all the computational work in this thesis.

After selecting the AB-shares, there are about 6,045 .txt files left and the total size is about 40 GB. To prepare the data for use, the .txt files for each share are imported into MATLAB and then exported as a MAT-file. This has the advantage of a relatively small size and quick loading speed. For example, stock 600679 has 36 .txt files with a total size of 350MB. The corresponding MAT-file only requires 115MB. In total, there are 172 MAT-files with an overall size of about 8.55GB. It is important to note that even though the data size is significantly reduced from 40GB to 8.55GB, analysing the dataset still imposes a heavy computational burden on a personal computer[17]. To relieve some of the computational burden, only the required variables are extracted from each MAT-file and then merged into two new MAT-files. For example, if the required variables are trading price and volume, one new MAT-file will contain all AB-shares' trading price and volume for one exchange.

3.3.2 Data Description

To examine the effects of price limits on price behaviour and volatility, the study employs intraday trade and quote (TAQ) data that covers the period from 4th January 2010 to 31st December 2012. During this study period, 44 companies issued both A- and B- shares on the SSE, while there are 42 such firms on the SZSE. Due to the fact that either (i) A- or B-share do not experience price-limit-hits; or (ii) they are traded as ST-shares, a final dataset of 37 companies on the SSE and 32 companies on the SZSE are used. The daily closing price, trade price, trading volume, trading date and time are collected from the China Securities Market Level-1 Trade & Quote Research Database which is provided by Guo Tai An (GTA), a national high-tech company. The logarithmic returns are calculated in the usual way using trade prices. The turnover ratio is defined as the latest trading turnover divided by daily market value. The latest trade price multiply by the latest trading volume defines the latest trading turnover.

In daily data, the daily closing price determines whether there is a price-limit-hit. In other words, the price can only hit either the upper limit or the lower limit. In intraday data, however, the trade price is updated over time in a trading day. It is possible to identify three types of price-limit-hits: closing price-limit-hit, single price-limit-hit and consecutive price-limit-hit. A closing price-limit-hit appears when there are no other trades during the rest of the day after price hits the limit. A single price-limit-hit occurs when only one of two consecutive trade prices hits the limits, but the later trades occur within the price limits. A consecutive price-limit-hit occurs when two or more consecutive trade prices hit the limits. Therefore, a trading day can have a combination of single and consecutive price-limit-hits, but these two events and the closing price-limit-hit are mutually exclusive. To

[17] The PC used in the PhD study is quite advanced: i7 processor, 256 GB SSD hard drive, 24GB memory.

illustrate the three types of price limits hit, two examples based on artificial data are shown in Panels A and B of Table 3.1.

As can be seen from Panel A of Table 3.1, there is a single upper price-limit-hit at 09:30:35 when the trade price reaches the upper limits. A consecutive upper price-limit-hit occurs at 09:31:00, 09:31:03 and 09:31:07. Thus, the hitting frequency in this consecutive price limits is three. In Panel B, the closing price-limit-hit occurs at 09:30:35 and there is no other trade during the rest of the day. For the purpose of estimation, the data in Panel A of Table 3.1 are consolidated into the format shown in Panel C. It is important to note that the dummy variable for price limits is transformed to a score variable. It is discussed in the model section below.

[Insert Table 3.1 about here]

There are two trading sessions in the Chinese stock market. The morning session is from 9:30:00 to 11:30:00, while the afternoon session is from 13:00:00 to 15:00:00. Different from the daily data, intraday data provide detailed information regarding which session has the limit-hits. Table 3.2 and 3.3 show the number of closing and single price-limits-hits in both sessions for the firms in the dataset. In addition, Tables 3.2 and 3.3 display the number of consecutive price-limit-hits with 10 categories of hitting frequencies.

The 37 A-shares on the SSE that experienced price-limit-hits during the study period are shown in the Panel A of Table 3.2. There were a total of 25,347 trading days, which suggests that each share had an average of 228 (=25,347÷37÷3) trading days per year. For the events of price-limit-hits, these shares did not experience closing price-limit-hits. They had 362 (140) single upper (lower) price-limit-hits in the morning trading session, while 736 (467) in the afternoon trading session. Moreover, they had 327 (101) consecutive upper (lower) price-limit-hits with a hitting frequency of 2 to 10 in the morning session, while 547 (339) with the same hitting frequency in the afternoon session. MA means that morning trading session closes at limit-hit and the following afternoon trading session also opens at a limit-hit. For instance, two in the MA with the hitting frequency 2 to 10 indicate that limit-hits transactions at the end of two morning sessions were followed by limit=hits transactions at the afternoon sessions and the total number of transactions was less than 10 in each MA. For consecutive price-limit-hit, same explanation applies to other categories of frequencies. Similar results for the SZSE is shown in Table 3.3.

According to Tables 3.2 and 3.3, for both exchanges the afternoon session dominates the morning session no matter which limits are hit. A-shares have more limit-hits than B shares. Furthermore, for both A and B shares, shares on the SSE are more inclined to hit limits than shares on the SZSE. There is a large number of upper consecutive price-limit-hits in MA, 117 in SSE A-shares and 65 in SZSE A-shares, with a frequency greater than 100. This may imply that if there are many limit-hits transactions at the end of morning session, investors are more eager to buy when the market is reopened in the afternoon. It is interesting to find that there are only 6 for B-shares on both exchanges, which may suggest that local investors are more sensitive to the price-limit-hits. According to the Chi-square tests shown in Appendix 3.1, the afternoon session is significantly greater the morning session no matter which limits are hit on the SSE at the 0.1% significance level. Moreover, limit-hits of A-shares are significantly greater than those of B shares on both exchanges at the 0.1% significance level.

[Insert Table 3.2 & 3.3 about here]

3.4 Methodology

This section first introduces the models. It then discusses the heavy computational burden based on intraday data.

3.4.1 Model

Similar to the models used in the daily study in Chapter 2, the model is constructed as follows

$$R_t = \mu_t + \varepsilon_t \qquad \varepsilon_t | \ \Omega_t \sim N(0, \sigma_t^2), \tag{3.1}$$

Or

$$R_t = \mu_t + \varepsilon_t \qquad \varepsilon_t | \Omega_t \sim TN(0, \sigma_t^2), \tag{3.2}$$

with

$$\mu_t = \beta_1 + (\beta_2 + \beta_3 Tor_{t-1} + \beta_4 \sigma_{t-1} + \beta_5 SU_{t-1} + \beta_6 SL_{t-1} + \beta_7 SU9_{t-1} + \beta_8 SL9_{t-1}) R_{t-1} ,$$

$$\sigma_t^2 = \beta_9 + \beta_{10} \varepsilon_{t-1}^2 + \beta_{11} \sigma_{t-1}^2 + \beta_{12} SU_{t-1} + \beta_{13} SL_{t-1} + \beta_{14} SU9_{t-1} + \beta_{15} SL9_{t-1} .$$

where Ω_t denotes information available at time t. R_t is the latest trade return at time *t*. Tor_{t-1} is the latest turnover ratio at time *t-1*. SU_{t-1} ($SU9_{t-1}$) and SL_{t-1} ($SL9_{t-1}$) are upper (90% upper) and lower (90% lower) price-limit-hit score variables as illustrated in Panel C of Table 3.1. Estimated parameters are denoted with the $\wedge$ symbol and referred to collectively as $\hat{\theta} = \{\hat{\beta}_1, \hat{\beta}_2, \ldots, \hat{\beta}_{15}\}$. *TN* denotes the truncated normal distribution.

The null hypotheses for upper price limits that are tested are as follows:

Price continuation (PC): $H_0: \beta_2 + \beta_5 = 0$ vs $H_1: \beta_2 + \beta_5 > 0$ and $H_0: \beta_5 = \beta_7$ vs $H_1: \beta_5 > \beta_7$.

Price reversal (PR): $H_0: \beta_2 + \beta_5 = 0$ vs $H_1: \beta_2 + \beta_5 < 0$ and $H_0: \beta_5 = \beta_7$ vs $H_1: \beta_5 < \beta_7$.

Volatility increase (VI): $H_0: \beta_{12} = 0$ vs $H_1: \beta_{12} > 0$ and $H_0: \beta_{12} = \beta_{14}$ vs $H_1: \beta_{12} > \beta_{14}$.

Volatility decrease (VD): $H_0: \beta_{12} = 0$ vs $H_1: \beta_{12} < 0$ and $H_0: \beta_{12} = \beta_{14}$ vs $H_1: \beta_{12} < \beta_{14}$.

The null hypotheses for lower price limits that are tested are as follows:

Price continuation (PC): $H_0: \beta_2 + \beta_6 = 0$ vs $H_1: \beta_2 + \beta_6 < 0$ and $H_0: \beta_6 = \beta_8$ vs $H_1: \beta_6 < \beta_8$.

Price reversal (PR): $H_0: \beta_2 + \beta_6 = 0$ vs $H_1: \beta_2 + \beta_6 > 0$ and $H_0: \beta_6 = \beta_8$ vs $H_1: \beta_6 > \beta_8$.

Volatility increase (VI): $H_0: \beta_{13} = 0$ vs $H_1: \beta_{13} > 0$ and $H_0: \beta_{13} = \beta_{15}$ vs $H_1: \beta_{13} > \beta_{15}$.

Volatility decrease (VD): $H_0: \beta_{13} = 0$ vs $H_1: \beta_{13} < 0$ and $H_0: \beta_{13} = \beta_{15}$ vs $H_1: \beta_{13} < \beta_{15}$.

A comparison of these variables between daily and intraday data is presented in Table 3.4. The major differences are the intraday latest trading price P_{lt} and turnover To_{lt} at time *t* against the daily closing price P_t and turnover To_t on day *t*. Moreover, the price limit dummies are transformed to a score variable in intraday data as shown in Panel C of Table 3.1. That is to say, a significant coefficient value of price limit dummy not only suggests the effect of price limits but also highlight the influence of consecutive price-limit-hit. For example, $\hat{\beta}_5 \times 1$ is the effect from single upper price-limit-hit and $\hat{\beta}_5 \times (\text{value} > 1)$ is the effect from consecutive upper price-limit-hit. If $\hat{\beta}_5$ is significantly different from zero, the consecutive upper price-limit-hit would have a stronger effect. The same logic is applied to lower price-limit-hit. Furthermore, it is important to note that the time intervals between trades are most unequal in general. Following Engle (2002) and standard practice, the variables in the model are scaled by division by the square root of the time interval

[Insert Table 3.4 about here]

Owing to the fact that the morning trading behaviour is different from the afternoon trading behaviour (Tian & Guo, 2007), a trading session dummy variable (morning trading = 1, afternoon trading = 0) is introduced to equation (3.1) and (3.2). The model is revised to incorporate the morning dummy variable as follows

$$R_t = \mu_t + \varepsilon_t \quad \varepsilon_t | \; \Omega_t \sim N(0, \sigma_t^2), \tag{3.3}$$

Or

$$R_t = \mu_t + \varepsilon_t \quad \varepsilon_t | \; \Omega_t \sim TN(0, \sigma_t^2), \tag{3.4}$$

with

$$\mu_t = \beta_1 + (\beta_2 + \beta_3 Tor_{t-1} + \beta_4 \sigma_{t-1} + \beta_5 SU_{t-1} + \beta_6 SL_{t-1} + \beta_7 SU9_{t-1} + \beta_8 SL9_{t-1} + \beta_9 M) R_{t-1} \,,$$
$$\sigma_t^2 = \beta_{10} + \beta_{11} \varepsilon_{t-1}^2 + \beta_{12} \sigma_{t-1}^2 + \beta_{13} SU_{t-1} + \beta_{14} SL_{t-1} + \beta_{15} SU9_{t-1} + \beta_{16} SL9_{t-1} \,.$$

where *M* denotes the trading session dummy variable taking a value of one if the trade occurs in the morning session, otherwise zero.

Due to a large amount of time required to deal with intraday data. The model specification in this chapter follows the study of daily data. A discussion of the heavy computational burden is presented in the following section.

3.4.2 Heavy Computational Burden

The number of observations is summarised in Table 3.5[18]. According to the mean values, there are about 725,990 (876,618) and 141,908 (150,909) observations for an A-share and B-share on the SSE (SZSE), respectively. The 725,990 observations are almost equal to 2,900[19] years' daily observations of a share. The very large dataset significantly increases the estimation time, especially when more variables are included in the model. For example, there are 16 estimated parameters at equation (3.4), $\hat{\theta} = \{\hat{\beta}_1, \hat{\beta}_2, \dots, \hat{\beta}_{16}\}$, then a share with 725,990 observations has a data size of 725,990-by-16. It is important to note that the estimated parameters are obtained by maximizing the log-likelihood function shown in Chapter 2. The complex log-likelihood function of the truncated-GARCH-M aggravates the computational burden.

[Insert Table 3.5 about here]

3.5 Empirical Results

The section first compares the results between the modified- and truncated-GARCH-M models then discusses the price discovery and volatility spillover for AB-shares based on the truncated model. The tables in this section contain results at 5%, 1% and 0.1% significance level. The evaluation is done at 0.1% significance level which is the appropriate level of intra-day data.

3.5.1 Comparison of the Modified- and Truncated-GARCH-M Models

Both models have incorporated dummy variables, if the dummy variables indeed add values to the models, the values of log likelihood function from the unrestricted model would be significantly higher than the restricted model that all the coefficients of dummy variables equal to 0. Restricted model is

$$\mu_t = \beta_1 + (\beta_2 + \beta_3 Tor_{t-1} + \beta_4 \sigma_{t-1}) R_{t-1}, \quad (3.5)$$

[18] Details for individual shares are illustrated in Appendix 3.2.

[19] There are about 250 trading days in a year, so 725,900/250=2900 years.

$$\sigma_t^2 = \beta_5 + \beta_6 \varepsilon_{t-1}^2 + \beta_7 \sigma_{t-1}^2$$

To compare the unrestricted and restricted models, the likelihood ratio test has been conducted. The large likelihood statistics reported in Table 3.6 suggest that the price limits dummy variables indeed have certain explanatory power on price behaviour and volatility.

[Insert Table 3.6 about here]

The results of the model (3.1) and (3.2) are shown in Table 3.7 for the SSE and Table 3.8 for the SZSE. It can be seen that the increase of volatility after price-limit-hits are presented from both models on both exchanges. For example, one the one hand 25 (16) out of 37 A-shares experience volatility increase after upper (lower) price-limit-hits on the SSE, while 19 (7) out of 32 A-shares also show volatility increase after upper (lower) price-limit-hits on the SZSE from the truncated-GARCH-M model. On the other hand, there are 23 (13) A-shares for the SSE and 27 (12) A-shares for the SZSE from the modified-GARCH-M model. The same pattern is displayed in B-shares.

From Tables 3.7 and 3.8, it can also be seen that there is no obvious price continuation after price-limit-hits. One the one hand the truncated-GARCH-M model shows that there are 2 (1) A-shares experience price continuation after upper (lower) price-limit-hits on the SSE, while there is 1 (0) A-share on the SZSE. On the other hand, the modified-GARCH-M shows 6 (0) A-shares on the SSE and 7 (1) A-shares on the SZSE. The same pattern is displayed in B-shares.

[Insert Tables 3.7 and 3.8 about here]

The price continuation suggests that price limits delay price discovery. This has been found in Chapter 2 from both models. It is important to note that, however, the effect of price limits on the models for return is less severe for intraday data than it is for daily data. For example, the differences in the number of significant results at the 0.1% level for TGM and MGM for daily and intraday are shown below.

	SSE A		SSE B		SZSE A		SZSE B	
MGM - TGM	Daily	Intraday	Daily	Intraday	Daily	Intraday	Daily	Intraday
Upper	-6	-3	-4	0	0	-2	-2	-1
Lower	-4	-2	-5	1	-5	0	-3	-1

The less difference for intraday data could be due the fact that investors do not have enough time to absorb the information and then react on the signal of extreme price movement sent out by price-limit-hits. Busse and Green (2002) show that media coverage for individual stocks will attract investor to initiate the trades. In China, there is widespread media coverage for the stocks which hit price limits on the previous day. Investors will be attracted by the media coverage and then induce the price continuation. Therefore, lack of intraday information dissemination make little difference between the truncated-GARCH-M and modified-GARCH-M model in terms of price continuation.

In addition to test the unrestricted and restricted models mentioned above, the likelihood ratio test between the model without morning dummy and model with morning dummy also indicates the coefficient of trading session dummy is significantly different from 0 according to Table 3.6. After taking the morning and afternoon trading sessions into account, the overall results of model (3.3) and (3.4) in Tables 3.9 and 3.10 are similar to the results of model (3.1) and (3.2) in Tables 3.7 and 3.8. The majority of the coefficients for the dummy are significant at the 0.1% level as shown in Table 3.13, which suggests the variable makes a good contribution to the model. A detailed discussion on coefficients is presented in the next section. In other words, the effects of price limits on price behaviour and volatility are not due to the different trading sessions.

[Insert Tables 3.9 and 3.10 about here]

As discussed in Chapter 2, the tail probability is the probability of price going beyond the restricted level if there are no price limits[20]. If the threshold value *P=0.50* is chosen to

[20] The interpretation of tail probability is the same as the one in Table 2.14. There are about 2000 upper price-limit-hits (details in the Appendix 2.1) in A-shares on the SSE and the tail probabilities are computed for each price-limit-hit. For the Truncated-GARCH model for upper price limits in SSE A, about 20% of the tail

determine the effect of price limits on price behaviour. From Table 3.11, both models suggest that there will be a 40-50% chance of price continuation after a price-limit-hit. That is, given all the price-limit-hits, there are 40-50% of times that the prices exceed the restricted level. However, these results are not consistent with the findings shown in Table 3.9 and 3.10 which do not present obvious price continuation. The percentage of stocks (%S) suggesting price continuation and the percentage of all price-limit-hits (%PL) indicating large tail probability (*P>0.50*) from the truncated-GARCH-M is shown below.

	Daily				Intraday			
	SSE A	SSE B	SZSE A	SZSE B	SSE A	SSE B	SZSE A	SZSE B
%S	15%	13%	21%	26%	5%	14%	0%	0%
%PL	25-30%				40-50%			

This is not a surprise outcome because investors do not have adequate time to react to the price-limit-hits on an intraday basis as discussed above. For the daily data, the tail probability is more or less consistent with the findings, which leads to the application of trading rules based on the tail probability in Chapter 2 Therefore, the tail probability is not a good indicator for the effects of price limits on price behaviour in the study of intraday data.

The goodness of fit for the model is presented in Table 3.12. Panel A of the table shows the values of R-squared and the probability of the F-ratio test for all stocks on both exchanges. Panel B contains a summary of the R-squared values. The Truncated-GARCH model is not only better than the Modified GARCH in theory by taking the truncation into account, but also in the empirical analysis. Comparing the truncated-GARCH-M with the modified-GARCH-M model, the R-squared for the former have higher minimum and mean values. It is also important to note that the R-squared values for the truncated-GARCH-M models are quite similar; the standard deviation is lower than that for the modified-GARCH-M model. In other words, the truncated-GARCH-M model is a more stable model.

probabilities are greater than 0.52. That is, given 2000 upper price-limit-hits, there are about 400 times that the price has a probability of 0.52 of exceeding the restricted level.

[Insert Tables 3.11 and 3.12 about here]

3.5.2 Analysis of Price Discovery and Volatility Spillover for AB-shares

It is demonstrated above that the truncated-GARCH-M model is superior to the modified-GARCH-M model. Thus, the analysis of AB-shares is based on the results from the truncated-GARCH-M model presented in Table 3.9 and 3.10. First, for price behaviour, the effects of price limits are almost negligible for both AB-shares. For example, at the 0.1% significance level, 2 (0) and 0 (1) A-shares show price continuation and price reversal respectively after upper (lower) price-limit-hits, while 1 (4) and 0 (0) B-shares present price continuation and price reversal respectively after upper (lower) price-limit-hits on the SSE. There are similar results for SZSE AB-shares.

For volatility spillover, price limits induce volatility increase rather than volatility decrease. For instance, at the 0.1% significance level, 26 (17) A-shares suffer from volatility increase against 2 (0) experiencing volatility decrease after upper (lower) price-limit-hits on the SSE. The results for the SSE B-shares and SZSE AB-shares are similar. In addition, on both exchanges, A-shares are more likely to suffer from volatility increase than B-shares, especially after upper price-limit-hits. For instance, after upper price-limit-hits, 26 A-shares against 12 B-shares show volatility increase on the SSE and 24 A-shares against 8 B-shares on the SZSE. After lower price-limit-hits, there are 17 (11) A-shares and 17 (15) B-shares suffering volatility increase on the SSE (SZSE). The results are almost the same when they are reported at the 0.1% significance level. Overall, price limits increase volatility on both A- and B-shares.

In this intraday study, the delayed price discovery hypothesis is rejected because of no price continuation after price-limit-hits. However, the volatility spillover is not rejected since there is obvious volatility increase after price-limit-hits. The increase of volatility contradicts the results of Kim and Yang (2008) who show the decrease of volatility. The difference may be due to the market (Taiwan Stock Exchange) and methodology they used. They define volatility from three ways: (1) the standard deviation of returns; (2) the mean of absolute returns; (3) the log of high price to low price, then compares the volatility before and after price-limit-hits. The time-varying volatility is not considered.

A summary of the individual parameters is displayed in Table 3.13. It can be seen that the turnover ratio and price limit dummy variables do not have an effect on stock return autocorrelation. The conditional variance, however, has strong effect on stock return autocorrelation. For example, at the 0.1% significance level, 27 (19) and 25 (20) A-shares (B-shares) on the SSE and SZSE respectively show positive effect, while 10 (17) and 7 (11) A-shares (B-shares) show negative effect. Similar results are discovered for the trading session dummy variable, which is shown below.

Trading session dummy	SSE A	SSE B	SZSE A	SZSE B
Positive	19	15	14	14
Negative	16	20	15	13

As can be seen that there is not a large difference between the number of shares showing positive and negative coefficients on the trading session dummy variable. This suggests that neither positive nor negative stock return autocorrelation dominates the trading session.

[Insert Table 3.13 about here]

3.6 Daily Study versus Intraday Study

In the daily study, the results show the existence of price continuation and volatility increase after price-limit-hits. In this intraday study, however, there is only the evidence of volatility increase. As shown above, A-shares are more inclined to suffer from an increase of volatility after price-limit-hit on both exchanges, which is similar to the finding in the daily study. But, it is important to note that the number of shares with a volatility increase in intraday study is overwhelming, for instance at the 0.1% significance result, a total number of 70 (26+12+24+8) shares out of 138 (37*2+32*2) AB-shares in the upper events from intraday study against 4 (1+0+2+1) shares out of 156 (40*2+38*2) AB-shares in the upper limit events from daily study. This profound effect is also present in the lower limit events; 60 (17+17+11+15) out of 138 AB-shares against 6 (3+0+1+2) out of 156 AB-shares. There is a similar finding at the 0.1% significance level.

The increase of volatility is more prevalent in the intraday study. Compared with the daily study, this is straightforward to interpret because the maximum price fluctuation between trading days is 10%, whereas the maximum price fluctuation within a trading day is more than 10%. The common finding from the intraday and daily study is that A-shares are more likely to experience volatility increase than B-shares. To explain this, it can be argued that foreign investors react less to price-limit-hits. Tong and Wu (2012) explain that B-shares' investors, who are mainly foreign investors, are more concerned about the quality of the corporate governance. In other words, the events of price-limit-hits are just temporary and foreign investors would not pay much attention to them.

It is interesting to see that there is price continuation shown in the daily study rather than the intraday study. This can be explained by the herding behaviour which states that there is a positive correlation between investors from a daily basis (Chiang and Zheng, 2010). When the closing price hits the limits, the long overnight period sends out a signal of the extreme price movement on previous trading day. Moreover, the closing price is determined by the volume-weighted average price of all the trades before one minute of the last trade, including the last trade. This indicates that all the trades hit the limits in that last minute. Therefore, the magnitude of the signal from the price-limit-hits leads to herding behaviour in the next trading day. With intraday data, however, most of the investors do not have enough time to assimilate the information, unless someone keeps an eye open for the trading screen. Moreover, the tail probability confirms the price continuation in the daily data to a certain extent, but it fails to indicates the price continuation in the intraday data due to a lack of information dissemination. In other words, the trading strategy based on the tail probability is not suitable to intraday trading.

As can be seen from Table 3.14, the number of significant individual coefficients between daily and intraday data show some disparity. It is obvious to see that the major differences are from the intercept, the coefficients on the interaction variables and the coefficients on the dummy variables from the variance equation. The non-zero intercept suggests non-zero return in the intraday data. In addition, the return autocorrelations are more correlated with turnover ratio and conditional variance. Moreover, as discussed above, the large number of significant coefficients on the dummy variables suggests that the maximum price fluctuation within a trading day is more than 10%.

[Insert Table 3.14 about here]

3.7 Magnet Effect

The magnet effect which induces the price of near-limit-hit to reach the limits is well documented in the literature (Subrahmanyam (1994), Cho *et al.* (2003), Wong, Chang and Tu (2009), Wong, Liu and Zeng (2009) and Hsieh, Kim and Yang (2009). In other words, the probability of a price hitting the limits is higher when the price is close to the limits. In order to demonstrate this, the following formula is proposed

$$\text{Probability} = \frac{X}{Y}, \tag{3.6}$$

where X is the number of days that the trading price first reaches 90% of upper (lower) limits then hits the limits in the following trades. Y is the total number of days that the trading price is greater (smaller) than 90% of limits.

As can be seen from Table 3.15, the probability of upper (lower) limit-hit is quite high for A-shares on both exchanges, with mean values of 64% (52%) on the SSE and 69% (44%) on the SZSE. B-shares also present high values which are 51% (58%) on the SSE and 61% (55%) on the SZSE. The number of shares display magnet effect is summarised below[21].

	SSE A	SSE B	SZSE A	SZSE B
Upper	16	7	14	11
Lower	5	8	5	8

[21] Details for individual shares are illustrated in Appendix 3.6 and 3.7.

According to equation (3.6), the magnet effect is more common for upper limit-hits for A-shares. 16 and 14 A-shares on both exchanges display magnet effect when price approaches upper limit.

An alternative way to demonstrate the magnet effect is through the distance from a trading price to the limit price. More specifically, when a trade is closer to the limits, the distance as measured by the tick size (1 tick size = 0.01) should be smaller. It can be shown empirically as follows

$$Upper: P_{max,t} - P_{tr,t-1} < P_{max,t} - P_{tr,t-2} < \cdots < P_{max,t} - P_{tr-n}, \qquad (3.7)$$

$$Lower: P_{tr,t-1} - P_{min,t} < P_{tr,t-2} - P_{min,t} < \cdots < P_{tr,t-n} - P_{min,t}, \qquad (3.8)$$

where $P_{max,t}$ or $P_{min,t}$ denote that a trading price reaches the maximum or minimum price at time *t*. $P_{tr,t-1}$is the trading price of 1 trade before the limits-hit. $P_{tr,t-2}$is the trading price of 2 trades before the limits-hit. $P_{tr,t-n}$is the trading price of *n* trades before the limits-hit. *n*=10 is chosen because (i) the trades which are far away from a limit-hit are not relevant to the magnet effect (ii) the trades which are too close to a limit-hit always indicate the magnet effect.

According to Panel B of Table 3.15, the distance is smaller when the trade is closer to the limits-hit. For example, the tick sizes are 11.53, 10.89, 10.32, 9.55, 8.83, 8.02, 7.00, 5.58, 4.45 and 3.56 for the trading prices of 10, 9, 8, 7, 6, 5, 4, 3, 2, and 1 trades before the upper limits-hit on the SSE A-shares[22]. For the lower limits-hit, the tick sizes are 11.93, 11.69, 11.39, 10.92, 10.52, 10.26, 9.60, 8.78, 8.57 and 8.73. There are similar findings for the SSE B-shares, SZSE A- and B-shares. Therefore, the magnet effect is present for some stocks. To test the magnet effect, the regression analysis is conducted as follows

---

[22] Details for individual shares are illustrated in Appendix 3.8.

$$TS_{in} = \alpha_0 + \beta_1 n + \varepsilon_{in} \tag{3.9}$$

where TS_{in} is the tick size for the *n* trades (n=1, 2, …, 10) before the limit-hit, *i* denotes upper or lower price-limit-hits.

If there is a magnet effect, the estimated beta should be significantly different from zero. This suggests that when the trade is far away from a limit-hit, the tick size will be widened, and vice versa. As can be seen from Table 3.16, the estimated betas are significantly different from zero, especially for A shares on both exchange with p-values that are smaller than 0.1%. The values of R-squared, however, are small. This suggests that the magnet effect is largely determined by unknown factors.

[Insert Table 3.15 about here]

[Insert Table 3.16 about here]

3.8 Conclusion

Kim and Rhee (1997) propose that if price limits play an important role in stock markets, the delayed price discovery hypothesis and volatility spillover hypothesis should be rejected. The delayed price discovery hypothesis states that the price will continue to move in the same direction after the price-limit-hits, which means that price continuation would impose a relative high trading cost on investors on the following trading day. The volatility spillover hypothesis asserts that the pent-up volatility on the day of a price-limit-hit is transferred to the next trading day, which implies that the price limits create another volatile trading day. According to the daily study reported in Chapter 2, neither hypothesis can be rejected. However, the effects of price limits are different in an intraday framework. This is because for daily data there is a long overnight period for investors to absorb information when a closing price hits the limits. This is not the case for intraday data. Therefore, the purpose of this chapter is to investigate the effects of price limits on price behaviour and volatility in the context of intraday trading.

The daily study has shown that the truncated-GARCH-M model is better than the modified-GARCH-M model. In the intraday study, the empirical evidence also suggests that the truncated-GARCH-M model provides a better fit. According to the results, there is no price continuation after price-limit-hits. Thus, the delayed price discovery hypothesis is rejected. The absence of price continuation could be due to the lack of time of information dissemination: there is no chance for price limits to send out a signal of extreme price movement which will cause the herding behaviour. The tail probability, however, suggests a high chance of price continuation which is not consistent with the estimation results. This is due to the fact that information is not widely disseminated to most investors. In other words, the tail probability is not a good indicator in the intraday data. The increase of volatility after price-limit-hits is more substantial, especially for A-shares on both exchanges and so the volatility spillover hypothesis cannot be rejected. The strong evidence of volatility increase can be understood by the maximum fluctuation which is 10% between trading days but more than 10% within a trading day. Moreover, the less volatile B-shares' markets could be due to the different perspectives between domestic investors and foreign investors who pay more attention to a firm's fundamentals rather than the temporary events like price-limit-hits when they invest in a share.

There is no evidence of price continuation after price-limit-hits in the intraday study. The rejection of the delayed price discovery hypothesis, however, does not mean the usefulness of the price limits. The initial reason behind the implementation of price limits is to stop market crash in the downward movement and to prevent overreaction in the upward movement. There are no signs of price recovery and overreaction after price-limit-hits. In addition, one point can be confirmed that the stock markets, especially domestic A-shares market, are more volatile under price limits. As discussed in Chapter 2, efficient market hypothesis is rejected in the context of price-limit-hits. Investors then can construct their trading strategies to make a profit or avoid a loss when price hits the upper or lower limits. This, however, is not the case in the intraday data. In addition, intraday traders should be aware of the high risk brought by the price limits.

Table 3.1 Data Example

Panels A and B of this table shows the three types of price limits hits: single, consecutive and closing price limits, using simple cases that are constructed by artificial data. Assuming the closing price of the last day is 6.65, then the maximum (minimum) today's trade price is 7.32 (5.99) RMB. Upper dummy equals to 1 when the latest trading price reaches the maximum level. Panel C aggregates the sample data in Panel A for the purpose of econometric modelling. The upper dummy variable is then transformed to a score variable. The same logic applies to lower dummy variable.

Panel A

Time (HH:MM:SS)	Trade price (RMB)	Return	Upper Dummy	Turnover	Duration (seconds)
09:30:05	7.30	NA	NA	NA	NA
09:30:20	6.73	-0.0813	0	2530	15
09:30:35	7.32	0.0840	1	19500	15
09:30:42	6.75	-0.0811	0	2800	7
09:30:46	6.73	-0.0030	0	3600	4
09:30:50	6.73	0.0000	0	25000	4
09:31:00	7.32	0.0840	1	12500	10
09:31:03	7.32	0.0000	1	3500	3
09:31:07	7.32	0.0000	1	69000	4
09:31:15	6.74	-0.0826	0	200	8

Panel B

Time (HH:MM:SS)	Trade price (RMB)	Return	Upper Dummy	Turnover	Duration (seconds)
09:30:05	7.30	NA	NA	NA	NA
09:30:20	6.73	-0.0813	0	2530	15
09:30:35	7.32	0.0840	1	19500	15
No other trades during the rest of the day					

Panel C

Time (HH:MM:SS)	Trade price (RMB)	Return	Score Upper	Turnover	Duration (seconds)
09:30:05	7.30	NA	NA	NA	NA
09:30:20	6.73	-0.0813	0	2530	15
09:30:35	7.32	0.0840	1	19500	15
09:30:42	6.75	-0.0811	0	2800	7
09:30:46	6.73	-0.0030	0	3600	4
09:30:50	6.73	0.0000	0	25000	4
09:31:00	7.32	0.0840	3	85000	17
09:31:15	6.74	-0.0826	0	200	8

Table 3.2 Details of Intraday Price Limits Hits on the SSE AB

This table summarises the number of the three types of price limits hit on the SSE. A-shares are shown in Panel A and B-shares are shown in Panel B. Moreover, the consecutive price limits hits are reported based on 10 categories of different frequencies. MA means morning to afternoon.

Panel A	Number of upper price limits hits			Number of lower price limits hits		
Session	Morning	MA	Afternoon	Morning	MA	Afternoon
Closing	0	0	0	0	0	0
Single	362	0	736	140	0	467
Consecutive	10 categories of different frequencies					
2 to 10	327	2	547	101	0	339
11 to 20	56	0	63	20	1	51
21 to 30	30	2	38	10	1	16
31 to 40	13	1	24	3	0	13
41 to 50	6	0	15	3	1	11
51 to 60	9	0	10	1	0	3
61 to 70	5	0	15	2	0	6
71 to 80	2	0	12	1	0	3
81 t0 90	5	1	6	0	0	0
91 to 100	5	0	6	0	0	3
>100	38	117	126	2	2	29
Total Number of Shares: 37; total Number of trading days: 25,347						

Panel B	Number of upper price limits hits			Number of lower price limits hits		
Session	Morning	MA	Afternoon	Morning	MA	Afternoon
Closing	0	0	0	0	0	0
Single	149	0	273	119	0	216
Consecutive	10 categories of different frequencies					
2 to 10	135	1	175	105	0	165
11 to 20	8	0	20	21	1	39
21 to 30	2	0	8	5	0	16
31 to 40	3	2	5	4	0	7
41 to 50	5	0	6	2	1	5
51 to 60	0	0	1	1	0	1
61 to 70	0	1	6	2	0	4
71 to 80	1	0	0	1	0	2
81 t0 90	0	1	5	0	0	0
91 to 100	0	1	1	1	0	1
>100	5	6	5	1	3	6
Total Number of Shares: 37; total Number of trading days: 25,262						

Table 3.3 Details of Intraday Price Limits on the SZSE AB

This table summarises the number of the three types of price limits hit on the SZSE. A shares are shown in Panel A and B-shares are shown in Panel B. Moreover, the consecutive price limits hits are reported based on 10 categories of different frequencies. MA means morning to afternoon.

Panel A	Number of upper price-limit-hits			Number of lower price-limit-hits		
Session	Morning	MA	Afternoon	Morning	MA	Afternoon
Closing	0	0	1	0	0	0
Single	279	0	592	195	0	406
Consecutive			10 categories of different frequencies			
2 to 10	276	3	479	119	0	261
11 to 20	43	0	61	13	0	33
21 to 30	19	0	38	6	0	9
31 to 40	7	0	26	6	0	10
41 to 50	11	0	15	4	0	8
51 to 60	4	1	9	3	0	5
61 to 70	4	0	10	3	0	10
71 to 80	4	0	11	1	0	3
81 t0 90	6	0	5	1	0	6
91 to 100	1	0	5	1	0	1
>100	29	65	86	9	1	22
Total Number of Shares: 32 ;total Number of trading days: 22,079						

Panel B	Number of upper price-limit-hits			Number of lower price-limit-hits		
Session	Morning	MA	Afternoon	Morning	MA	Afternoon
Closing	0	0	3	0	0	3
Single	82	0	152	116	0	149
Consecutive			10 categories of different frequencies			
2 to 10	67	0	107	100	0	116
11 to 20	7	0	16	12	1	12
21 to 30	4	0	11	9	3	10
31 to 40	0	0	2	1	1	4
41 to 50	0	0	1	2	1	8
51 to 60	1	1	0	0	1	0
61 to 70	1	1	3	0	0	1
71 to 80	0	2	0	2	0	1
81 t0 90	0	1	2	0	0	0
91 to 100	0	1	2	1	2	0
>100	1	6	2	1	3	1
Total Number of Shares: 32; total Number of trading days: 22,065						

Table 3.4 Variables Comparison

This table shows the differences between daily and intraday variables used in the model. The first difference would be the daily closing price P_t against the intraday latest trading price P_{lt}. Then, the second one is daily turnover To_t against the intraday latest trading turnover To_{lt}.

Variable	Daily	Intraday
Return	$R_t = \ln(\frac{P_t}{P_{t-1}})$	$R_{lt} = \ln(\frac{P_{lt}}{P_{lt-1}})$
Turnover ratio	$Tor_t = \frac{To_t}{MV_t}$	$Tor_{lt} = \frac{To_{lt}}{MV_t}$
Upper price limits dummy	$Up_t = \begin{cases} 1, when\ P_t = maxP_t \\ 0, \quad otherwise \end{cases}$	$Up_{lt} = \begin{cases} 1, when\ P_{lt} = maxP_t \\ 0, \quad otherwise \end{cases}$
Lower price limits dummy	$Lo_t = \begin{cases} 1, when\ P_t = minP_t \\ 0, \quad otherwise \end{cases}$	$Lo_{lt} = \begin{cases} 1, when\ P_{lt} = minP_t \\ 0, \quad otherwise \end{cases}$
90% of upper price limits	$Up9_t = \begin{cases} 1, when\ P_t = 0.9 * maxP_t \\ 0, \quad otherwise \end{cases}$	$Up9_{lt} = \begin{cases} 1, when\ P_{lt} = 0.9 * maxP_t \\ 0, \quad otherwise \end{cases}$
90% of lower price limits	$Lo9_t = \begin{cases} 1, when\ P_t = 0.9 * minP_t \\ 0, \quad otherwise \end{cases}$	$Lo9_{lt} = \begin{cases} 1, when\ P_{lt} = 0.9 * minP_t \\ 0, \quad otherwise \end{cases}$
Maximum daily price	$maxP_t = P_{t-1} * 1.1$	$maxP_t = P_{t-1} * 1.1$
Minimum daily price	$minP_t = P_{t-1} * 0.9$	$minP_t = P_{t-1} * 0.9$

Table 3.5 Number of Observations

This table summarises the number of observations in the model estimation on the SSE and SZSE. A detailed information is shown in Appendix 3.2.

	SSE (37)		SZSE (32)	
	A	B	A	B
Min	47,253	10,879	397,702	40,948
Mean	725,990	141,908	876,618	150,909
Median	695,130	132,847	745,485	112,435
Max	1,359,422	306,018	2,112,518	499,830

Table 3.6 Log-likelihood Ratio Statistics[a]

This table summarises the log-likelihood (LL) ratio statistics for the truncated-GARCH-M without morning dummy variable (noMS) and the restricted model (Res) presented in equation (3.5). It also summarises the log-likelihood (LL) ratio statistics for the truncated-GARCH-M without morning dummy variable (noMS) and the model (Ms) with morning dummy variable. The log-likelihood (LL) ratio statistics are equal to $LL1=2*(LL_{noMs}-LL_{Res})$ and $LL2=2*(LL_{Ms}-LL_{noMs})$ which follow chi-squared distribution. Note: Very large statistics are due to the very large number of observations (T) in the model estimation. For example, stock 600604, the LL1 is 10 when T is 500 (LL1=100 when T=1000; LL1=54 when T=2500; LL1=903 when T=5000; LL1=24897 when T=10000).

	SSEA		SSEB		SZSEA		SZSEB	
	LL1	LL2	LL1	LL2	LL1	LL2	LL1	LL2
Mean	1454991	807212	250612	223589	1229235	1463650	149874	192861
SD	1222373	1200523	248551	178638	1162281	1863195	209241	455063
Min	8967.67	300.81	43.68	2658.17	111.08	0.02	34.21	106.43
Q1	312906	144761	42649	87639	318742	409486	14267	38175
Median	1174537	418730	256008	197361	1000201	1060769	81915	96904
Q3	1984077	820113	334749	283985	1785147	1619698	209722	152854
Max	4267210	5672317	1055669	889138	4122069	9521342	1022071	2610175

[a] Detailed results are shown in Appendix 3.5.

Table 3.7 Models Estimation for AB-shares on the SSE

This table reports the number of stocks that show price continuation (PC), price reversal (PR), volatility increase (VI) and volatility decrease (VD) after price limits. There are 37 AB-shares on the SSE. For upper price limit (PC): β_2+β_5 >0 and β_2+β_5 > β_2+β_7; (PR):β_2+β_5 <0 and β_2+β_5 < β_2+β_7; (VI): β_{12}>0 and $\beta_{12} > \beta_{14}$; (VD): β_{12}<0 and $\beta_{12} < \beta_{14}$. For lower price limit (PC): β_2+β_6 <0 and β_2+β_6 < β_2+β_8; (PR):β_2+β_6>0 and β_2+β_6 > β_2+β_8; (VI): β_{13}>0 and $\beta_{13} > \beta_{15}$; (VD): β_{13}<0 and $\beta_{13} < \beta_{15}$. The signs '>' and '<' imply significant 'larger than' and 'smaller than'.

$$R_t = \mu_t + \varepsilon_t \quad \varepsilon_t\,|\Omega_t \sim N(0,\sigma_t^2) \text{ or } \varepsilon_t\,|\Omega_t \sim TN(0,\sigma_t^2)$$

$$\mu_t = \beta_1 + (\beta_2 + \beta_3 Tor_{t-1} + \beta_4\sigma_{t-1} + \beta_5 SU_{t-1} + \beta_6 SL_{t-1} + \beta_7 SU9_{t-1} + \beta_8 SL9_{t-1})R_{t-1}\ ,$$
$$\sigma_t^2 = \beta_9 + \beta_{10}\varepsilon_{t-1}^2 + \beta_{11}\sigma_{t-1}^2 + \beta_{12}SU_{t-1} + \beta_{13}SL_{t-1} + \beta_{14}SU9_{t-1} + \beta_{15}SL9_{t-1}\ .$$

where R_t is the daily stock return on day *t*. Tor_{t-1} is the daily negotiable turnover ratio on day *t-1,* which is measured by daily negotiable turnover divided by daily negotiable market value. U_{t-1} ($SU9_{t-1}$) and SL_{t-1} ($SL9_{t-1}$) are upper (90% upper) and lower (90% lower) price-limit-hit score variables as illustrated in Panel C of Table 3.1.

SSE	Modified-GARCH-M				Truncated-GARCH-M			
5% significance results								
SSE A (37)	PC	PR	VI	VD	PC	PR	VI	VD
Upper	6	8	23	0	4	2	28	5
Lower	4	5	15	2	1	2	18	1
SSE B (37)	PC	PR	VI	VD	PC	PR	VI	VD
Upper	1	14	19	5	1	0	13	7
Lower	2	15	19	4	3	3	13	5
1% significance results								
SSE A (37)	PC	PR	VI	VD	PC	PR	VI	VD
Upper	6	8	23	0	2	2	27	4
Lower	3	5	14	2	1	1	18	1
SSE B (37)	PC	PR	VI	VD	PC	PR	VI	VD
Upper	1	12	15	6	1	0	12	6
Lower	2	13	19	3	3	2	14	5
0.1% significance results								
SSE A (37)	PC	PR	VI	VD	PC	PR	VI	VD
Upper	5	7	23	0	2	2	25	4
Lower	3	2	13	2	1	0	16	1
SSE B (37)	PC	PR	VI	VD	PC	PR	VI	VD
Upper	1	11	13	4	1	0	9	6
Lower	2	13	18	3	3	2	13	5

Table 3.8 Models Estimation for AB-shares on the SZSE

This table reports the number of stocks that show price continuation (PC), price reversal (PR), volatility increase (VI) and volatility decrease (VD) after price limits. There are 32 AB-shares on the SZSE. For upper price limit (PC): β_2+β_5 >0 and β_2+β_5 > β_2+β_7; (PR):β_2+β_5 <0 and β_2+β_5 < β_2+β_7; (VI): β_{12}>0 and $\beta_{12} > \beta_{14}$; (VD): β_{12}<0 and $\beta_{12} < \beta_{14}$. For lower price limit (PC): β_2+β_6 <0 and β_2+β_6 < β_2+β_8; (PR):β_2+β_6>0 and β_2+β_6 > β_2+β_8; (VI): β_{13}>0 and $\beta_{13} > \beta_{15}$; (VD): β_{13}<0 and $\beta_{13} < \beta_{15}$. The signs '>' and '<' imply significant 'larger than' and 'smaller than'.

$$R_t = \mu_t + \varepsilon_t \quad \varepsilon_t\,|\Omega_t \sim N(0,\sigma_t^2) \text{ or } \varepsilon_t\,|\Omega_t \sim TN(0,\sigma_t^2)$$

$$\mu_t = \beta_1 + (\beta_2 + \beta_3 Tor_{t-1} + \beta_4 \sigma_{t-1} + \beta_5 SU_{t-1} + \beta_6 SL_{t-1} + \beta_7 SU9_{t-1} + \beta_8 SL9_{t-1})R_{t-1}\,,$$
$$\sigma_t^2 = \beta_9 + \beta_{10}\varepsilon_{t-1}^2 + \beta_{11}\sigma_{t-1}^2 + \beta_{12} SU_{t-1} + \beta_{13} SL_{t-1} + \beta_{14} SU9_{t-1} + \beta_{15} SL9_{t-1}\,.$$

where R_t is the daily stock return on day *t*. Tor_{t-1} is the daily negotiable turnover ratio on day *t-1,* which is measured by daily negotiable turnover divided by daily negotiable market value. U_{t-1} ($SU9_{t-1}$) and SL_{t-1} ($SL9_{t-1}$) are upper (90% upper) and lower (90% lower) price-limit-hit score variables as illustrated in Panel C of Table 3.1.

SZSE	Modified-GARCH-M				Truncated-GARCH-M			
5% significance results								
SZSE A (32)	PC	PR	VI	VD	PC	PR	VI	VD
Upper	4	4	27	0	1	1	23	0
Lower	0	10	12	1	0	1	10	0
SZSE B (32)	PC	PR	VI	VD	PC	PR	VI	VD
Upper	1	5	7	2	0	0	10	1
Lower	4	14	11	6	2	0	17	1
1% significance results								
SZSE A (32)	PC	PR	VI	VD	PC	PR	VI	VD
Upper	4	4	27	0	1	0	22	0
Lower	0	10	12	1	0	1	10	0
SZSE B (32)	PC	PR	VI	VD	PC	PR	VI	VD
Upper	1	5	6	2	0	0	9	1
Lower	4	13	9	5	2	0	14	1
0.1% significance results								
SZSE A (32)	PC	PR	VI	VD	PC	PR	VI	VD
Upper	3	3	27	0	1	0	19	0
Lower	0	10	12	1	0	1	7	0
SZSE B (32)	PC	PR	VI	VD	PC	PR	VI	VD
Upper	1	5	5	2	0	0	7	1
Lower	3	13	9	5	2	0	12	1

Table 3.9 Models Estimation with Morning Dummy for AB-shares on the SSE[a]

This table reports the number of stocks that show price continuation (PC), price reversal (PR), volatility increase (VI) and volatility decrease (VD) after price limits. There are 37 AB-shares on the SSE. For upper price limit (PC): $\beta_2+\beta_5>0$ and $\beta_2+\beta_5 > \beta_2+\beta_7$; (PR):$\beta_2+\beta_5<0$ and $\beta_2+\beta_5 < \beta_2+\beta_7$; (VI): $\beta_{13}>0$ and $\beta_{13} > \beta_{15}$; (VD): $\beta_{13}<0$ and $\beta_{13} < \beta_{15}$. For lower price limit (PC): $\beta_2+\beta_6<0$ and $\beta_2+\beta_6 > \beta_2+\beta_8$; (PR):$\beta_2+\beta_6>0$ and $\beta_2+\beta_6 > \beta_2+\beta_8$; (VI): $\beta_{14}>0$ and $\beta_{14} > \beta_{16}$; (VD): $\beta_{14}<0$ and $\beta_{14} < \beta_{16}$. The signs '>' and '<' imply significant 'larger than' and 'smaller than'.

$$R_t = \mu_t + \varepsilon_t \quad \varepsilon_t|\Omega_t \sim N(0,\sigma_t^2) \text{ or } \varepsilon_t|\Omega_t \sim TN(0,\sigma_t^2)$$

$$\mu_t = \beta_1 + (\beta_2 + \beta_3 Tor_{t-1} + \beta_4\sigma_{t-1} + \beta_5 SU_{t-1} + \beta_6 SL_{t-1} + \beta_7 SU9_{t-1} + \beta_8 SL9_{t-1} + \beta_9 M)R_{t-1},$$
$$\sigma_t^2 = \beta_{10} + \beta_{11}\varepsilon_{t-1}^2 + \beta_{12}\sigma_{t-1}^2 + \beta_{13}SU_{t-1} + \beta_{14}SL_{t-1} + \beta_{15}SU9_{t-1} + \beta_{16}SL9_{t-1}.$$

where R_t is the daily stock return on day t. Tor_{t-1} is the daily negotiable turnover ratio on day *t-1,* which is measured by daily negotiable turnover divided by daily negotiable market value. U_{t-1} ($SU9_{t-1}$) and SL_{t-1} ($SL9_{t-1}$) are upper (90% upper) and lower (90% lower) price-limit-hit score variables as illustrated in Panel C of Table 3.1. *M* denotes the trading session dummy variable taking a value of one if the trade occurs in the morning session, otherwise zero.

SSE	Modified-GARCH-M				Truncated-GARCH-M			
5% significance results								
SSE A (37)	PC	PR	VI	VD	PC	PR	VI	VD
Upper	3	12	26	2	3	0	27	2
Lower	4	12	20	0	1	1	23	0
SSE B (37)	PC	PR	VI	VD	PC	PR	VI	VD
Upper	6	13	14	4	0	0	16	2
Lower	6	9	22	2	5	2	21	4
1% significance results								
SSE A (37)	PC	PR	VI	VD	PC	PR	VI	VD
Upper	3	12	26	2	3	0	27	2
Lower	4	11	21	0	0	1	20	0
SSE B (37)	PC	PR	VI	VD	PC	PR	VI	VD
Upper	5	12	13	4	0	0	13	2
Lower	6	9	21	1	4	1	19	4
0.1% significance results								
SSE A (37)	PC	PR	VI	VD	PC	PR	VI	VD
Upper	3	10	26	2	2	0	26	2
Lower	4	11	21	0	0	1	17	0
SSE B (37)	PC	PR	VI	VD	PC	PR	VI	VD
Upper	3	10	9	4	1	0	12	2
Lower	6	9	19	1	4	0	17	4

[a] Detailed estimation results are shown in Appendix 3.3a, 3.3b, 3.3c and 3.3d.

Table 3.10 Models Estimation with Morning Dummy for AB-shares on the SZSE[a]

This table reports the number of stocks that show price continuation (PC), price reversal (PR), volatility increase (VI) and volatility decrease (VD) after price limits. There are 32 AB-shares on the SZSE. For upper price limit (PC): β_2+β_5 >0 and β_2+β_5 > β_2+β_7; (PR):β_2+β_5 <0 and β_2+β_5 < β_2+β_7; (VI): β_{13}>0 and $\beta_{13} > \beta_{15}$; (VD): β_{13}<0 and $\beta_{13} < \beta_{15}$. For lower price limit (PC): β_2+β_6 <0 and β_2+β_6 < β_2+β_8; (PR):β_2+β_6>0 and β_2+β_6 > β_2+β_8; (VI): β_{14}>0 and $\beta_{14} > \beta_{16}$; (VD): β_{14}<0 and $\beta_{14} < \beta_{16}$. The signs '>' and '<' imply significant 'larger than' and 'smaller than'.

$$R_t = \mu_t + \varepsilon_t \quad \varepsilon_t\,|\Omega_t \sim N(0,\sigma_t^2) \text{ or } \varepsilon_t\,|\Omega_t \sim TN(0,\sigma_t^2)$$

$$\mu_t = \beta_1 + (\beta_2 + \beta_3 Tor_{t-1} + \beta_4\sigma_{t-1} + \beta_5 SU_{t-1} + \beta_6 SL_{t-1} + \beta_7 SU9_{t-1} + \beta_8 SL9_{t-1} + \beta_9 M)R_{t-1}\,,$$
$$\sigma_t^2 = \beta_{10} + \beta_{11}\varepsilon_{t-1}^2 + \beta_{12}\sigma_{t-1}^2 + \beta_{13}SU_{t-1} + \beta_{14}SL_{t-1} + \beta_{15}SU9_{t-1} + \beta_{16}SL9_{t-1}\,.$$

where R_t is the daily stock return on day *t*. Tor_{t-1} is the daily negotiable turnover ratio on day *t-1,* which is measured by daily negotiable turnover divided by daily negotiable market value. U_{t-1} ($SU9_{t-1}$) and SL_{t-1} ($SL9_{t-1}$) are upper (90% upper) and lower (90% lower) price-limit-hit score variables as illustrated in Panel C of Table 3.1. *M* denotes the trading session dummy variable taking a value of one if the trade occurs in the morning session, otherwise zero.

SZSE	Modified-GARCH-M				Truncated-GARCH-M			
5% significance results								
SZSE A (32)	PC	PR	VI	VD	PC	PR	VI	VD
Upper	2	5	25	1	0	0	26	1
Lower	1	7	15	3	0	0	12	0
SZSE B (32)	PC	PR	VI	VD	PC	PR	VI	VD
Upper	1	3	10	2	0	1	13	0
Lower	3	8	12	4	0	2	17	1
1% significance results								
SZSE A (32)	PC	PR	VI	VD	PC	PR	VI	VD
Upper	2	4	25	1	0	0	26	1
Lower	1	7	15	2	0	0	11	0
SZSE B (32)	PC	PR	VI	VD	PC	PR	VI	VD
Upper	1	3	10	1	0	1	10	0
Lower	3	7	12	3	0	2	16	1
0.1% significance results								
SZSE A (32)	PC	PR	VI	VD	PC	PR	VI	VD
Upper	2	4	25	1	0	0	24	1
Lower	1	6	16	1	0	0	11	0
SZSE B (32)	PC	PR	VI	VD	PC	PR	VI	VD
Upper	1	3	10	1	0	1	8	0
Lower	3	6	11	3	0	2	15	1

[a] Detailed estimation results are shown in Appendix 3.4a, 3.4b, 3.4c and 3.4d.

Table 3.11 Summary of Tail Probability

This table summarises the computed tail probabilities on the days of upper (U) and lower (L) price limits hits. The vigintiles are reported.

	Modified-GARCH								Truncated-GARCH							
	SSEA		SSEB		SZSEA		SZSEB		SSEA		SSEB		SZSEA		SZSEB	
Vigintiles	U	L	U	L	U	L	U	L	U	L	U	L	U	L	U	L
5%	0.06	0.03	0.01	0.00	0.13	0.02	0.02	0.01	0.23	0.24	0.13	0.05	0.27	0.08	0.04	0.04
10%	0.19	0.10	0.04	0.06	0.35	0.08	0.18	0.07	0.33	0.36	0.28	0.17	0.38	0.16	0.12	0.15
15%	0.28	0.17	0.08	0.13	0.42	0.16	0.25	0.13	0.38	0.41	0.37	0.27	0.42	0.24	0.21	0.25
20%	0.34	0.22	0.14	0.21	0.46	0.22	0.30	0.18	0.42	0.44	0.42	0.33	0.45	0.32	0.28	0.31
25%	0.40	0.27	0.18	0.25	0.48	0.27	0.35	0.23	0.44	0.45	0.44	0.37	0.46	0.38	0.31	0.35
30%	0.44	0.33	0.24	0.30	0.48	0.32	0.38	0.28	0.45	0.46	0.45	0.40	0.47	0.42	0.38	0.39
35%	0.46	0.36	0.30	0.35	0.49	0.36	0.42	0.31	0.46	0.47	0.47	0.42	0.48	0.45	0.42	0.41
40%	0.48	0.40	0.35	0.38	0.49	0.39	0.44	0.35	0.47	0.48	0.48	0.44	0.49	0.46	0.45	0.44
45%	0.48	0.44	0.39	0.40	0.49	0.42	0.46	0.38	0.48	0.49	0.48	0.45	0.49	0.47	0.47	0.46
50%	*0.49*	*0.46*	*0.45*	*0.42*	*0.50*	*0.45*	*0.47*	*0.40*	*0.48*	*0.49*	*0.49*	*0.47*	*0.50*	*0.48*	*0.48*	*0.48*
55%	0.49	0.48	0.48	0.45	0.50	0.47	0.48	0.42	0.49	0.50	0.50	0.47	0.50	0.48	0.48	0.49
60%	0.50	0.49	0.48	0.47	0.50	0.48	0.49	0.43	0.49	0.50	0.50	0.48	0.50	0.49	0.49	0.49
65%	0.50	0.49	0.49	0.49	0.50	0.49	0.49	0.45	0.49	0.50	0.50	0.49	0.50	0.49	0.49	0.50
70%	0.50	0.50	0.50	0.50	0.50	0.50	0.49	0.46	0.50	0.50	0.50	0.50	0.51	0.49	0.49	0.51
75%	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.48	0.50	0.50	0.52	0.50	0.51	0.50	0.50	0.53
80%	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.49	0.51	0.51	0.54	0.51	0.52	0.50	0.50	0.55
85%	0.50	0.50	0.50	0.51	0.50	0.50	0.52	0.50	0.52	0.52	0.58	0.52	0.54	0.51	0.51	0.58
90%	0.54	0.52	0.52	0.54	0.51	0.50	0.64	0.52	0.56	0.53	0.63	0.55	0.58	0.52	0.58	0.63
95%	0.67	0.62	0.58	0.65	0.52	0.51	0.77	0.66	0.74	0.61	0.69	0.70	0.71	0.56	0.81	0.74

Note: Values are shown rounded to two decimal places.

Table 3.12 Goodness of Fit

Panel A reports the adjusted R-square (R^2) and p-value of the overall F-test (PF) for the models. A small p-value of the F-test (PF) suggests that at least one of the coefficients' values is significantly different from zero. A summary statistics of R-squared values are reported in panel B. Due to a large F-statistics, the respective p-value is approximately to equal to 0. In order to save space, values are rounded to two decimal places only.

Panel A		Modified GARCH-M						Truncated-GARCH-M							
SSE A (40)		SSE B (40)		SZSE A (38)		SZSE B (38)		SSE A (40)		SSE B (40)		SZSE A (38)		SZSE B (38)	
R^2	PF	R^2	PF	R^2	PF	R^2	PF	R^2	PF	R^2	PF	R^2	PF	R^2	PF
0.50	0.00	0.15	0.00	0.50	0.00	0.50	0.00	0.50	0.00	0.17	0.00	0.34	0.00	0.50	0.00
0.50	0.00	0.50	0.00	0.50	0.00	0.09	0.00	0.50	0.00	0.46	0.00	0.50	0.00	0.50	0.00
0.25	0.00	0.48	0.00	0.50	0.00	0.50	0.00	0.50	0.00	0.49	0.00	0.50	0.00	0.50	0.00
0.50	0.00	0.08	0.00	0.50	0.00	0.50	0.00	0.50	0.00	0.48	0.00	0.50	0.00	0.50	0.00
0.50	0.00	0.50	0.00	0.29	0.00	0.05	0.00	0.51	0.00	0.50	0.00	0.49	0.00	0.45	0.00
0.50	0.00	0.16	0.00	0.50	0.00	0.50	0.00	0.50	0.00	0.50	0.00	0.50	0.00	0.50	0.00
0.19	0.00	0.16	0.00	0.50	0.00	0.25	0.00	0.50	0.00	0.50	0.00	0.50	0.00	0.47	0.00
0.50	0.00	0.16	0.00	0.50	0.00	0.19	0.00	0.49	0.00	0.50	0.00	0.50	0.00	0.50	0.00
0.13	0.00	0.12	0.00	0.48	0.00	0.42	0.00	0.32	0.00	0.50	0.00	0.50	0.00	0.49	0.00
0.31	0.00	0.50	0.00	0.50	0.00	0.25	0.00	0.50	0.00	0.46	0.00	0.50	0.00	0.48	0.00
0.48	0.00	0.50	0.00	0.50	0.00	0.09	0.00	0.50	0.00	0.50	0.00	0.50	0.00	0.50	0.00
0.45	0.00	0.46	0.00	0.50	0.00	0.50	0.00	0.50	0.00	0.50	0.00	0.50	0.00	0.49	0.00
0.50	0.00	0.49	0.00	0.50	0.00	0.08	0.00	0.50	0.00	0.49	0.00	0.49	0.00	0.50	0.00
0.50	0.00	0.50	0.00	0.45	0.00	0.49	0.00	0.50	0.00	0.50	0.00	0.50	0.00	0.50	0.00
0.50	0.00	0.46	0.00	0.49	0.00	0.06	0.00	0.50	0.00	0.50	0.00	0.42	0.00	0.50	0.00
0.46	0.00	0.50	0.00	0.49	0.00	0.12	0.00	0.50	0.00	0.50	0.00	0.50	0.00	0.27	0.00
0.48	0.00	0.50	0.00	0.44	0.00	0.11	0.00	0.50	0.00	0.50	0.00	0.45	0.00	0.50	0.00
0.13	0.00	0.28	0.00	0.15	0.00	0.12	0.00	0.50	0.00	0.50	0.00	0.50	0.00	0.50	0.00
0.30	0.00	0.50	0.00	0.22	0.00	0.46	0.00	0.50	0.00	0.48	0.00	0.53	0.00	0.50	0.00
0.49	0.00	0.07	0.00	0.53	0.00	0.13	0.00	0.50	0.00	0.46	0.00	0.26	0.00	0.33	0.00
0.50	0.00	0.47	0.00	0.50	0.00	0.50	0.00	0.50	0.00	0.50	0.00	0.51	0.00	0.50	0.00
0.50	0.00	0.14	0.00	0.50	0.00	0.50	0.00	0.48	0.00	0.50	0.00	0.50	0.00	0.14	0.00
0.50	0.00	0.13	0.00	0.48	0.00	0.13	0.00	0.50	0.00	0.49	0.00	0.50	0.00	0.50	0.00
0.22	0.00	0.45	0.00	0.50	0.00	0.09	0.00	0.50	0.00	0.20	0.00	0.50	0.00	0.50	0.00
0.50	0.00	0.12	0.00	0.47	0.00	0.09	0.00	0.50	0.00	0.52	0.00	0.51	0.00	0.51	0.00
0.50	0.00	0.50	0.00	0.50	0.00	0.09	0.00	0.50	0.00	0.50	0.00	0.50	0.00	0.50	0.00
0.50	0.00	0.18	0.00	0.50	0.00	0.10	0.00	0.51	0.00	0.50	0.00	0.50	0.00	0.50	0.00
0.46	0.00	0.49	0.00	0.36	0.00	0.35	0.00	0.49	0.00	0.50	0.00	0.51	0.00	0.49	0.00
0.50	0.00	0.50	0.00	0.49	0.00	0.16	0.00	0.50	0.00	0.50	0.00	0.49	0.00	0.49	0.00
0.15	0.00	0.46	0.00	0.22	0.00	0.42	0.00	0.50	0.00	0.50	0.00	0.50	0.00	0.50	0.00
0.45	0.00	0.28	0.00	0.26	0.00	0.42	0.00	0.50	0.00	0.48	0.00	0.52	0.00	0.50	0.00
0.30	0.00	0.50	0.00	0.50	0.00	0.12	0.00	0.50	0.00	0.50	0.00	0.50	0.00	0.50	0.00
0.49	0.00	0.22	0.00					0.50	0.00	0.50	0.00				
0.49	0.00	0.48	0.00					0.50	0.00	0.50	0.00				
0.10	0.00	0.50	0.00					0.50	0.00	0.50	0.00				
0.50	0.00	0.50	0.00					0.52	0.00	0.50	0.00				
0.21	0.00	0.50	0.00					0.50	0.00	0.50	0.00				

Panel B	Modified GARCH-M				Truncated-GARCH-M			
	SSE A	SSE B	SZSE A	SZSE B	SSE A	SSE B	SZSE A	SZSE B
Mean	0.41	0.36	0.45	0.26	0.50	0.48	0.49	0.47
SD	0.14	0.17	0.10	0.18	0.03	0.07	0.05	0.08
Min	0.10	0.07	0.15	0.05	0.32	0.17	0.26	0.14
Q1	0.30	0.16	0.47	0.10	0.50	0.49	0.50	0.49
Median	0.49	0.47	0.50	0.18	0.50	0.50	0.50	0.50
Q3	0.50	0.50	0.50	0.47	0.50	0.50	0.50	0.50
Max	0.50	0.50	0.53	0.50	0.52	0.52	0.53	0.51

Table 3.13 Summary of Truncated-GARCH-M Model' Parameters

This table summarises the number of estimated parameters which are significant at 0.1%, 1% and 5% from the truncated-GARCH-M mode.

SSE (N=40)	β_1	β_2	β_3	β_4	β_5	β_6	β_7	β_8	β_9	β_{10}	β_{11}	β_{12}	β_{13}	β_{14}	β_{15}	β_{16}
5% significance results																
SSE A Total	34	35	1	37	3	2	3	1	36	37	37	37	37	25	37	27
Positive	12	9	1	27	3	1	0	1	20	36	37	37	35	25	16	24
Negative	22	26	0	10	0	1	3	0	16	1	0	0	2	0	21	3
SSE B Total	32	37	0	36	1	7	5	4	35	37	36	36	22	32	28	27
Positive	17	12	0	19	1	5	3	3	15	35	36	36	20	26	18	21
Negative	15	25	0	17	0	2	2	1	20	2	0	0	2	6	10	6
1% significance results																
SSE A Total	33	34	0	37	3	1	3	0	35	37	37	36	37	22	37	25
Positive	11	9	0	27	3	0	0	0	19	36	37	36	35	22	16	22
Negative	22	25	0	10	0	1	3	0	16	1	0	0	2	0	21	3
SSE B Total	31	37	0	36	1	5	5	4	35	37	36	36	19	30	25	27
Positive	17	12	0	19	1	4	3	3	15	35	36	36	17	24	15	21
Negative	14	25	0	17	0	1	2	1	20	2	0	0	2	6	10	6
0.1% significance results																
SSE A Total	33	34	0	37	2	1	2	0	35	37	37	36	35	18	37	23
Positive	11	9	0	27	2	0	0	0	19	36	37	36	33	18	16	20
Negative	22	25	0	10	0	1	2	0	16	1	0	0	2	0	21	3
SSE B Total	30	37	0	36	1	4	4	4	35	37	36	36	17	27	20	25
Positive	17	12	0	19	1	4	2	3	15	35	36	36	15	21	11	19
Negative	13	25	0	17	0	0	2	1	20	2	0	0	2	6	9	6

SZSE (N=38)	β_1	β_2	β_3	β_4	β_5	β_6	β_7	β_8	β_9	β_{10}	β_{11}	β_{12}	β_{13}	β_{14}	β_{15}	β_{16}
5% significant results																
SZSE A Total	31	32	2	32	1	0	1	2	31	32	32	32	30	21	29	22
Positive	17	8	1	25	1	0	0	0	19	32	32	32	29	21	28	20
Negative	14	24	1	7	0	0	1	2	12	0	0	0	1	0	1	2
SZSE B Total	28	31	1	31	1	2	6	15	29	32	32	32	16	23	17	25
Positive	10	10	1	20	0	0	3	7	14	31	32	32	16	22	8	12
Negative	18	21	0	11	1	2	3	8	15	1	0	0	0	1	9	13
1% significant results																
SZSE A Total	30	32	2	32	1	0	1	2	31	32	32	32	29	20	29	21
Positive	16	8	1	25	1	0	0	0	19	32	32	32	28	20	28	19
Negative	14	24	1	7	0	0	1	2	12	0	0	0	1	0	1	2
SZSE B Total	26	31	0	31	1	2	5	14	29	32	32	32	13	22	16	23
Positive	8	10	0	20	0	0	3	6	14	31	32	32	13	21	7	10
Negative	18	21	0	11	1	2	2	8	15	1	0	0	0	1	9	13
0.1% significance results																
SZSE A Total	30	32	2	32	1	0	1	2	31	32	32	32	26	19	24	17
Positive	16	8	1	25	1	0	0	0	19	32	32	32	25	19	23	15
Negative	14	24	1	7	0	0	1	2	12	0	0	0	1	0	1	2
SZSE B Total	24	30	0	31	1	2	5	14	27	32	31	32	10	21	15	22
Positive	7	10	0	20	0	0	3	6	14	31	31	32	10	20	6	9
Negative	17	20	0	11	1	2	2	8	13	1	0	0	0	1	9	13

Note: Detailed estimated parameters' values are shown in Appendix 3.3c, 3.3d, 3.4c and 3.4d.

Table 3.14 Comparison of Coefficients

This table compares the number of significant individual coefficients between daily and intraday models at the 0.1% significance level. Note: β_9 in daily model is β_{10} in intraday model, same logic is applied to other following betas.

$$R_t = \mu_t + \varepsilon_t \quad \varepsilon_t\,|\Omega_t \sim N(0, \sigma_t^2) \text{ or } \varepsilon_t\,|\Omega_t \sim TN(0, \sigma_t^2)$$

Daily

$$\mu_t = \beta_1 + (\beta_2 + \beta_3 Tor_{t-1} + \beta_4 \sigma_{t-1} + \beta_5 Up_{t-1} + \beta_6 Lo_{t-1} + \beta_7 Up9_{t-1} + \beta_8 Lo9_{t-1})R_{t-1},$$
$$\sigma_t^2 = \beta_9 + \beta_{10}\varepsilon_{t-1}^2 + \beta_{11}\sigma_{t-1}^2 + \beta_{12}Up_{t-1} + \beta_{13}Lo_{t-1} + \beta_{14}Up9_{t-1} + \beta_{15}Lo9_{t-1},$$

Intraday

$$\mu_t = \beta_1 + (\beta_2 + \beta_3 Tor_{t-1} + \beta_4 \sigma_{t-1} + \beta_5 SU_{t-1} + \beta_6 SL_{t-1} + \beta_7 SU9_{t-1} + \beta_8 SL9_{t-1} + \beta_9 M)R_{t-1},$$
$$\sigma_t^2 = \beta_{10} + \beta_{11}\varepsilon_{t-1}^2 + \beta_{12}\sigma_{t-1}^2 + \beta_{13}SU_{t-1} + \beta_{14}SL_{t-1} + \beta_{15}SU9_{t-1} + \beta_{16}SL9_{t-1}.$$

Daily - Intraday	β_1	β_2	β_3	β_4	β_5	β_6	β_7	β_8	β_9	β_{10}	β_{11}	β_{12}	β_{13}	β_{14}	β_{15}
SSE A Total	-33	-30	8	-33	4	-1	-1	2	-4	-1	3	-34	-15	-31	-17
Positive	-11	-8	0	-23	4	0	0	2	-3	-1	3	-32	-15	-16	-20
Negative	-22	-22	8	-10	0	-1	-1	0	-1	0	0	-2	0	-15	3
SSE B Total	-29	-36	2	-34	4	-3	-4	-3	2	3	4	-16	-25	-15	-23
Positive	-17	-12	0	-17	4	-4	-2	-3	4	3	4	-15	-21	-11	-19
Negative	-12	-24	2	-17	0	1	-2	0	-2	0	0	-1	-4	-4	-4
SZSE A Total	-30	-32	2	-31	6	1	0	-2	-1	3	6	-24	-17	-23	-11
Positive	-16	-8	-1	-24	6	1	0	0	-1	3	6	-23	-18	-23	-14
Negative	-14	-24	3	-7	0	0	0	-2	0	0	0	-1	1	0	3
SZSE B Total	-23	-28	3	-30	6	2	-4	-12	5	6	6	-9	-15	-12	-13
Positive	-6	-9	0	-19	7	3	-3	-5	6	6	6	-9	-18	-5	-8
Negative	-17	-19	3	-11	-1	-1	-1	-7	-1	0	0	0	3	-7	-5

Table 3.15 Magnet Effect

Panel A of this table summarises the probability (X/Y) of price hitting the limits when it is close to the limits on the SSE and SZSE. X is the number of days that the trading price first reaches 90% of upper (lower) limits then hits the limits in the following trades. Y is the total number of days that the trading price is greater (smaller) than 90% of limits. Panel B summarises the distance, as measure by tick size (1 tick size = 0.01), from 10 trades to the limits-hit. The first row of figures in panel B implies the tick size of 10 trades before the limits-hits. The final row of figures in panel B suggests the tick size of 1 trade before the limits-hits.

Panel A

	SSE					SZSE			
	A		B			A		B	
	Upper	Lower	Upper	Lower		Upper	Lower	Upper	Lower
Min	25%	0%	0%	0%	Min	22%	0%	0%	0%
Mean	64%	52%	51%	58%	Mean	69%	44%	61%	55%
Median	67%	58%	50%	50%	Median	68%	50%	50%	50%
Max	92%	100%	100%	100%	Max	100%	100%	100%	100%

Panel B

	SSE A		SSE B		SZSE A		SZSE B	
n	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower
10	11.53	11.93	1.29	1.65	10.45	9.33	16.52	16.37
9	10.89	11.69	1.29	1.50	9.84	9.47	16.72	16.01
8	10.32	11.39	1.28	1.47	8.89	9.13	16.72	16.35
7	9.55	10.92	1.25	1.37	8.28	8.73	16.15	15.90
6	8.83	10.52	1.25	1.34	7.45	8.33	15.99	15.51
5	8.02	10.26	1.17	1.23	6.76	8.01	15.87	14.82
4	7.00	9.60	1.25	1.21	6.03	5.52	15.17	13.60
3	5.58	8.78	1.20	1.15	5.31	5.37	14.53	12.70
2	4.45	8.57	0.85	0.95	4.68	5.36	13.95	12.54
1	3.56	8.73	0.84	0.76	3.83	4.12	13.07	7.97

Table 3.16 Test of Magnet Effect

This table reports the coefficients of the following regression. If there is a magnet effect, the estimated beta should be significantly different from zero.

$$TS_{in} = \alpha_0 + \beta_1 n + \varepsilon_{in} ,$$

where TS_{in} is the tick size for the *n* trades (n=1, 2, …, 10) before the limit-hit, *i* denotes upper or lower price-limit-hits.

	SSE A		SSE B		SZSE A		SZSE B	
	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower
α_0	3.0621	3.2683	0.3200	0.4580	2.8408	2.5294	5.6949	5.0168
p-value	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000
β_1	0.9112	0.3792	0.0274	0.0666	0.6779	0.3114	0.4843	0.5210
p-value	0.0000	0.0000	0.0286	0.0000	0.0000	0.0000	0.0360	0.0018
R-squared	0.0411	0.0082	0.0026	0.0164	0.0245	0.0137	0.0040	0.0063

Appendix 3.1a Chi-squared Test

This table reports the Chi-squared tests for intraday price-limit-hits between the morning and afternoon session, as well as the A and B-shares on the SSE. MarProb denotes marginal probability.

SSE	AM	PM	Total	MarProb	SSE	A	B	Total	MarProb
1	502	1203	1705	0.46	1	1705	757	2462	0.47
2 to 10	428	886	1314	0.36	2 to 10	1314	580	1894	0.36
11 to 20	76	114	190	0.05	11 to 20	190	88	278	0.05
21 to 30	40	54	94	0.03	21 to 30	94	31	125	0.02
31 to 40	16	37	53	0.01	31 to 40	53	19	72	0.01
41 to 50	9	26	35	0.01	41 to 50	35	18	53	0.01
51 to 60	10	13	23	0.01	51 to 60	23	3	26	0.00
61 to 70	7	21	28	0.01	61 to 70	28	12	40	0.01
71 to 80	3	15	18	0.00	71 to 80	18	4	22	0.00
81 t0 90	5	6	11	0.00	81 t0 90	11	5	16	0.00
91 to 100	5	9	14	0.00	91 to 100	14	3	17	0.00
>100	40	155	195	0.05	>100	195	17	212	0.04
Total	1141	2539	3680		Total	3680	1537	5217	
MarProb	0.31	0.69			MarProb	0.71	0.29		
Expected	AM	PM	Total	Chi-stat	Expected	A	B	Total	Chi-stat
1	529	1176	1705	32.10	1	1737	725	2462	59.42
2 to 10	407	907	1314	Dof	2 to 10	1336	558	1894	Dof
11 to 20	59	131	190	11	11 to 20	196	82	278	11
21 to 30	29	65	94	p-value	21 to 30	88	37	125	p-value
31 to 40	16	37	53	7.34E-04	31 to 40	51	21	72	1.19E-08
41 to 50	11	24	35		41 to 50	37	16	53	
51 to 60	7	16	23		51 to 60	18	8	26	
61 to 70	9	19	28		61 to 70	28	12	40	
71 to 80	6	12	18		71 to 80	16	6	22	
81 t0 90	3	8	11		81 t0 90	11	5	16	
91 to 100	4	10	14		91 to 100	12	5	17	
>100	60	135	195		>100	150	62	212	
Total	1141	2539	3680		Total	3680	1537	5217	

Appendix 3.1b Chi-squared Test

This table reports the Chi-squared tests for intraday price-limit-hits between the morning and afternoon session, as well as the A and B-shares on the SZSE. MarProb denotes marginal probability.

SZSE	AM	PM	Total	MarProb	SZSE	A	B	Total	MarProb
1	474	998	1472	0.47	1	1472	499	1971	0.47
2 to 10	395	740	1135	0.36	2 to 10	1135	390	1525	0.37
11 to 20	56	94	150	0.05	11 to 20	150	47	197	0.05
21 to 30	25	47	72	0.02	21 to 30	72	34	106	0.03
31 to 40	13	36	49	0.02	31 to 40	49	7	56	0.01
41 to 50	15	23	38	0.01	41 to 50	38	11	49	0.01
51 to 60	7	14	21	0.01	51 to 60	21	1	22	0.01
61 to 70	7	20	27	0.01	61 to 70	27	5	32	0.01
71 to 80	5	14	19	0.01	71 to 80	19	3	22	0.01
81 t0 90	7	11	18	0.01	81 t0 90	18	2	20	0.00
91 to 100	2	6	8	0.00	91 to 100	8	3	11	0.00
>100	38	108	146	0.05	>100	146	5	151	0.04
Total	1044	2111	3155		Total	3155	1007	4162	
MarProb	0.33	0.67			MarProb	0.76	0.24		
Expected	AM	PM	Total	Chi-stat	Expected	A	B	Total	Chi-stat
1	487	985	1472	9.80	1	1494	477	1971	56.20
2 to 10	376	759	1135	Dof	2 to 10	1156	369	1525	Dof
11 to 20	50	100	150	11	11 to 20	149	48	197	11
21 to 30	24	48	72	p-value	21 to 30	80	26	106	p-value
31 to 40	16	33	49	0.55	31 to 40	42	14	56	4.66E-08
41 to 50	13	25	38		41 to 50	37	12	49	
51 to 60	7	14	21		51 to 60	17	5	22	
61 to 70	9	18	27		61 to 70	24	8	32	
71 to 80	6	13	19		71 to 80	17	5	22	
81 t0 90	6	12	18		81 t0 90	15	5	20	
91 to 100	3	5	8		91 to 100	8	3	11	
>100	48	98	146		>100	114	37	151	
Total	1044	2111	3155		Total	3155	1007	4162	

Appendix 3.1c Chi-squared Test

This table reports the Chi-squared tests for intraday price-limit-hits between the SSE and SZSE. MarProb denotes marginal probability.

	SSE A	SZSE A	Total	MarProb		SSE B	SZSE B	Total	MarProb
1	1705	1472	3177	0.46	1	757	499	1256	0.49
2 to 10	1314	1135	2449	0.36	2 to 10	580	390	970	0.38
11 to 20	190	150	340	0.05	11 to 20	88	47	135	0.05
21 to 30	94	72	166	0.02	21 to 30	31	34	65	0.03
31 to 40	53	49	102	0.01	31 to 40	19	7	26	0.01
41 to 50	35	38	73	0.01	41 to 50	18	11	29	0.01
51 to 60	23	21	44	0.01	51 to 60	3	1	4	0.00
61 to 70	28	27	55	0.01	61 to 70	12	5	17	0.01
71 to 80	18	19	37	0.01	71 to 80	4	3	7	0.00
81 t0 90	11	18	29	0.00	81 t0 90	5	2	7	0.00
91 to 100	14	8	22	0.00	91 to 100	3	3	6	0.00
>100	195	146	341	0.05	>100	17	5	22	0.01
Total	3680	3155	6835		Total	1537	1007	2544	
MarProb	0.54	0.46		6835	MarProb	0.60	0.40		2544
Expected	SSE A	SZSE A	Total	Chi-stat	Expected	SSE B	SZSE B	Total	Chi-stat
1	1711	1466	3177	8.30	1	759	497	1256	11.99194
2 to 10	1319	1130	2449	Dof	2 to 10	586	384	970	Dof
11 to 20	183	157	340	11	11 to 20	82	53	135	11
21 to 30	89	77	166	p-value	21 to 30	39	26	65	p-value
31 to 40	55	47	102	0.69	31 to 40	16	10	26	0.36
41 to 50	39	34	73		41 to 50	18	11	29	
51 to 60	24	20	44		51 to 60	2	2	4	
61 to 70	30	25	55		61 to 70	10	7	17	
71 to 80	20	17	37		71 to 80	4	3	7	
81 t0 90	16	13	29		81 t0 90	4	3	7	
91 to 100	12	10	22		91 to 100	4	2	6	
>100	184	157	341		>100	13	9	22	
Total	3680	3155	6835		Total	1537	1007	2544	

Appendix 3.2 Number of Observations

This appendix illustrates the number of observations (#Obs) for AB-shares on the SSE and SZSE.

SSE				SZSE			
A	#Obs	B	#Obs	A	#Obs	B	#Obs
600094	190,236	900940	41,404	000002	2,112,518	200002	449,197
600190	483,689	900952	100,042	000011	1,064,972	200011	137,087
600221	1,359,422	900945	133,229	000012	1,905,329	200012	499,830
600272	814,678	900943	85,315	000016	935,277	200016	126,869
600295	930,322	900936	306,018	000019	554,723	200019	47,974
600320	1,128,855	900947	291,823	000020	591,003	200020	82,173
600555	773,462	900955	103,047	000022	523,258	200022	79,798
600602	909,238	900901	132,847	000025	452,999	200025	40,948
600604	47,253	900902	10,879	000026	615,681	200026	103,353
600611	915,163	900903	178,737	000029	786,853	200029	80,003
600612	770,640	900905	257,790	000037	499,857	200037	73,111
600613	572,248	900904	68,328	000039	1,569,179	200039	357,143
600614	1,180,769	900907	198,539	000045	511,734	200045	57,736
600618	1,065,136	900908	239,243	000055	945,191	200055	167,503
600619	624,469	900910	158,975	000056	505,924	200056	72,107
600623	664,894	900909	169,053	000058	465,446	200058	65,857
600639	625,588	900911	102,297	000413	544,883	200413	102,204
600648	498,889	900912	92,519	000418	739,660	200418	79,286
600663	770,537	900932	186,847	000429	397,702	200429	85,966
600679	708,347	900916	102,362	000488	1,118,043	200488	222,713
600680	569,971	900930	78,058	000521	864,974	200521	116,174
600689	537,524	900922	64,490	000530	779,412	200530	93,631
600695	727,623	900919	156,724	000539	751,309	200539	153,884
600726	585,994	900937	103,673	000541	1,332,450	200541	170,068
600776	925,223	900941	160,432	000550	693,805	200550	95,485
600801	991,769	900933	172,896	000553	703,613	200553	108,696
600818	603,763	900915	98,811	000570	818,692	200570	125,318
600819	550,872	900918	109,559	000581	987,240	200581	175,994
600822	695,130	900927	110,903	000596	598,156	200596	164,027
600827	687,568	900923	133,955	000625	1,425,501	200625	359,991
600835	891,616	900925	185,820	000725	1,837,056	200725	189,598
600841	374,418	900920	141,291	000761	419,324	200761	145,369
600843	455,669	900924	126,358				
600844	1,023,006	900921	193,802				
600845	328,235	900926	96,022				
600848	632,410	900928	113,934				
600851	1,247,000	900917	244,563				

Appendix 3.3a Detailed Estimation Results for Modified-GARCH-M on the SSE A-Shares

β_1	β_2	β_3	β_4	β_5	β_6	β_7	β_8	β_9	β_{10}	β_{11}	β_{12}	β_{13}	β_{14}	β_{15}	β_{16}
0.00b	-0.43c	16.2	0.45c	-2.06	-0.65a	0.42	0.27	0	0.00c	0.14c	0.78c	111.53c	0.00c	0.07c	0.00c
0.00c	-0.51c	-9.75	1.72c	-3.71c	-19.41c	-0.16	-30.6	0	0.00c	0.09c	0.85c	0.00c	1.48c	0.00c	631.53c
0.00c	-0.53c	12.31	1.31c	-5.79c	-1.16c	0.49c	0.31b	0.01c	0.00c	0.08c	0.87c	0.14c	0.00c	0	0.00b
0.00c	-0.89c	-85.07c	12.81c	4.69c	-1.53	2.05c	20.10c	-0.02c	0.00c	0.02c	0.90c	0.01c	1.81c	0.00c	0.11c
0	26.35c	-1.85	-15.33c	0.43	0.3	0.44	0.01	-8.60c	0.35c	0.10c	0.80c	-0.22c	24.07c	-0.97c	2.11b
0.00c	-0.68c	7.9	5.37c	-4.26	[]	1.85c	[]	0.00a	0.00c	0.07c	0.88c	24.34c	[]	0	[]
0.00b	-0.09c	31.47	-7.96c	-28.96c	-17.31c	4.26c	-19.61c	0.06c	0.00c	0.04c	0.67c	0.17c	0.18c	0.44c	0.25c
0.00c	-0.36c	-174.85c	-2.20c	-5.38	8.84c	-0.36	0.16	0.02c	0.00c	0.10c	0.84c	2006.81c	0.03	0.29c	0.01c
0.00b	-0.36c	-2.79	0.06	-1.11c	-0.36	-0.78c	-1.16	-0.01	0.00c	0.16c	0.82c	0	0.00c	0.00b	0.03a
0	-0.52c	112.41a	2.64c	44.49c	[]	0.69c	[]	-0.02c	0.00c	0.08c	0.88c	0.41c	[]	0.31c	[]
0.00c	-0.37c	-2.71	0.13b	1.42	-5.27c	2.99c	-1.05a	-0.01c	0.00c	0.14c	0.85c	305.69c	0.08c	0.00c	0.00c
0.00c	-0.37c	18.35	0.15b	1.58	-5.87c	-0.3	2.01c	0.02c	0.00c	0.17c	0.80c	45.71c	0.00c	0.01c	0.01c
0	-0.38c	-451.93c	-0.95c	0	0.2	-0.61c	12.68c	0.00b	0.00c	0.13c	0.85c	92.64c	0.08c	0.00c	0.05c
0.00c	-0.45c	-13.74	0.83c	-5.98	-17.55c	-32.41c	-6.48c	0.02c	0.00c	0.19c	0.79c	278.22c	0.01c	0.04c	0.01c
0	-0.44c	-4.87	1.45c	1.54	48.26c	1.24c	0.75	-0.02c	0.00c	0.13c	0.84c	9.45c	27.47c	0.01c	0.00c
0.00c	-0.44c	-4.72	1.61c	-5.91c	-57.14c	4.19c	6.37c	-0.04c	0.00c	0.09c	0.89c	0.01c	3.97c	0.07c	0.00c
0.00c	-0.44c	7.91	1.17c	-1	[]	-1.61	[]	0	0.00c	0.14c	0.81c	0.00c	[]	0.06c	[]
0.00c	-0.37c	-9.98	0.51c	-0.4	-2.26c	1.11c	-1.40c	-0.02c	0.00c	0.15c	0.83c	0.07c	0.00c	0.00c	0.00c
0.00c	-0.43c	-2.27	1.37c	-1.17b	[]	-0.33	[]	-0.01c	0.00c	0.17c	0.79c	0.00c	[]	0.00c	[]
0.00c	-0.39c	2.37	0.15c	2.85	-1.94c	1.68c	2.91c	0.01c	0.00c	0.17c	0.81c	235.14c	0.00c	0.01c	0.00c
0.00c	-0.39c	-13.28	0.12b	-6.09	-0.03	0.25	-0.44	0	0.00c	0.17c	0.81c	1443.20c	334.12c	0.00b	0
0.00c	-0.38c	-16.5	0.10a	1.24	-3.66	-0.33	1.15	0	0.00c	0.15c	0.82c	1847.78c	557.50c	0.00c	0
0.00c	-0.51c	-24.31	1.66c	-8.58	-1.53c	-1.41c	1.17c	0.01c	0.00c	0.10c	0.85c	62.49c	0.02c	0.03c	0.00c
0	-0.48c	6.48	0.67c	-2.78c	0.16	-1.69c	-5.19c	0.00a	0.00c	0.05c	0.91c	0.00c	0.43	0	0.01
0	-0.16c	-0.38	-7.06c	-207.23c	145.28c	-211.14c	20.49a	0.03c	0.00c	0.07c	0.84c	0.21c	33.77c	2.80c	88.80c
0.00c	-0.36c	-4.4	-0.41c	0.64	0.28	-0.22	1.10c	-0.01c	0.00c	0.13c	0.86c	190.84c	220.62c	0.00c	0.00a
0.00c	-0.13c	-2.61	-8.05c	5.83c	0.34	-1.60c	2.31	-0.03c	0.00c	0.10c	0.79c	0.00c	794.93c	0.00c	206.68c
0.00c	-0.33c	7.01	-0.66c	-8.22c	-23.93	-1.84c	-2.66c	0	0.00c	0.12c	0.84c	2.87c	63.84c	0.00c	0.00c
0.00c	-0.81c	-270.07c	10.39c	-43.48c	-105.17c	-2.43	2.84b	-0.04c	0.00c	0.32c	0.68c	0.26c	2.20c	0.36c	0.17c
0.00c	-0.38c	-9.94	-0.41c	-1.25c	[]	-0.05	[]	0.00a	0.00c	0.17c	0.81c	0.00c	[]	0.05c	[]
0.00c	-0.45c	22.73	0.85c	-7.42	[]	0.1	[]	0.01c	0.00c	0.10c	0.87c	43.24c	[]	0	[]
0.00c	-0.29c	1.36	-0.66c	-1.17c	-0.29	-0.35	-0.1	-0.02c	0.00c	0.20c	0.80c	0.00c	0.00c	0.00c	0.01c
0.00b	-0.34c	-17.31	0.15b	-9.06	70.75c	-0.02	2.74c	-0.01b	0.00c	0.17c	0.81c	247.64c	8.94c	0.00c	0.00b
0.00c	-0.39c	-32.19	0.25c	-0.47	-2.62	-0.91c	0.72c	-0.01c	0.00c	0.12c	0.87c	0.74c	111.39c	0	0.00c
0.00c	-0.30c	-10.52	-0.23c	-0.02	-0.03	-1.19	3.87	0	0.00c	0.13c	0.86c	0.01c	0.52	0.00b	0.63a
0.01c	-0.61c	3.09	17.21c	2.28	0.28	-18.46c	2.5	-0.26c	0.00c	0.08c	0.78c	1837.98c	304.14c	0.22c	400.50c
0	-0.13c	473.34c	-7.15c	-7.07b	-8.53c	-2.03c	-1.52c	0.01c	0.00c	0.00c	0.74c	0.42c	0.08c	0.15c	0.00c

Note: a, b and c mean the coefficients are significant at 5%, 1% and 0.1% level. [] suggests no price-limits-hit.

Appendix 3.3b Detailed Estimation Results for Modified-GARCH-M on the SSE B-Shares

β_1	β_2	β_3	β_4	β_5	β_6	β_7	β_8	β_9	β_{10}	β_{11}	β_{12}	β_{13}	β_{14}	β_{15}	β_{16}
0.00b	-0.15c	2.89	-2.75c	-2.42c	-1.5	1.99c	21.27c	-0.03c	0.00c	0.13c	0.80c	0.00b	0.07c	0.00c	0.03c
0	-0.29c	1.64	-0.49c	-147.51c	-20.69c	-7.16	-0.26	-0.01	0.00c	0.10c	0.71c	4.22	0.04b	28.68c	0.02c
0.00c	-1.73c	5.94	27.00c	-21.05c	-34.72c	29.46c	10.85c	-0.15c	0.00c	0.01c	0.62c	0.76c	0.04c	0.38c	0.01c
0.00c	-0.21c	31.94	-1.58c	[]	1.63c	[]	-0.74	0.03c	0.00c	0.12c	0.85c	[]	0.01a	[]	0.04c
0.00c	0.02c	-0.42	-7.18c	0.57	1.33	4.32c	-6.09c	-0.08c	0.00c	0.07c	0.88c	64.17c	0.03c	0.00b	0.01c
0.00c	-0.39c	-1.31	0.03	-1.18c	-1.62c	-0.07	0.03	0.02c	0.00c	0.08c	0.90c	0.01c	0	0.00a	0.00c
0.00c	-0.43c	-1.32	1.99c	-2.66c	-3.45c	7.10c	1.58	0.04c	0.00c	0.12c	0.81c	0	0	0	0.73c
0	-0.36c	0.46	1.38c	-2.99	-3.31c	-53.78c	-7.11c	-0.02c	0.00c	0.12c	0.84c	0.00b	0.01c	0.62	0.21c
0.00c	-0.35c	22.44	0.96	-4.82	[]	0.43	[]	-0.01	0.00c	0.18c	0.70c	1.22c	[]	0	[]
0.00c	-0.65c	-1.88	8.39c	143.56c	[]	-2.24	[]	-0.01	0.00c	0.11c	0.83c	5.84c	[]	28.89c	[]
0.00a	-0.31c	-532.29c	-0.85c	-1210.65c	108.43	-403.74c	4336.16c	-0.05c	0.00c	0.47c	0.53c	107.25b	4407.69c	35.85b	0.02c
0.00c	-0.17c	116.64c	-1.10c	-75.44c	0.27	-14.80c	-14.92a	-0.03c	0.00c	0.07c	0.29c	39.90c	213.22c	-0.01c	1.56a
0.00c	-0.29c	11.84	-0.61c	-0.84	-1.96c	-1.40c	2.37c	0.02c	0.00c	0.12c	0.85c	101.73c	0.00c	0.00c	0.00c
0.00b	-0.34c	16.22	-1.09c	3.74c	2.24	-1.48c	1.18	0.02c	0.00c	0.15c	0.79c	0.01a	488.88c	0	0.07c
0.00a	-0.23c	4.97	-2.99c	-1.68c	0.8	0.35	-2.97c	0.01	0.00c	0.18c	0.54c	0.00a	67.19a	0.01c	0.00c
-0.03c	17.47c	-5.93	-42.30c	11.21b	-23.27	-52.14c	-2.58b	-0.83c	0.16c	0.00c	0.07c	20.42c	231.95c	-0.18a	-0.34c
0.00b	-0.71c	0.17	11.02c	-3.16	-157.13c	-37.26	8.72c	0.08c	0.00c	0.39c	0.58c	11.16c	-66.76c	2.89c	-0.02c
0.00a	-0.41c	2.66	2.52c	-7.40c	36.29	32.70c	[]	-0.01a	0.00c	0.27c	0.40c	-1.09c	2.5	-0.01c	[]
0	-0.24c	-6.98	-4.30c	1.35b	11.14	2.01c	-7.17c	0.12c	0.00c	0.05c	0.90c	0.00b	481.57c	0.00c	-0.02c
0	-0.21c	11.13	-1.32c	-4.92b	-1	0.63b	-0.1	0.03c	0.00c	0.20c	0.77c	0.02	0.09c	0.04	0.01c
0	-0.24c	44.87	-0.45c	0	0.24	-9.59c	-0.82	0	0.00c	0.20c	0.79c	353.17b	238.95c	-0.01c	0.01
0.00c	-0.21c	0.42	-0.36c	9.08c	-0.76	-0.91c	-6.16	0.02a	0.00c	0.20c	0.80c	0.00c	19.61c	0.00c	0.01c
0.00c	-0.33c	1.39	-1.04c	-1.41b	-1.48	4.55c	2.13c	0.02c	0.00c	0.11c	0.83c	0.00b	0.24c	0.04c	0.00a
0	-0.68c	-1.97	6.63c	-1.94c	-2.13c	-29.26c	-15.59c	0.07c	0.00c	0.12c	0.08c	-0.01c	0.00c	10.81c	0.00c
0.00c	-0.36c	5.86	0.29a	[]	-3.55	[]	0.23	0.01	0.00c	0.10c	0.85c	[]	0.30c	[]	0.00c
0.00c	-0.25c	10.45	-1.20c	-21.59c	-3.97	4.76	-97.66c	0.02c	0.00c	0.06c	0.91c	0.52c	3000.99c	31.45c	0
0.00b	-0.25c	17.6	-0.12	-1.66	-2.32c	6.29	0.24	-0.02c	0.00c	0.18c	0.80c	0.00c	0.01c	331.61c	0.11c
0.00c	-0.29c	16.32	-1.04c	-10.19a	334.66c	162.35c	-5.84c	0.06c	0.00c	0.16c	0.77c	0.1	7.00c	30.14c	0.10c
0.06c	-2.26c	69.83	-8.87c	0.15	33.22c	62.93c	23.64c	4.36c	0.04c	0.27c	0.34c	3.91	-0.03c	1.47	-0.06c
0.00b	-0.31c	2.39	-0.33c	-9.42	-1.20b	7.43	-17.29c	0.05c	0.00c	0.16c	0.84c	0.37c	0.02b	442.80c	-0.03
0.00c	-0.40c	-14.17	0.27c	10.04b	60.68c	-20.61a	44.06b	0.02c	0.00c	0.41c	0.59c	0.25	0	-0.02	3.99
0.04c	-24.30c	-0.07	48.73c	0.56	0.75	2.8	8.20c	2.47c	0.10c	0.10c	0.38c	-0.06c	0.40c	1.06c	-0.06a
0.00c	-0.42c	6.33	0.53c	26.57a	-0.76c	-53.79	-0.25	0.05c	0.00c	0.23c	0	18.41	0.00a	9.49a	0.02c
0.00b	-0.30c	33.25	-0.07	[]	-109.18c	[]	-0.24	0	0.00c	0.17c	0.82c	[]	312.84c	[]	0.02c
0.00c	-0.93c	2.01	17.01c	[]	7.40c	[]	0.80a	0.03c	0.00c	0.04c	0.31c	[]	0.02c	[]	0.00c
0.00c	-0.62c	-11.55	9.46c	4.08	32.14c	22.88c	6.60c	-0.21c	0.00c	0.07c	0.35c	3.76c	18.03c	66.93c	-0.01c
0.00c	-0.40c	46.91	0.69c	-0.94	0.15	-9.48	0.7	-0.01a	0.00c	0.21c	0.66c	629.75c	0.02c	355.53c	0.02c

Note: a, b and c mean the coefficients are significant at 5%, 1% and 0.1% level. [] suggests no price-limits-hit.

Appendix 3.3c Detailed Estimation Results for Truncated-GARCH-M on the SSE A-Shares

β_1	β_2	β_3	β_4	β_5	β_6	β_7	β_8	β_9	β_{10}	β_{11}	β_{12}	β_{13}	β_{14}	β_{15}	β_{16}
0	-5.28c	-1.91	6.45c	0.81	0.49	0.28	0.18	-3.45c	0.25c	0.06c	0.69c	67.13c	55.76c	-13.09c	20.49c
0.25c	-1.74c	-1.88	5.85c	1.22	0.95	-0.21	0.04	-1.43c	0.06c	0.03c	0.36c	74.64b	146.48c	151.19c	289.21c
-0.06c	-11.74c	-1.95	12.44c	4.4	2.01	-0.91	0.91	-4.77c	0.20c	0.06c	0.63c	611.57c	318.95c	-235.08c	264.38c
-0.06c	-2.63c	-1.91	3.41c	0.77	0.58	-0.28	0.17	3.69c	0.18c	0.04c	0.45c	91.25c	98.78c	-41.84c	24.25c
0.03c	-2.21c	-1.91	-2.28c	-0.04	0.27	0.15	-0.1	2.21c	0.23c	0.05c	0.50c	-69.91c	13.23	31.06c	-17.17c
0.00c	-0.56c	65.56	2.38c	10.91	[]	-5.38	[]	0.00a	0.00c	0.05c	0.93c	364.85c	[]	-0.52c	[]
-0.04c	-1.07c	-1.92	-2.10c	-0.14	0.23	-1.38	-0.16	2.84c	0.14c	0.04c	0.36c	-37.29c	1.05	135.05c	-6.51c
0.12c	2.34c	-1.03	-0.44c	-15.82	0.19	-1.46	-0.15	-6.67c	0.02c	0.12c	0.28c	313.18c	27.38	680.31c	73.64c
0.04c	-0.09c	-1.92	-0.22c	-5.83	-1.82c	-10.88c	-0.29	0.17c	-0.01c	0.04c	0.00a	70.52b	39.27b	9.08c	-12.48
-0.11c	5.01c	-1.91	-12.29c	0.27	[]	-57.42c	[]	-1.76c	0.10c	0.02c	0.24c	8.12c	[]	94.76c	[]
0.02c	0.61c	-2.59	3.63c	0.76	-0.49	-0.06	0.12	-0.18c	0.09c	0.27c	0.24c	29.43c	19.79a	95.55c	2.09a
0	-2.23c	-1.93	3.05c	0.99	0.42	0.83	0.08	0.45c	0.23c	0.05c	0.57c	85.92c	53.13c	-43.62c	10.17c
-0.08c	-2.32c	-1.94	2.80c	1.55	0.77	1.13	0.91	0.51c	0.21c	0.07c	0.56c	299.40c	154.76c	-44.87c	83.87c
-0.08c	-3.50c	-1.91	4.17c	1.49	0.38	0.35	0.26	6.73c	0.15c	0.04c	0.45c	303.17c	46.07b	-56.03c	43.93c
-0.03c	-1.43c	-1.91	3.14c	0.87	0.16	-0.27	-0.08	0.33c	0.24c	0.05c	0.57c	69.00c	32.50b	-30.17c	8.45c
-0.08c	1.67c	-1.91	5.06c	0.6	0.42	0.07	-0.01	-1.76c	0.19c	0.04c	0.44c	48.98c	26.04	-24.85c	12.37c
-0.03c	2.66c	-1.86	-13.00c	0.34	[]	-0.55	[]	1.18c	0.07c	0.03c	0.21c	151.72c	[]	281.00c	[]
-0.04c	1.80c	-1.91	3.03c	0.56	0.33	0.07	0.04	0.38c	0.25c	0.05c	0.57c	30.47c	29.87a	-12.35c	3.79
0.00c	-1.04c	2.64	0.31c	1.18	[]	-1.8	[]	1.00c	0.00c	0.25c	0.10c	920.19c	[]	256.81c	[]
-0.05c	-0.99c	-1.92	2.41c	1.56	0.5	1.07	0.18	-2.76c	0.15c	0.04c	0.45c	148.88c	87.32c	-68.00c	12.15c
-0.07c	-0.36c	-1.92	3.20c	0.51	0.37	0.27	0.11	-0.20c	0.19c	0.04c	0.44c	37.36c	35.04c	-11.91c	5.25c
-0.05c	0.06	-1.91	1.24c	0.51	0.33	0.03	0.01	-0.59c	0.25c	0.05c	0.57c	37.44c	35.61c	-12.20c	3.74a
-0.10c	-1.89c	-1.9	2.69c	0.96	0.53	0.14	0.31	5.56c	0.08c	0.02c	0.26c	139.18c	67.48c	-20.96c	51.52c
-0.11c	-8.77c	-1.9	4.00c	1.03	0.32	-0.35	0.05	9.04c	0.17c	0.04c	0.43c	138.57c	25.81	-25.79c	6.03
-0.07c	1.94c	-1.94	5.43c	2.54	0.86	0.44	-0.35	-7.49c	0.08c	0.03c	0.38c	338.63c	92.78c	-6.06c	87.57c
0.10c	-6.60c	-1.91	9.43c	0.66	0.51	0.3	0.03	0.08	0.16c	0.05c	0.50c	275.36c	202.53c	199.03c	43.38c
0.05c	-4.38c	-8.76	2.33c	25.23c	8.33	8.35	31.41a	-0.86c	0.15c	0.03c	0.35c	36.28c	33.61c	-7.26c	23.50b
0.01a	-0.91c	-1.92	1.48c	0.67	0.51	-0.08	0.24	2.13c	0.23c	0.05c	0.54c	59.56c	52.73c	-11.84c	31.96c
-0.04c	-0.37a	-1.91	2.24c	0.84	0.37	0	-0.04	-1.23c	0.24c	0.05c	0.57c	64.33c	47.84c	-15.92c	8.28c
0.03c	0	-1.02	-3.07c	0.98	[]	-9.86	[]	2.60c	0.00c	0.08c	0.18c	1243.72c	[]	267.93c	[]
0	9.29c	-1.98	-13.30c	12.03c	[]	0.07	[]	-2.59c	0.19c	0.08c	0.45c	1.54c	[]	144.97c	[]
-0.07c	-2.57c	-1.81	1.39c	-1.29	-6.93	-8.46	3.64	4.99c	0.19c	0.19c	0.51c	119.27c	88.84c	20.61c	13.52c
0.05c	-4.53c	-1.92	3.35c	0.11	0.54	-0.09	0.03	0.76c	0.20c	0.04c	0.47c	39.54c	40.90c	-3.05c	9.75b
0.00c	-5.29c	39.13a	3.49c	19.33b	112.19a	6.34	8.15	6.45c	0.00c	0.22c	0.27c	124.61c	485.33c	147.60c	232.52c
0.02c	8.48c	-0.77	-5.71c	5.32	-19.86	-0.05	0.1	-5.69c	0.09c	0.20c	0.24c	145.12c	26.06	73.48c	3.62
-0.07c	-1.96c	-5.12	-0.93c	0.4	-0.29	-9.15b	-1.57	0.51c	0.15c	0.09c	0.33c	28.86c	26.96a	-34.83c	-3.19c
-0.07c	-4.63c	-1.86	7.75c	-0.13	0.19	-0.49	-0.12	-1.47c	0.06c	0.03c	0.34c	18.55c	24.47b	384.40c	31.67c

Note: a, b and c mean the coefficients are significant at 5%, 1% and 0.1% level. [] suggests no price-limits-hit.

Appendix 3.3d Detailed Estimation Results for Truncated-GARCH-M on the SSE B-Shares

β_1	β_2	β_3	β_4	β_5	β_6	β_7	β_8	β_9	β_{10}	β_{11}	β_{12}	β_{13}	β_{14}	β_{15}	β_{16}
0	-0.31c	-207.29	0.07	-6.4	28.95c	8.53	-8.31c	-0.01	0.00c	0.20c	0.76c	54.02c	-0.94c	27.17c	0.01
0.03c	1.47c	-1.65	-0.69c	14.07	0.87	28.09	-0.16	-1.96c	0.00c	0.49c	0.04c	38.60a	147.18b	37.42b	94.47c
0.05c	1.62c	-1.13	-3.10c	1.54	-4.25	0.83	-2.13	-2.31c	0.01c	0.39c	0.05c	193.42c	191.88c	3.36c	4.50b
0.12c	0.29c	-1.79	4.25c	[]	-1.56a	[]	-2.22	0.17c	0.08c	0.22c	0.23c	[]	6.96c	[]	-41.55c
-0.05c	-3.56c	-1.7	9.32c	0.61	0.45	0.97	-0.46	0.43c	0.06c	0.40c	0.30c	163.38b	195.76c	47.71	102.71c
-0.16c	-2.55c	-1.68	4.03c	0.43	0.3	-0.21	-0.35	-0.66c	0.19c	0.05c	0.57c	4.12	15.75c	-5.79c	3.24c
-0.05c	-5.10c	-1.68	14.09c	0.63	0.27	-0.04	-0.12	-5.43c	0.15c	0.04c	0.48c	20.48c	11.16c	4.60c	2.49c
-0.07c	-9.35c	-1.68	15.44c	0.38	0.28	-0.06	0.09	-1.31c	0.20c	0.05c	0.60c	3.94	13.73c	-0.11	0.13
0.12c	12.74c	-1.68	-27.30c	0.13	[]	0.03	[]	-0.90c	0.09c	0.10c	0.17c	5.96c	[]	57.48c	[]
0.01c	2.36c	-1.76	-4.72c	-5.56	[]	-60.06c	0.16	0.47c	0.02c	0.14c	0.04c	-3.81	[]	0.55a	[]
0.11c	5.48c	-1.67	-5.40c	1.03	0.2	-0.19	-0.07	-4.55c	0.18c	0.05c	0.52c	2.06c	9.27a	-0.19	0.73
0.03c	-0.98c	-2.3	-1.00c	-1.61	-0.5	0.1	-2.62	2.48c	0.00c	0.13c	0.03c	102.49b	44.76c	-57.63c	25.43
0.04c	-0.21c	-1.68	-1.11c	-0.59	-0.04	-4.61	-0.97	0.11c	-0.06c	0	0	155.67c	61.10c	10.51c	85.64c
0	-0.44c	-57.79	1.31c	-1.63	64.58	-30.77c	12.21c	-0.01	0.00c	0.17c	0.76c	0.01	138.85c	-2.49c	1.55c
0.08c	-2.90c	-1.69	2.11c	0.54	0.19	-0.28	1.43	1.88c	0.01c	0.05c	0.16c	166.31c	11.76	79.62b	103.75c
-0.07c	-4.97c	-1.68	10.03c	0.92	0.5	0.18	0.2	2.42c	0.03c	0.12c	0.21c	38.58c	114.45c	18.33a	191.12c
0.02c	1.88c	-1.69	-5.08c	0.42	0.32	-1.63	-0.04	-2.42c	0.00c	0.11c	0.08c	176.05c	16.25b	2.49c	13.93c
-0.06c	5.02c	-1.54	-8.03c	-12.19	-0.28	3.62	[]	-2.81c	0.19c	0.62c	0.12c	81.29	-3.04c	-11.81c	[]
0.04c	-0.04c	6.03	-1.39c	-5.11	8.18c	-77.48	13.41	-0.42c	0.00c	0.47c	0.04c	123.39	71.47c	319.24c	56.17
0	-0.30c	-11.54	-0.72c	1.29	117.34c	7.55	8.82	-0.04c	0.00c	0.44c	0.17c	89.18	-19.88c	56.55b	139.02c
0.03c	0.34c	-1.29	3.78c	0.4	0.15	0.68	-5.37	-1.21c	0.00c	0.36c	0.13c	187.56	143.26c	108.46	151.08c
0.13c	-4.49c	-1.68	12.74c	-0.06	0.06	-1	-0.07	1.81c	0.02c	0.03c	0.33c	23.55c	8.61c	93.22c	2.78c
0.09c	4.44c	-1.71	-4.96c	-0.4	-0.35	-2.5	8.88c	-1.91c	0.09c	0.34c	0.30c	26.82c	12.17c	62.86c	-1.47c
0	-0.38c	9.55	0.57c	6.19	10.06a	-0.17	10.71	0.02c	0.00c	0.07c	0.89c	-0.17c	6.69c	0.02c	-5.63c
-0.08c	-2.83c	-1.67	0.81c	[]	0.54	[]	25.85c	3.89c	0.02c	0.02c	0.13c	[]	70.92	[]	1.68c
-0.04c	-2.52c	-1.7	8.49c	8.15c	-10.79	13.45b	1.84	-4.66c	0.09c	0.27c	0.40c	7.02c	7.75c	0	-2.53c
-0.08c	-1.33c	-1.65	-1.42c	0.58	3.93	-0.9	0.23	0.74c	0.03c	0.10c	0.15c	60.79a	104.00a	8.7	25.21b
-0.03b	-10.36c	-1.68	12.33c	0.37	0.19	-0.65	-0.09	-2.49c	0.21c	0.05c	0.60c	4.06a	9.61c	-1.57c	-0.62c
0.04c	-1.52c	-1.63	10.67c	0.34	0.47	0.91	-1.82	-3.53c	0.10c	0.14c	0.29c	8.7	18.03b	-9.68b	75.89c
-0.01a	-1.14c	-1.68	4.44c	0.18	1.2	-0.84	-0.1	-0.51c	0.05c	0.61c	0.17c	8.65c	24.76c	60.85b	2.73
-0.05c	-0.63c	-1.46	-0.19c	18.72	-0.63	-0.06	-0.1	1.54c	0.01c	0.17c	0.24c	110.92	-5.08c	146.55	87.56
-0.07c	-1.43c	-1.94	8.09c	0.65	-10.61b	47.25c	-3.72	0.17c	-0.01c	0.06c	0.38c	367.15c	675.46c	-0.01c	841.22c
0.08c	-2.26c	-1.67	9.19c	0.44	0.31	-0.11	0.33	0.15c	0.06c	0.19c	0.21c	11.93	47.24c	-73.65c	43.84c
0.02c	-2.54c	-1.68	-1.44c	[]	-0.61	[]	8.61	-0.03c	0.02c	0.27c	0.15c	[]	125.49c	[]	112.44c
-0.10c	-0.79c	-1.66	2.84c	[]	9.04	[]	-0.36	-1.27c	0.02c	0.75c	0.08c	[]	33.01	[]	79.38c
-0.02c	6.19c	106.48	-4.80c	-11.2	10.52c	62.51c	-2.82	-4.40c	0.07c	0.33c	0.20c	434.99c	-0.10c	-0.19c	255.43c
0.01	2.32c	-10.98	-7.54c	6.88	1.59	5.14	21.63	7.09c	0.28c	0.08c	0.75c	-56.41c	-5.45c	-6.20c	-22.38c

Note: a, b and c mean the coefficients are significant at 5%, 1% and 0.1% level. [] suggests no price-limits-hit.

Appendix 3.4a Detailed Estimation Results for Modified-GARCH-M on the SZSE A-Shares

β_1	β_2	β_3	β_4	β_5	β_6	β_7	β_8	β_9	β_{10}	β_{11}	β_{12}	β_{13}	β_{14}	β_{15}	β_{16}
0.00b	-0.60c	70.25	2.89c	-10.48c	[]	0.14	[]	0.01c	0.00c	0.08c	0.88c	-17.37c	[]	440.59c	[]
0.00c	-0.46c	44.11c	0.95c	0.24	3.43c	-7.06c	14.79c	0	0.00c	0.11c	0.86c	361.35c	0.00c	0.01c	0.01c
0.00c	-0.41c	46.86c	-0.97c	-2.14	-1.95	-5.75c	1.35b	0.01c	0.00c	0.10c	0.88c	728.37c	12.33c	0.01c	0.00c
0.00c	-0.48c	40.61b	0.47c	0.1	0.64	-5.10c	1.86c	0.01c	0.00c	0.06c	0.92c	501.86c	0.00c	0.00c	0
0.00c	-0.44c	373.95c	0.99c	-4.16	-9.75c	-15.71c	-3.40c	-0.04c	0.00c	0.48c	0.00c	30.67c	2.77c	5.94c	0.01c
0.00c	-0.36c	118.84c	0.19c	-25.71	-4.17	-3.82c	2.83c	-0.03c	0.00c	0.17c	0.81c	3840.17c	918.50c	0.05c	0.00b
0.00c	-0.35c	7.03	0.76c	-3.26	[]	-5.56a	[]	-0.02c	0.00c	0.08c	0.87c	0.01c	[]	0.02	[]
0.00c	-0.26c	-37.53a	-2.28c	1.66c	-3.58c	-218.02c	2.47c	0.01c	0.00c	0.26c	0.69c	0.04c	0	3.36c	0.00c
0.00c	-0.37c	63.05c	0.49c	1.36	-0.77	0.59	-0.93a	-0.01c	0.00c	0.13c	0.85c	178.39c	0.00c	0	0.06c
0.00c	-0.51c	28.09	1.57c	-2.23	-1.83c	-1.26c	-0.55c	-0.01b	0.00c	0.08c	0.88c	69.98c	0.00c	0.00a	0.00b
0.00c	-0.44c	73.38	0.52c	-19.48	-38.92	-171.14c	0.82c	0	0.00c	0.15c	0.76c	13704.42c	3667.09c	1168.74c	0.00c
0.00c	-0.48c	1.66	1.47c	-0.97a	-1.57c	0.17	3.60c	0	0.00c	0.13c	0.83c	0	0.02c	209.68c	0.00c
0.00c	-0.33c	-1.9	-0.45c	1.28	-0.4	0.05	2.31c	0	0.00c	0.15c	0.83c	560.03c	0.01c	0.01c	0.01b
0.00c	-0.44c	18.26c	0.17c	-50.55c	0.23	0.54c	-13.66c	-0.01c	0.00c	0.28c	0	153.90c	0.00b	0.01c	107.39c
0.00c	-0.36c	-18.02a	-0.03	1.28	0.26	-6.17c	-1.81c	0	0.00c	0.17c	0.82c	1003.14c	275.40c	0.01c	0.00b
0	-0.42c	27.55	-0.58c	-0.02	-1.09	0.90b	-1.58c	0.01a	0.00c	0.06c	0.90c	24.33c	0.02c	0.00b	0.00c
0.00c	-0.39c	-11.23	0.49c	-0.92	-2.02	-0.05	-1.72c	-0.03c	0.00c	0.14c	0.84c	33.24c	0.10c	0	0.00c
0.00c	-0.40c	-3.18	0.30c	-0.24	[]	-2.55c	[]	0.01b	0.00c	0.11c	0.88c	0.00c	[]	0.00c	[]
0.00b	-0.51c	-4.03	1.71c	-1.91	[]	1.00c	[]	0	0.00c	0.09c	0.83c	0	[]	0	[]
0	-5.81c	555.87c	136.38c	72.24c	[]	[]	[]	0.00a	0.00c	0.00c	0.40c	0.00c	[]	[]	[]
0.00c	-0.45c	145.27c	0.69c	37.57	-2.42	1.14a	2.98	-0.01c	0.00c	0.07c	0.91c	2140.10c	0	0.01c	87.96c
0.00c	-0.37c	-1.53	-0.41c	0.59	0.04	0.42	-1.54c	0.01c	0.00c	0.11c	0.85c	370.58c	0.00a	0.06c	0.00c
0.00b	-0.49c	-44.22	1.18c	94.39c	[]	-7.63	[]	0.00a	0.00c	0.07c	0.91c	0.16b	[]	206.16c	[]
0	-0.50c	24.88	1.66c	-0.94	-13.10c	-1.82c	-1.94c	0.02c	0.00c	0.10c	0.86c	1211.12c	43.21c	0.00c	0.00c
0.00c	-0.40c	133.29	0.79c	0.88	27.11c	-2.69c	[]	0	0.00c	0.13c	0.86c	195.47c	0.14	0.00c	[]
0.00c	-0.45c	8.55	0.87c	-8.63	-1.46	-1.77c	-0.39	0.01b	0.00c	0.12c	0.84c	901.74c	364.70c	0	0.00a
0.00c	-0.45c	0.36	-0.19c	-1.17	6.90c	-2.82	-5.88c	0.04c	0.00c	0.12c	0.84c	738.21c	0.00c	461.07c	0.00c
0.00c	-0.43c	85.41c	-0.25c	-97.21c	-181.28b	-6.03c	-2.34c	0.02c	0.00c	0.53c	0.00c	496.12c	29.38	0.00c	0.01
0.00c	-0.34c	10.17	0.20c	0.3	-0.2	4.57c	-0.72	-0.02c	0.00c	0.14c	0.86c	307.40c	0.98c	0.00b	0
0.00b	-0.48c	30.66	0.68c	-9.88c	[]	-0.63	[]	0.00b	0.00c	0.05c	0.95c	0.00c	[]	0.00c	[]
0.00c	-0.47c	134.21c	-0.03	3.57	-49.72c	-13.33c	-7.21c	-0.02c	0.00c	0.03c	0.97c	29.98c	0.60c	3.40c	0.00b
0.00c	-0.39c	7.81	0.19b	-2.13	[]	0.44c	[]	0.01b	0.00c	0.11c	0.83c	275.22c	[]	0.00c	[]

Note: a, b and c mean the coefficients are significant at 5%, 1% and 0.1% level. [] suggests no price-limits-hit.

Appendix 3.4b Detailed Estimation Results for Modified-GARCH-M on the SZSE B-Shares

β_1	β_2	β_3	β_4	β_5	β_6	β_7	β_8	β_9	β_{10}	β_{11}	β_{12}	β_{13}	β_{14}	β_{15}	β_{16}
-0.02b	19.43c	-2.63	-10.95c	0.65	0.11	0.06	0.22	-12.49c	0.51c	0.13c	0.67c	8.27c	2.92b	-1.29c	-0.37
0.00c	-0.30c	14.54	0.19a	-1.69	-1.50a	-0.61a	0.83	0.01	0.00c	0.13c	0.84c	0.16c	0.02c	0.00c	0.01c
0.00c	-0.42c	1.09	0.74c	[]	1.39c	[]	-38.67c	0.01b	0.00c	0.10c	0.86c	[]	0.01c	[]	375.04c
0.00a	-0.39c	322.74c	0.85c	[]	-396.54c	[]	0.73	0	0.00c	0.08c	0.86c	[]	1235.81c	[]	0.03c
0	-0.20c	-1.48	0.06	-2.06c	-3	-2.10c	-1.33a	0.01	0.00c	0.13c	0.82c	0.00c	0.36c	0.00c	0.02c
0	-0.35c	37.19	1.11c	-66.07	-5.12	-0.82c	-4.19c	-0.01	0.00c	0.14c	0.80c	507.28c	2.22c	0.00c	0.00c
0.00c	-0.36c	1705.26b	0.12	15.94c	158.17b	[]	[]	0.06c	0.00c	0.24c	0.76c	4.21c	69.02	[]	[]
0.00a	-0.19c	30.69	-0.30a	0	73.91c	89.04c	3.78c	0	0.00c	0.34c	0.46c	58.8	0.13c	7.84c	0.00c
0.00c	-0.18c	16.51	-1.46c	-6.51	-3.42b	-2.77	8.70b	0.05c	0.00c	0.29c	0.71c	0.03	0	139.03a	0.06b
0	-0.28c	50.44	0.23	-0.11	-20.31c	-0.29	-0.17	-0.03c	0.00c	0.13c	0.83c	1.74	0.07a	0	103.81c
0.00c	-0.29c	-0.34	-0.44c	1.47	-3.83	-1.93c	0.64	0.02a	0.00c	0.13c	0.83c	0.22	1.08c	0	0
0.00c	-0.40c	937.34c	0.18c	[]	561.79	[]	-5855.41c	-0.03c	0.00c	0.52c	0.01c	[]	29500.82a	[]	69107.13c
0	-0.27c	1.55	0.17	-0.23	0.28	2.64	7.71c	0.03c	0.00c	0.24c	0.76c	-0.12a	0.05b	0.00c	0.10c
0.00b	-0.35c	8.71	0.23a	-192.05c	-4.46c	2.12c	4.17c	-0.01a	0.00c	0.14c	0.79c	17.01c	0.03c	0	0.01c
0.00c	-0.22c	1.83	-0.05	-0.94c	-1.69c	2.67c	1.38a	-0.05c	0.00c	0.16c	0.83c	0.00c	0.00a	0.34c	0.01c
0	-0.37c	508.09c	0.56a	-1.01	0.11	0.71	[]	0.02b	0.00c	0.10c	0.83c	0	15.35a	0.00c	[]
0.00c	-0.32c	1.71	-0.15c	2.58c	1.08	-0.37b	-0.86	0.05c	0.00c	0.11c	0.89c	0.02c	-0.01c	0.00c	0.56c
0.00c	-0.23c	-0.64	-0.31c	-15.93	-0.45a	11.87	-2.86a	0.02c	0.00c	0.10c	0.90c	-0.55c	0.04a	7.02c	0.04c
0.00c	-0.39c	321.41	0.17b	[]	1.39c	[]	44.44	-0.01a	0.00c	0.32c	0.16c	[]	0.00c	[]	772.91c
0.00a	-0.38c	1483.04c	0.55c	0.65	[]	[]	[]	0.01a	0.00c	0.06c	0.92c	1.92	[]	[]	[]
0	0.05c	-1.49	-10.60c	0.18	0.61a	2.83	24.82c	0.12c	0.00c	0.09c	0.78c	23.95c	0.00c	0.32c	0.31c
0.00b	-0.28c	301.85b	-0.30a	-24.76	-2.46	-0.98	135.35c	0.04c	0.00c	0.18c	0.76c	117.45c	-145.83c	16.15	197.32c
0	-0.38c	109.61	0.55b	0.34	[]	[]	[]	0	0.00c	0.07c	0.89c	0.44a	[]	[]	[]
0.00c	-0.25c	-2.31	-1.37c	0.94	-4.99c	-4.20c	-5.24c	0	0.00c	0.13c	0.83c	0.01	0.00c	0.00c	0
0.00c	-0.30c	914.33	0.71c	4.02	-2043.46c	[]	[]	0.01b	0.00c	0.18c	0.82c	0.87	2.07	[]	[]
0	-0.28c	74.18	-1.49c	0.65	0.36	[]	1.37	0	0.00c	0.26c	0.48c	3.5	0.03c	[]	0.00c
0.00c	-0.33c	49.4	0.36b	[]	-3.33	[]	0.28	0.01	0.00c	0.14c	0.80c	[]	3.31c	[]	0.02c
0.00c	-0.26c	-10.64	-0.93c	-3.31c	-89.34c	2.01c	73.02c	0.01c	0.00c	0.37c	0.59c	0.01c	20.89	0.00c	0.38b
0.00c	-0.30c	4.85	-0.1	46.85	-15.18c	-4.22	0.52	0.04c	0.00c	0.16c	0.84c	125.57c	0.13c	0.15c	-0.01c
0.00c	-0.45c	73.33	1.21c	-15.02	-0.14	-9.71c	33.04c	0.01b	0.00c	0.09c	0.89c	115.37c	0.13c	0.00a	0.33c
0	-0.18c	11.46	-2.42c	1.1	-1.53	1.26b	-0.27	-0.01	0.00c	0.04c	0.93c	0	0.09	0.32c	0.24c
0	-0.36c	126.24	0.54c	[]	-0.82	[]	0.53a	0	0.00c	0.06c	0.89c	[]	0.03	[]	-0.03c

Note: a, b and c mean the coefficients are significant at 5%, 1% and 0.1% level. [] suggests no price-limits-hit.

Appendix 3.4c Detailed Estimation Results for Truncated-GARCH-M on the SZSE A-Shares

β_1	β_2	β_3	β_4	β_5	β_6	β_7	β_8	β_9	β_{10}	β_{11}	β_{12}	β_{13}	β_{14}	β_{15}	β_{16}
0.00c	-0.58c	26.22	2.29c	-0.24	[]	-0.41	[]	0.00c	0.00c	0.07c	0.90c	-31.63c	[]	1.66c	[]
-0.02c	-3.29c	-3.26	-2.26c	1.18	0.4	0.54	-0.1	8.78c	0.28c	0.11c	0.51c	159.66c	30.74c	60.18c	23.97c
0.01c	-10.35c	-3.26	9.30c	1.42	0.74	0.41	0.13	-0.51c	0.24c	0.10c	0.45c	470.68c	83.52c	184.06c	29.87c
0.03c	1.35c	-3.29	2.81c	3.68	0.65	0.28	0.83	-5.63c	0.06c	0.05c	0.24c	651.96c	44.38c	180.18c	60.60b
0.01c	-0.95c	-4.23	0.89c	2.17	5.11	-19.15c	-30.68c	1.89c	0.00c	0.75c	0.02c	106.86c	115.92c	-47.22c	-44.44c
0.06c	2.19c	-3.22	-3.32c	-0.6	-2.18	-0.55	0.63	-3.68c	0.01c	0.13c	0.21c	310.35c	177.52c	216.11c	254.91c
0.01c	-4.76c	-3.28	5.87c	0.85	[]	0.1	[]	0.74c	0.13c	0.05c	0.21c	72.52c	[]	4.71	[]
-0.03c	-1.73c	-3.28	2.05c	1.2	0.37	0.14	0.17	-2.82c	0.22c	0.09c	0.40c	85.36c	23.93c	10.79c	9.47c
0.05c	-2.83c	-3.04	4.60c	0.82	0.8	1.69	-0.09	2.04c	0.01c	0.58c	0.07c	387.47c	206.91c	216.96b	277.05c
0.00c	-2.15c	-288.83c	1.25c	6	1.85	21.39	5.15	5.90c	0.02c	0.13c	0.54c	921.87c	246.29c	373.78c	285.66c
0.01c	2.34c	-3.22	-0.57c	6.27	6.86	3.24	-25.13c	-0.11c	0.00c	0.45c	0.24c	504.47c	120.93c	16.07c	-4.04c
0.02c	-2.90c	-3.25	11.83c	1.23	2.11	1.72	0.09	-9.56c	0.23c	0.10c	0.46c	57.80a	143.06c	461.47c	213.77c
0.12c	2.10c	-3.27	-1.15c	1.14	0.01	0.5	-0.21	-2.69c	0.06c	0.03c	0.15c	158.78c	52.79b	64.79c	17.04b
-0.04c	-9.36c	-3.23	4.66c	1.62	0.78	-1.05	0.5	6.43c	0.19c	0.08c	0.36c	205.77c	131.05c	126.07c	40.45c
0.07c	0.90c	-3.17	-0.07c	0.48	0.34	0.48	-0.21	-4.52c	0.02c	0.09c	0.21c	335.22c	124.66c	104.66c	54.38c
0.04c	-4.84c	-16.04	2.79c	7.61	-1.09	6.23	-70.42	9.85c	0.01c	0.24c	0.33c	333.85c	163.27c	69.19c	509.05c
0.14c	0.98c	-3.2	0.14c	0.54	0.64	-0.32	0.06	-2.01c	0.03c	0.20c	0.13c	222.35c	204.48c	132.10c	59.81b
0.01c	-4.91c	2.29	1.80c	2.84c	[]	-0.72	[]	1.23c	0.03c	0.27c	0.06c	68.42c	[]	50.45c	[]
0.01c	-4.82c	-3.27	3.60c	0.9	[]	0.28	[]	6.26c	0.14c	0.05c	0.23c	28.69	[]	12.07c	[]
0.00c	-0.55c	290.05c	2.43c	7.14	[]	[]	[]	0	0.00c	0.04c	0.94c	0.05b	[]	[]	[]
-0.03c	-8.32c	-3.27	1.71c	1.3	0.07	0.32	-0.05	13.08c	0.13c	0.05c	0.23c	107.64b	10.6	13.25b	12.61b
-0.03c	-6.21c	-3.27	1.65c	2.38	0.54	-0.46	-0.34	9.05c	0.17c	0.09c	0.39c	355.98c	55.00c	82.67c	122.61c
-0.02c	-0.40c	-22.25	4.43c	25.96	[]	51	[]	-0.45c	0.01c	0.23c	0.02c	596.53c	[]	627.22	[]
0.00c	-7.73c	-3.25	4.26c	2.23	1.32	-0.24	-0.39	14.43c	0.20c	0.11c	0.50c	713.60c	54.51c	148.35c	171.51c
-0.10c	-2.57c	-3.26	2.20c	0.94	0.13	-0.01	[]	2.36c	0.01c	0.91c	0.02c	109.19	12.67	101.52b	[]
-0.03c	-7.90c	-3.27	1.84c	1.74	2.29	-0.3	-0.4	11.19c	0.19c	0.08c	0.39c	299.48c	168.33c	36.38c	34.88c
0	-11.55c	-3.27	8.76c	3.19	1.36	1.79	0.39	10.77c	0.20c	0.09c	0.40c	473.68c	83.44c	318.90c	100.43c
-0.11c	-6.64c	17.96	3.11c	5.83	-5.18	-10.19	5.45	7.85c	0.08c	0.14c	0.16c	483.46c	59.71	134.44b	24.75
0.03c	1.72c	-3.27	-1.31c	0.67	-0.21	-0.2	-0.03	-0.88c	0.00c	0.50c	0.06c	261.96c	116.70c	57.86b	33.38a
0.04c	0.24c	-3.33	3.72c	3.47	[]	-3.45	[]	-2.98c	0.00c	0.23c	0.11c	749.37c	[]	852.63c	[]
0.00c	-1.13c	-3.29	-0.65c	1	0.08	0.51	-0.08	0.07c	0.09c	0.04c	0.17c	95.89b	45.06a	76.98c	37.01c
0.01a	-4.72c	-3.28	1.28c	1.93	[]	0.89	[]	7.40c	0.21c	0.08c	0.39c	193.49c	[]	70.91c	[]

Note: a, b and c mean the coefficients are significant at 5%, 1% and 0.1% level. [] suggests no price-limits-hit.

Appendix 3.4d Detailed Estimation Results for Truncated-GARCH-M on the SZSE B-Shares

β_1	β_2	β_3	β_4	β_5	β_6	β_7	β_8	β_9	β_{10}	β_{11}	β_{12}	β_{13}	β_{14}	β_{15}	β_{16}
-0.06c	-0.41c	-2.6	3.21c	2.69	1.72	0.27	-19.81c	-0.79c	0.00c	0.28c	0.10c	555.38c	218.86c	242.77c	-0.81c
-0.04c	1.49c	-2.57	-6.57c	0.48	0.35	28.28	-46.88c	1.73c	0.01c	0.12c	0.06c	239.13c	122.11c	151.24c	38.48c
0.30c	-1.44c	-2.63	4.57c	[]	0.33	[]	-0.01	5.44c	0.28c	0.07c	0.39c	[]	11.99c	[]	105.10c
0.00c	-0.90c	12.22a	10.97c	[]	-72.04c	[]	-69.77c	-0.07c	0.00c	0.07c	0.42c	[]	115.48c	[]	33.28c
-0.05c	0.22c	-2.61	-0.94c	1.04	0.33	0.52	-15.81c	0.09c	0.01c	0.34c	0.03c	100.89	49.57	6.72b	-0.25c
0.00c	-0.59c	8.18	4.70c	-25.11	-57.58	18.26c	-34.5	-0.02b	0.00c	0.50c	0.18c	269.00b	388.04c	-0.32c	236.99b
0.01a	-1.56c	-2.62	2.86c	1.18	1.54	[]	[]	-1.32c	0.06c	0.11c	0.08c	21.74c	58.16c	[]	[]
-0.03c	0.18c	-2.7	5.64c	0.78	0.08	1.49	62.05c	-3.31c	0.04c	0.12c	0.05c	27.5	50.66	-0.38c	-14.51c
-0.04c	-1.62c	-2.62	-1.09c	0.73	0.21	0.7	0.22	2.76c	0.01c	0.33c	0.02c	107.79a	37.24	3.89	6.22
0.04c	1.08c	-2.62	-4.42c	0.65	0.58	0.08	-4.9	-0.16	0.11c	0.05b	0.14c	17.18	26.10c	-1.88c	-4.01c
0.06c	3.47c	-2.61	-11.41c	0.73	-0.91	-0.43	28.39c	8.24c	0.26c	0.24c	0.35c	18.2	-1.38c	32.70c	-0.42c
0.01c	-0.43c	-1.24	9.92c	[]	0.66	[]	1.67	-1.75c	0.11c	0.03c	0.16c	[]	87.33	[]	43.38c
-0.15c	-0.05	-2.61	3.60c	0.82	0.19	0.15	-7.29c	-2.10c	0.10c	0.62c	0.13c	20.44	11.95	53.14	-0.78c
-0.02c	-3.58c	-33.77	4.70c	17.24	14.77	212.88c	-4.66c	2.02c	0.01c	0.17c	0.15c	1104.72c	1291.18c	47.40c	-0.05c
-0.08c	-0.93c	-1.57	-1.28c	2.82	5.25	-6.23c	8.09	3.22c	0.02c	0.06c	0.21c	176.06c	94.82c	-1.69c	-29.30c
0	-0.35c	27.54	-0.37c	0.3	-0.48	17.18c	[]	-0.01	0.00c	0.32c	0.01c	233.06	77.49	-2.23c	[]
0.08c	-1.79c	-2.55	2.83c	2.47	1.36	-0.30a	1.14	0.68c	0.05c	0.19c	0.28c	116.88c	74.80c	-1.14c	41.17c
-0.02c	-0.06b	-2.62	-2.43c	0.83	-7.98	-1.58	-34.71c	-0.50c	0.01c	0.23c	0.30c	68.27c	62.98c	-1.29c	-34.03c
-0.01c	8.14c	-17.74	-18.81c	[]	-24.34c	[]	41.44c	-3.49c	0.06c	0.26c	0.09c	[]	31.60c	[]	189.41c
0.00a	-0.75c	-8.66	5.93c	0.65	[]	[]	[]	0.23c	0.00c	0.20c	0.29c	63.68	[]	[]	[]
-0.12c	1.91c	-2.61	-12.44c	2.01	0.69	0.04	0.12	3.85c	0.27c	0.07c	0.36c	31.15c	26.33c	-23.04c	-11.20c
0.00b	-0.29c	-2.28	0	-0.1	-19.86	0.08	6.71c	0.04c	0.00c	0.16c	0.79c	84.64a	3.79	1.67	0.05a
-0.15c	-0.29c	-2.62	2.73c	1.9	[]	[]	[]	3.68c	0.08c	0.47c	0.10c	19.04	[]	[]	[]
0	-4.41c	-2.62	10.71c	0.74	1.41	-0.08	69.57c	-0.29b	0.13c	0.09c	0.19c	24.64	86.41c	5.79c	-3.24c
-0.04c	-20.13c	-3.02	62.08c	0.69	0.35	[]	[]	-1.15c	0.10c	0.05c	0.08c	17.33c	3.28c	[]	[]
-0.03c	0.24c	-2.61	6.82c	0.65	0.3	[]	-0.19	-1.28c	0.02c	0.10c	0.03c	17.82	87.82c	[]	38.79a
-0.01c	0.37c	-2.62	-1.98c	[]	0.71	[]	-0.24	-0.63c	0.01c	0.50c	0.03c	[]	58.18c	[]	92.39c
0	2.55c	-2.61	2.89c	1.16	-0.31	0.2	0.38	-0.19c	0.15c	0.11c	0.23c	165.07b	3.16a	158.82a	-15.30c
0.01b	-1.66c	-2.57	6.87c	0.69	0.33	0.15	57.62a	-0.29c	0.05c	0.09c	0.08c	92.43a	62.29c	28.75	-2.2
0.00c	-0.46c	-5.57	1.46c	1.31	1.42	2.28	3.28	0.01c	0.00c	0.07c	0.91c	35.04b	149.19c	460.07c	69.01c
0	-0.66c	64.61	2.69c	-21.61c	60.05	-16.18c	4.42c	0	0.00c	0.14c	0.69c	32.92c	631.91b	-8.01c	0.16c
-0.01c	-0.84c	-6.16	13.91c	[]	0.02	[]	-105.86c	0.13c	0.00c	0.05c	0.20c	[]	81.00c	[]	-18.80c

Note: a, b and c mean the coefficients are significant at 5%, 1% and 0.1% level. [] suggests no price-limits-hit.

Appendix 3.5 Log-likelihood Ratio Statistics

This table reports the log-likelihood (LL) ratio statistics for the truncated-GARCH-M without morning dummy variable (noMS) and the restricted model (Res) presented in equation (14). It also summarises the log-likelihood (LL) ratio statistics for the truncated-GARCH-M without morning dummy variable (noMS) and the model (Ms) with morning dummy variable. The log-likelihood (LL) ratio statistics are equal to $LL1=2*(LL_{noMs}-LL_{Res})$ and $LL2=2*(LL_{Ms}-LL_{noMs})$ which follow chi-squared distribution.

A-shares	LL1	LL2	B-Shares	LL1	LL2	A-shares	LL1	LL2	B-Shares	LL1	LL2
600094	182258	22308	900940	11817	8671	000002	196160	193737	200002	171893.3491	128882.2
600190	1950426	188284	900952	2999	65230	000011	3135612	2042460	200011	42477.9374	122283.8
600221	905932	5672317	900945	277613	282005	000012	4035767	9521342	200012	168672.3946	2610175
600272	3306062	17707	900943	737	47663	000016	1089164	1588717	200016	81277.7322	43547.12
600295	810756	2343355	900936	80255	324642	000019	1491589	1236210	200019	22283.44261	9099.037
600320	4267210	4263204	900947	646469	239966	000020	40536	1088052	200020	1169.847306	3540.633
600555	2220965	621218	900955	334749	55932	000022	1986911	142107	200022	14565.35001	156682
600602	3553218	552656	900901	45896	532597	000025	1345096	451762	200025	84420.20815	75388.85
600604	8968	44463	900902	44	35431	000026	139718	139088	200026	76037.63649	3078.149
600611	2608671	451188	900903	299193	177698	000029	466458	1712642	200029	82551.96326	45166.39
600612	555913	1368558	900905	252922	163976	000037	1412936	527671	200037	84585.04328	192015.9
600613	224462	243571	900904	172382	139201	000039	2442281	5444238	200039	1022071.234	426959.3
600614	2726921	1306926	900907	844165	380472	000045	1380275	192178	200045	11261.43187	151578.4
600618	4027120	820113	900908	173237	889138	000055	2584601	1033487	200055	55524.94838	118468.6
600619	1132128	487211	900910	586282	238492	000056	915129	144062	200056	84499.12797	116810
600623	1772220	418730	900909	505733	102167	000058	1085273	639082	200058	34.21307872	5926.643
600639	1063336	76806	900911	270559	148808	000413	457262	282658	200413	216553.263	66572.05
600648	1894976	27768	900912	2484	199958	000418	380250	10863	200418	130060.7242	76998.8
600663	200303	2252434	900932	258569	605096	000429	106654	1477765	200429	207445.0421	39740.48
600679	200792	765143	900916	327436	316360	000488	111	0.02	200488	117.4703606	17456.29
600680	2027010	3862	900930	16372	2658	000521	1220482	2584531	200521	428935.9936	45011.69
600689	312906	301	900922	42649	65324	000530	911511	1431514	200530	630.3045764	106.4288
600695	1959467	170764	900919	132985	362496	000539	263	630174	200539	4362.860638	44394.94
600726	1748906	542580	900937	18289	283985	000541	4122069	2780347	200541	511697.2721	136128.2
600776	1611670	1554953	900941	73361	275847	000550	258620	1283579	200550	48138.22948	224913.7
600801	119076	2323	900933	281031	162538	000553	1717892	741985	200553	34.95980661	149056
600818	35366	6676	900915	365227	222492	000570	2626221	1327800	200570	262613.9376	128229.1
600819	368064	756475	900918	1733	197361	000581	109478	3022881	200581	226532.2218	33476.97
600822	1984077	310353	900927	263201	298736	000596	524448	594855	200596	40520.32371	325774
600827	1174537	342171	900923	365933	142578	000625	2443975	832775	200625	13370.15278	4050.216
600835	297164	930096	900925	46284	404209	000725	369989	2638789	200725	394440.164	386670.5
600841	12065	144761	900920	423309	245852	000761	338782	1099458	200761	307196.3856	283370.4
600843	667883	220892	900924	256008	87639						
600844	1543992	1993055	900921	504505	81901						
600845	793138	156620	900926	12455	258632						
600848	1820676	566430	900928	320108	64561						
600851	3746026	220564	900917	1055669	162486						

Appendix 3.6 Probability of Price Limits on the SSE

This table reports the probability(X/Y) of price hitting the limits when it is close to the limits for SSE AB-shares. X is the number of days that the trading price first reaches 90% of upper (lower) limits then hits the limits in the following trades. Y is the total number of days that the trading price is greater (smaller) than 90% of limits. P denotes the p-value.

	Upper				Lower					Upper				Lower			
	X	Y	X/Y	P	X	Y	X/Y	P		X	Y	X/Y	P	X	Y	X/Y	P
600094	12	13	92%	0%	3	6	50%	34%	900940	1	1	100%	0%	1	2	50%	25%
600190	3	6	50%	34%	1	1	100%	0%	900952	1	2	50%	25%	2	4	50%	31%
600221	7	11	64%	11%	4	8	50%	36%	900945	4	8	50%	36%	5	9	56%	25%
600272	16	23	70%	2%	6	10	60%	17%	900943	0	2	0%	75%	3	4	75%	6%
600295	4	7	57%	23%	1	4	25%	69%	900936	1	2	50%	25%	3	7	43%	50%
600320	1	2	50%	25%	0	1	0%	50%	900947	1	3	33%	50%	3	6	50%	34%
600555	11	15	73%	2%	3	4	75%	6%	900955	3	5	60%	19%	3	7	43%	50%
600602	10	13	77%	1%	1	3	33%	50%	900901	1	1	100%	0%	4	6	67%	11%
600604	1	4	25%	69%	2	3	67%	13%	900902	1	1	100%	0%	0	0	NaN	0%
600611	3	4	75%	6%	0	1	0%	50%	900903	1	3	33%	50%	0	2	0%	75%
600612	9	14	64%	9%	4	6	67%	11%	900905	1	4	25%	69%	1	1	100%	0%
600613	24	35	69%	1%	4	11	36%	73%	900904	4	4	100%	0%	2	5	40%	50%
600614	14	22	64%	7%	6	10	60%	17%	900907	5	9	56%	25%	4	9	44%	50%
600618	21	31	68%	1%	4	5	80%	3%	900908	1	4	25%	69%	4	6	67%	11%
600619	11	17	65%	7%	3	5	60%	19%	900910	1	1	100%	0%	2	3	67%	13%
600623	15	23	65%	5%	3	7	43%	50%	900909	1	2	50%	25%	2	5	40%	50%
600639	3	6	50%	34%	0	1	0%	50%	900911	1	2	50%	25%	1	3	33%	50%
600648	11	17	65%	7%	3	3	100%	0%	900912	1	3	33%	50%	1	3	33%	50%
600663	4	10	40%	62%	0	1	0%	50%	900932	1	4	25%	69%	2	2	100%	0%
600679	30	42	71%	0%	7	11	64%	11%	900916	1	1	100%	0%	3	9	33%	75%
600680	18	20	90%	0%	6	8	75%	4%	900930	1	2	50%	25%	2	2	100%	0%
600689	14	20	70%	2%	4	6	67%	11%	900922	3	8	38%	64%	4	10	40%	62%
600695	16	22	73%	1%	6	10	60%	17%	900919	1	3	33%	50%	3	6	50%	34%
600726	5	9	56%	25%	1	2	50%	25%	900937	0	0	NaN	0%	2	2	100%	0%
600776	11	13	85%	0%	3	5	60%	19%	900941	0	1	0%	50%	2	8	25%	86%
600801	14	25	56%	21%	2	5	40%	50%	900933	4	11	36%	73%	5	6	83%	2%
600818	10	15	67%	6%	3	4	75%	6%	900915	2	3	67%	13%	6	6	100%	0%
600819	11	20	55%	25%	5	10	50%	38%	900918	2	5	40%	50%	4	8	50%	36%
600822	8	12	67%	7%	5	7	71%	6%	900927	1	2	50%	25%	4	9	44%	50%
600827	2	8	25%	86%	0	0	NaN	0%	900923	3	4	75%	6%	2	4	50%	31%
600835	3	7	43%	50%	0	0	NaN	0%	900925	1	2	50%	25%	2	4	50%	31%
600841	12	17	71%	2%	7	12	58%	19%	900920	1	2	50%	25%	4	5	80%	3%
600843	11	17	65%	7%	5	11	45%	50%	900924	1	2	50%	25%	5	8	63%	14%
600844	15	22	68%	3%	7	18	39%	76%	900921	0	4	0%	94%	7	13	54%	29%
600845	6	9	67%	9%	1	1	100%	0%	900926	0	2	0%	75%	2	3	67%	13%
600848	13	15	87%	0%	1	4	25%	69%	900928	2	3	67%	13%	6	11	55%	27%
600851	17	25	68%	2%	4	9	44%	50%	900917	7	7	100%	0%	5	5	100%	0%
Total				16				7					8				9

Appendix 3.7 Probability of Price Limits on the SZSE

This table reports the probability (X/Y) of price hitting the limits when it is close to the limits for SZSE AB-shares. X is the number of days that the trading price first reaches 90% of upper (lower) limits then hits the limits in the following trades. Y is the total number of days that the trading price is greater (smaller) than 90% of limits. P denotes the p-value.

	Upper				Lower					Upper				Lower			
	X	Y	X/Y	P	X	Y	X/Y	P		X	Y	X/Y	P	X	Y	X/Y	P
000002	1	3	33%	50%	0	0	NaN	0%	200002	2	4	50%	31%	3	6	50%	34%
000011	16	25	64%	5%	7	11	64%	11%	200011	3	7	43%	50%	6	8	75%	4%
000012	10	16	63%	11%	3	6	50%	34%	200012	0	2	0%	75%	4	8	50%	36%
000016	5	7	71%	6%	1	2	50%	25%	200016	0	0	NaN	0%	1	3	33%	50%
000019	10	18	56%	24%	7	8	88%	0%	200019	4	5	80%	3%	3	10	30%	83%
000020	17	22	77%	0%	8	15	53%	30%	200020	2	4	50%	31%	6	9	67%	9%
000022	2	2	100%	0%	0	1	0%	50%	200022	2	2	100%	0%	1	2	50%	25%
000025	13	19	68%	3%	5	13	38%	71%	200025	1	3	33%	50%	3	6	50%	34%
000026	2	3	67%	13%	2	7	29%	77%	200026	1	1	100%	0%	1	4	25%	69%
000029	13	15	87%	0%	7	9	78%	2%	200029	1	6	17%	89%	4	5	80%	3%
000037	14	17	82%	0%	6	8	75%	4%	200037	1	2	50%	25%	6	7	86%	1%
000039	2	9	22%	91%	1	3	33%	50%	200039	0	0	NaN	0%	1	3	33%	50%
000045	8	15	53%	30%	3	6	50%	34%	200045	2	5	40%	50%	4	6	67%	11%
000055	9	14	64%	9%	2	5	40%	50%	200055	2	4	50%	31%	4	6	67%	11%
000056	17	28	61%	9%	6	9	67%	9%	200056	12	14	86%	0%	7	12	58%	19%
000058	6	8	75%	4%	4	5	80%	3%	200058	1	2	50%	25%	1	1	100%	0%
000413	11	17	65%	7%	6	10	60%	17%	200413	4	10	40%	62%	7	13	54%	29%
000418	5	9	56%	25%	0	2	0%	75%	200418	1	1	100%	0%	3	9	33%	75%
000429	1	1	100%	0%	0	1	0%	50%	200429	0	0	NaN	0%	2	3	67%	13%
000488	1	1	100%	0%	0	0	NaN	0%	200488	1	1	100%	0%	0	1	0%	50%
000521	4	7	57%	23%	1	3	33%	50%	200521	4	5	80%	3%	6	8	75%	4%
000530	14	16	88%	0%	5	10	50%	38%	200530	1	1	100%	0%	1	7	14%	94%
000539	3	3	100%	0%	0	1	0%	50%	200539	2	2	100%	0%	0	0	NaN	0%
000541	7	13	54%	29%	3	9	33%	75%	200541	1	3	33%	50%	4	5	80%	3%
000550	2	8	25%	86%	1	2	50%	25%	200550	1	1	100%	0%	1	3	33%	50%
000553	10	12	83%	0%	5	5	100%	0%	200553	1	2	50%	25%	1	1	100%	0%
000570	8	10	80%	1%	4	6	67%	11%	200570	0	1	0%	50%	4	8	50%	36%
000581	8	11	73%	3%	2	5	40%	50%	200581	5	6	83%	2%	1	5	20%	81%
000596	7	13	54%	29%	2	4	50%	31%	200596	1	3	33%	50%	3	6	50%	34%
000625	3	4	75%	6%	0	2	0%	75%	200625	3	4	75%	6%	2	5	40%	50%
000725	6	9	67%	9%	1	2	50%	25%	200725	2	3	67%	13%	3	4	75%	6%
000761	7	8	88%	0%	0	2	0%	75%	200761	0	0	NaN	0%	1	1	100%	0%
Total				14				5					11				8

Appendix 3.8a Distance to the Limit-hits

This appendix summarises the distance, as measure by tick size (1 tick size = 0.01), from 10 trades to the limit-hits. The first column of figures implies the tick size of 10 trades before the limit-hits. The final column of figures suggests the tick size of 1 trade before the limits-hits. Each row represents an average for each stock for which there is at least one limit hit.

				SSE A Upper					
n=10	n=9	n=8	n=7	n=6	n=5	n=4	n=3	n=2	n=1
9.65	10.12	9.47	8.24	7.94	7.41	6.24	4.53	4.82	2.59
3.75	4.00	3.75	3.75	3.00	3.25	3.25	2.25	1.75	2.50
2.76	2.52	2.62	2.38	2.43	2.19	2.05	1.71	1.71	1.29
11.03	10.88	9.91	9.29	8.41	7.94	6.65	5.76	4.53	2.79
10.60	11.80	11.60	10.80	10.60	11.20	9.80	7.60	8.80	3.60
4.50	4.25	3.50	3.00	2.75	2.25	2.00	1.75	1.25	1.00
10.46	10.23	10.23	10.00	9.00	7.85	6.31	5.08	3.23	2.46
6.17	5.70	5.30	5.22	4.48	4.52	4.00	3.04	2.09	2.57
4.00	3.86	4.00	3.57	3.57	3.86	1.57	1.29	1.29	1.57
4.00	4.00	4.00	2.00	3.00	3.00	1.00	2.00	2.00	1.00
16.56	12.72	13.33	11.39	10.56	10.00	9.28	7.22	6.78	4.17
14.37	13.43	12.33	11.59	10.78	9.52	8.72	7.83	6.28	4.26
10.38	9.88	8.67	8.58	7.92	7.04	5.71	5.67	4.42	2.96
10.90	10.50	10.40	9.14	8.50	7.76	6.98	5.90	4.12	3.52
4.88	3.92	4.00	4.04	4.08	3.46	3.69	2.65	2.69	1.54
24.07	21.71	21.43	18.50	15.71	13.36	11.86	11.07	7.29	7.86
9.67	8.33	8.33	7.33	6.67	4.67	5.33	2.67	3.00	2.00
13.89	12.00	10.89	9.79	9.26	7.32	7.05	6.00	5.21	3.58
11.29	7.29	8.86	9.43	5.57	5.14	5.43	3.00	2.29	2.43
11.68	11.11	9.88	9.55	8.88	8.09	7.05	6.04	4.23	2.70
25.29	23.43	20.00	15.76	16.24	14.48	12.29	12.57	8.90	6.14
11.16	10.47	9.05	9.21	7.89	6.68	5.05	4.21	1.68	3.16
7.96	7.12	6.54	6.58	6.08	5.54	4.50	4.54	3.67	2.87
9.80	9.40	9.00	7.40	5.60	5.20	4.80	4.80	2.80	2.40
5.80	5.50	5.20	4.20	4.23	3.43	3.23	3.00	2.17	1.60
16.70	17.35	15.52	14.13	15.48	13.35	12.96	8.35	6.52	6.04
22.19	21.44	19.69	19.38	18.75	16.94	16.38	6.75	5.00	5.31
6.55	7.60	7.30	6.15	6.15	6.45	5.90	5.60	4.90	4.65
9.48	9.20	9.12	8.60	7.64	7.16	6.76	6.04	5.80	4.40
11.67	12.00	11.67	12.00	11.33	11.67	12.00	11.33	12.33	12.67
5.00	4.00	2.00	3.00	3.00	2.00	1.00	2.00	1.00	1.00
23.80	24.15	23.55	24.25	21.85	20.20	17.80	15.90	8.50	5.80
5.28	5.39	5.33	5.50	4.33	3.78	2.50	2.06	1.61	2.22
15.38	12.88	13.31	12.06	10.88	9.69	10.00	6.63	5.69	6.00
35.20	34.60	34.40	31.00	30.20	28.80	19.60	10.20	7.80	5.80
11.67	11.24	9.71	9.48	7.81	6.71	5.81	5.52	5.48	3.10
9.27	8.97	7.77	7.07	6.30	5.00	4.50	4.00	3.17	2.27

Appendix 3.8b Distance to the Limit-hits

This appendix summarises the distance, as measure by tick size (1 tick size = 0.01), from 10 trades to the limit-hits. The first column of figures implies the tick size of 10 trades before the limit-hits. The final column of figures suggests the tick size of 1 trade before the limits-hits. Each row represents an average for each stock for which there is at least one limit hit.

SSE A Lower									
3.08	3.00	2.46	2.85	2.15	1.92	1.92	2.08	1.54	1.46
1.89	2.11	2.22	1.89	2.00	1.89	1.67	1.44	1.33	1.22
1.62	1.95	2.05	2.05	1.81	1.52	1.38	1.57	1.38	1.57
5.14	5.07	4.50	4.21	4.00	4.29	4.07	3.86	2.14	2.57
2.33	2.00	2.33	2.00	1.67	2.00	2.00	1.67	1.33	1.67
5.33	5.00	5.00	3.33	3.33	3.00	2.33	1.33	2.00	1.33
4.00	4.00	4.00	4.00	4.00	4.00	3.00	3.00	3.00	2.00
1.00	2.00	2.00	2.00	2.00	1.00	2.00	1.00	2.00	1.00
22.00	23.50	22.75	23.50	23.00	18.50	16.00	14.00	17.25	16.50
6.89	5.67	4.11	6.33	4.11	4.00	3.22	3.22	2.56	2.33
5.50	4.71	4.64	4.79	4.36	4.00	3.86	3.29	3.29	2.71
6.40	6.80	6.00	5.60	5.60	5.20	4.40	4.20	3.80	4.00
27.67	25.67	25.67	27.67	25.33	26.67	26.67	24.33	25.00	23.00
34.00	33.50	34.00	32.50	30.00	32.50	28.50	15.00	14.50	28.50
4.00	2.67	2.67	2.33	2.33	1.67	1.67	1.00	1.67	2.00
4.59	4.76	4.12	4.18	3.71	3.06	2.41	2.41	1.94	2.00
4.20	4.30	3.90	2.20	3.00	2.90	2.70	3.00	2.80	2.70
9.37	9.12	8.87	8.37	8.87	8.25	5.87	8.00	4.62	5.37
7.73	8.40	7.87	7.93	6.93	6.73	6.07	4.93	4.60	3.80
8.00	8.00	8.00	6.00	4.00	6.00	6.00	3.00	2.00	1.00
5.33	4.67	4.56	3.78	2.11	3.33	2.78	2.11	1.89	1.78
6.17	4.33	3.00	3.33	3.50	3.00	2.50	3.33	2.17	2.67
7.00	5.60	5.80	4.60	4.40	3.40	2.40	2.20	2.40	2.00
11.20	8.00	7.60	7.60	5.60	4.40	4.20	3.80	3.40	4.00
7.11	7.44	6.89	5.00	5.22	5.89	5.22	4.89	4.22	4.33
6.91	7.45	6.86	6.14	6.45	5.00	3.95	3.41	2.41	2.32
7.00	7.87	8.12	6.81	6.50	5.50	4.31	3.87	3.25	3.25
7.00	7.25	6.19	4.94	5.69	4.75	4.31	3.81	4.37	3.19
140.00	140.00	140.00	138.00	138.00	138.00	138.00	137.00	137.00	137.00
2.00	2.50	2.00	1.50	2.50	2.00	2.00	1.50	2.00	1.50
5.33	5.00	5.00	3.00	4.00	3.67	2.33	4.00	3.67	2.00

Appendix 3.8c Distance to the Limit-hits

This appendix summarises the distance, as measure by tick size (1 tick size = 0.01), from 10 trades to the limit-hits. The first column of figures implies the tick size of 10 trades before the limit-hits. The final column of figures suggests the tick size of 1 trade before the limits-hits. Each row represents an average for each stock for which there is at least one limit hit.

				SSE B Upper					
0.25	0.30	0.27	0.23	0.23	0.23	0.20	0.20	0.15	0.13
0.50	0.40	0.50	0.50	0.30	0.30	0.30	0.10	0.30	0.30
0.36	0.36	0.38	0.34	0.34	0.36	0.36	0.36	0.26	0.16
0.20	0.17	0.30	0.17	0.20	0.13	0.10	0.10	0.13	0.10
0.25	0.28	0.30	0.10	0.15	0.10	0.10	0.10	0.13	0.10
0.26	0.26	0.20	0.16	0.13	0.14	0.11	0.12	0.12	0.10
0.15	0.15	0.10	0.10	0.10	0.15	0.10	0.10	0.10	0.10
0.40	0.57	0.50	0.30	0.37	0.33	0.27	0.23	0.27	0.20
4.20	4.20	4.20	4.20	4.40	4.40	4.40	4.20	4.20	4.50
13.60	13.80	13.80	13.80	13.80	11.80	15.20	15.20	3.80	3.80
0.56	0.54	0.50	0.48	0.43	0.58	0.59	0.50	0.45	0.36
0.50	0.39	0.45	0.44	0.42	0.39	0.34	0.38	0.32	0.23
0.15	0.20	0.15	0.15	0.10	0.10	0.10	0.10	0.10	0.10
0.19	0.20	0.20	0.18	0.16	0.14	0.15	0.14	0.15	0.14
0.33	0.33	0.28	0.38	0.33	0.35	0.30	0.20	0.23	0.25
0.50	0.45	0.45	0.55	0.70	0.55	0.45	0.30	0.40	0.20
8.80	8.70	8.80	8.80	8.70	8.80	8.70	8.80	8.70	8.80
0.30	0.25	0.30	0.25	0.30	0.30	0.25	0.25	0.25	0.30
0.65	0.60	0.65	0.60	0.55	0.45	0.45	0.25	0.20	0.20
0.25	0.20	0.20	0.15	0.15	0.15	0.15	0.10	0.10	0.10
0.52	0.59	0.52	0.62	0.61	0.39	0.37	0.22	0.25	0.16
0.10	0.20	0.10	0.20	0.20	0.10	0.10	0.10	0.10	0.10
0.20	0.15	0.15	0.15	0.15	0.15	0.15	0.10	0.10	0.10
0.94	1.06	1.10	0.56	0.56	0.52	0.40	0.28	0.20	0.18
0.38	0.38	0.40	0.38	0.38	0.38	0.25	0.23	0.13	0.10
0.30	0.25	0.20	0.20	0.15	0.15	0.15	0.10	0.10	0.10
0.20	0.20	0.10	0.20	0.20	0.20	0.20	0.10	0.10	0.20
0.45	0.15	0.30	0.25	0.10	0.10	0.10	0.10	0.25	0.10
5.40	5.40	5.40	5.40	5.40	5.40	5.40	5.30	5.40	5.40
0.95	0.85	0.75	0.60	0.70	0.55	0.60	0.45	0.40	0.25
0.20	0.25	0.20	0.30	0.25	0.20	0.20	0.20	0.10	0.20
0.50	0.60	0.50	0.50	0.60	0.50	0.50	0.50	0.50	0.60
0.16	0.18	0.16	0.16	0.13	0.14	0.13	0.11	0.11	0.11

Appendix 3.8d Distance to the Limit-hits

This appendix summarises the distance, as measure by tick size (1 tick size = 0.01), from 10 trades to the limit-hits. The first column of figures implies the tick size of 10 trades before the limit-hits. The final column of figures suggests the tick size of 1 trade before the limits-hits. Each row represents an average for each stock for which there is at least one limit hit.

SSE B Lower									
0.25	0.23	0.28	0.15	0.18	0.18	0.13	0.18	0.13	0.13
0.40	0.10	0.20	0.10	0.20	0.10	0.10	0.10	0.10	0.10
0.97	0.93	1.07	0.82	0.82	0.78	0.62	0.42	0.30	0.15
2.85	3.20	2.90	2.90	2.90	2.90	2.65	1.85	1.20	1.20
0.25	0.17	0.17	0.22	0.20	0.15	0.20	0.20	0.10	0.10
0.90	1.00	1.03	0.95	1.02	0.93	0.33	0.22	0.90	1.03
0.83	0.85	0.76	0.73	0.55	0.71	0.36	0.39	0.25	0.31
0.59	0.50	0.39	0.23	0.26	0.16	0.17	0.16	0.14	0.11
1.60	1.68	1.65	1.75	1.83	1.25	1.38	1.38	1.38	1.20
3.90	3.80	3.60	3.40	3.40	2.30	2.30	3.30	0.10	0.10
0.65	0.63	0.58	0.55	0.50	0.34	0.26	0.24	0.18	0.21
0.32	0.34	0.28	0.31	0.32	0.31	0.27	0.22	0.20	0.16
0.60	0.40	0.20	0.20	0.20	0.10	0.20	0.10	0.10	0.20
0.45	0.50	0.20	0.20	0.35	0.10	0.10	0.10	0.10	0.10
1.40	1.30	0.80	0.80	0.10	0.10	0.80	0.80	0.10	0.80
7.30	7.20	7.20	7.10	7.20	7.20	7.10	7.00	7.00	0.30
4.75	2.95	3.00	2.95	2.75	2.55	3.00	1.70	0.10	1.45
0.97	0.83	0.93	0.78	0.55	0.55	0.70	0.42	0.47	0.12
0.30	0.30	0.20	0.20	0.30	0.25	0.25	0.25	0.10	0.10
2.90	2.33	2.45	1.85	1.55	1.60	1.45	1.93	1.90	1.38
0.40	0.35	0.38	0.40	0.45	0.33	0.20	0.20	0.20	0.20
0.80	0.50	0.67	0.43	0.33	0.43	0.33	0.33	0.33	0.17
0.55	0.55	0.30	0.35	0.30	0.30	0.25	0.30	0.30	0.30
1.65	0.75	1.28	0.37	0.52	0.62	0.33	0.42	0.23	0.22
2.83	2.50	2.38	2.35	2.23	2.03	1.82	1.75	1.38	1.23
0.40	0.48	0.44	0.40	0.46	0.38	0.24	0.22	0.16	0.22
0.50	0.40	0.40	0.28	0.30	0.32	0.26	0.20	0.14	0.14
0.70	0.30	0.50	0.30	0.20	0.20	0.20	0.10	0.10	0.10
3.67	3.93	3.73	3.50	3.73	3.50	3.87	3.73	3.63	2.97
0.53	0.47	0.45	0.55	0.40	0.22	0.38	0.25	0.25	0.25
1.28	1.16	1.07	0.95	1.02	0.86	0.70	0.66	0.52	0.42
9.60	9.60	9.50	9.50	9.40	9.30	9.30	9.40	9.80	9.80
0.65	0.66	0.77	0.72	0.70	0.63	0.66	0.57	0.35	0.53
0.24	0.23	0.26	0.19	0.23	0.18	0.15	0.14	0.14	0.14

Appendix 3.8e Distance to the Limit-hits

This appendix summarises the distance, as measure by tick size (1 tick size = 0.01), from 10 trades to the limit-hits. The first column of figures implies the tick size of 10 trades before the limit-hits. The final column of figures suggests the tick size of 1 trade before the limits-hits. Each row represents an average for each stock for which there is at least one limit hit.

SZSE A Upper									
3.50	4.00	3.50	3.50	3.50	3.50	3.00	3.00	2.00	2.50
6.93	6.62	6.48	6.10	5.17	4.79	3.66	3.48	3.07	2.59
9.50	8.61	8.17	7.17	7.11	5.22	5.28	4.33	3.89	3.17
5.18	4.36	4.55	4.36	3.91	4.00	3.36	3.00	1.82	1.73
13.10	13.10	9.60	11.50	9.20	8.40	6.50	6.80	5.30	2.80
8.04	7.91	5.74	6.04	5.39	4.70	4.52	4.57	3.35	3.48
7.00	7.00	5.00	5.50	3.50	3.00	3.00	1.50	2.00	2.00
14.83	15.30	14.78	14.04	13.70	13.39	9.09	12.78	7.57	3.35
6.25	5.92	5.75	5.92	5.38	4.33	4.54	3.08	2.67	2.46
4.62	4.55	4.14	3.79	3.52	3.38	2.76	2.72	1.97	1.83
8.00	8.00	6.00	5.00	7.00	6.00	6.00	8.00	6.00	6.00
10.58	9.50	7.75	8.25	7.08	6.58	5.50	5.75	4.42	2.75
11.89	11.11	10.67	10.33	9.44	7.33	6.56	5.33	5.67	4.89
9.88	9.40	8.42	7.19	7.67	6.63	5.37	4.93	3.74	3.74
9.33	7.83	7.00	7.50	6.17	5.50	6.33	4.83	4.33	4.00
20.45	18.00	17.73	15.64	13.64	13.64	10.36	9.36	10.27	8.09
23.86	23.57	23.43	22.29	22.43	21.86	21.57	20.86	20.86	20.71
18.00	20.00	15.00	14.00	14.00	12.00	7.00	7.00	5.00	2.00
6.00	5.40	5.80	5.00	5.40	4.20	4.80	3.20	2.40	3.00
7.25	6.68	6.25	5.21	5.07	4.29	4.21	3.50	3.46	2.82
24.00	23.00	20.00	20.00	15.00	15.00	15.00	9.00	13.00	6.00
8.36	6.82	7.24	7.09	5.12	4.48	4.45	3.82	3.18	2.39
7.00	7.00	3.00	5.00	3.00	3.00	3.00	2.00	3.00	1.00
7.36	6.57	5.64	5.07	4.64	4.00	4.07	2.93	2.57	2.21
6.65	6.59	5.76	5.29	4.29	3.88	3.53	3.12	2.18	1.82
13.33	10.78	11.89	9.11	7.56	4.78	6.56	4.33	2.78	3.33
23.36	18.79	20.14	15.00	13.71	13.71	12.00	8.79	8.57	9.00
4.00	4.00	3.50	1.50	1.00	1.00	1.00	1.00	1.50	1.00
2.40	2.40	2.20	1.80	1.50	1.70	1.30	1.40	1.20	1.10
12.71	12.43	11.57	10.14	9.43	8.57	6.43	4.86	2.57	3.00

Appendix 3.8f Distance to the Limit-hits

This appendix summarises the distance, as measure by tick size (1 tick size = 0.01), from 10 trades to the limit-hits. The first column of figures implies the tick size of 10 trades before the limit-hits. The final column of figures suggests the tick size of 1 trade before the limits-hits. Each row represents an average for each stock for which there is at least one limit hit.

SZSE A Lower									
6.36	7.27	5.64	6.36	5.73	5.18	5.18	5.18	4.73	4.73
6.33	5.67	5.33	6.00	5.67	5.33	5.00	3.67	4.67	4.33
1.25	1.25	1.25	1.25	1.00	1.00	1.00	1.00	1.00	1.00
4.16	4.52	4.40	3.72	3.52	3.52	3.32	2.88	3.00	2.44
5.43	4.43	3.96	4.09	3.61	2.74	2.43	2.57	2.48	2.57
3.64	3.00	3.18	2.09	2.18	1.36	1.82	1.18	1.18	1.09
6.00	6.00	6.40	6.60	8.20	7.60	3.00	2.20	6.80	1.80
2.76	2.41	2.53	2.29	2.24	2.00	1.71	1.65	1.47	1.59
3.90	3.60	3.60	3.30	2.90	2.40	2.00	1.80	1.70	1.50
5.50	5.50	5.50	5.00	3.50	4.00	3.50	3.50	2.50	3.50
2.67	4.89	2.67	3.00	2.33	2.67	2.33	1.78	1.67	1.33
3.92	3.75	3.33	3.08	3.08	2.75	2.50	2.00	2.08	1.75
12.33	12.25	10.92	11.25	10.17	10.67	8.50	7.83	6.75	7.17
4.00	3.67	2.33	2.67	2.33	2.00	2.00	1.33	1.67	2.00
5.94	6.12	5.87	5.44	5.37	4.87	4.06	3.87	2.75	2.81
8.00	9.00	9.00	9.00	9.00	9.00	8.00	9.00	8.00	1.00
11.25	11.00	11.88	10.88	6.25	5.88	8.88	10.63	10.88	9.13
2.29	2.57	2.14	2.43	1.86	1.86	1.71	1.43	1.43	1.57
94.00	94.00	94.00	94.00	94.00	92.00	44.00	44.00	44.00	29.00
5.40	4.93	4.87	3.47	3.47	3.00	3.07	2.67	2.67	2.07
3.12	3.00	3.00	2.75	2.75	2.62	2.25	2.12	2.25	2.00
16.00	15.00	15.00	15.00	15.00	14.00	11.00	11.00	11.00	11.00
7.50	10.50	9.50	3.50	3.50	3.50	3.50	3.50	2.00	1.00
2.27	3.00	2.73	2.27	2.36	2.27	1.82	2.18	2.09	2.55

Appendix 3.8g Distance to the Limit-hits

This appendix summarises the distance, as measure by tick size (1 tick size = 0.01), from 10 trades to the limit-hits. The first column of figures implies the tick size of 10 trades before the limit-hits. The final column of figures suggests the tick size of 1 trade before the limits-hits. Each row represents an average for each stock for which there is at least one limit hit.

SZSE B Upper									
1.67	1.83	1.67	1.33	1.50	1.00	1.00	1.00	1.33	1.17
1.25	1.25	1.25	1.00	1.25	1.00	1.00	1.00	1.00	1.25
7.75	8.00	5.00	5.00	5.25	2.75	3.25	2.75	2.75	2.25
2.00	1.00	2.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
83.00	97.00	107.00	98.00	97.00	106.00	106.00	105.00	87.00	87.00
19.00	16.00	10.00	8.00	8.00	8.00	3.00	3.00	2.00	1.00
7.00	6.00	3.00	3.00	2.00	1.00	1.00	1.00	2.00	1.00
1.00	3.00	3.00	1.00	4.00	3.00	4.00	4.00	2.00	1.00
20.00	20.00	24.00	24.00	15.00	15.00	15.00	7.00	15.00	1.00
0.80	1.00	1.20	1.40	1.20	1.20	1.20	1.00	1.00	1.00
12.29	12.25	12.25	9.96	9.88	7.54	7.29	6.25	5.29	4.92
3.00	1.67	1.67	3.67	2.33	2.00	1.67	1.33	1.33	1.33
3.00	2.86	2.00	2.14	2.00	1.57	2.00	1.43	1.71	1.71
4.25	4.75	5.00	5.75	4.50	3.75	3.25	4.75	3.50	2.50
3.80	5.40	5.80	4.00	5.20	6.80	5.60	5.20	4.00	5.60
9.00	4.00	4.00	3.00	9.00	9.00	7.00	2.00	7.00	5.00
47.00	46.00	46.00	46.00	43.00	43.00	40.00	43.00	43.00	42.00
2.00	3.00	2.00	2.00	3.00	1.00	1.00	1.00	2.00	1.00
134.00	133.00	133.00	132.00	133.00	131.00	134.00	131.00	130.00	131.00
11.56	12.00	11.22	10.67	11.11	10.44	7.22	8.00	5.00	4.89
3.00	1.00	1.00	3.00	1.00	1.00	1.00	1.00	1.00	1.00
2.00	2.00	1.00	4.00	6.00	6.00	1.00	1.00	1.00	1.00
1.50	1.50	1.50	1.50	1.50	2.00	1.50	1.50	1.00	1.00

Appendix 3.8h Distance to the Limit-hits

This appendix summarises the distance, as measure by tick size (1 tick size = 0.01), from 10 trades to the limit-hits. The first column of figures implies the tick size of 10 trades before the limit-hits. The final column of figures suggests the tick size of 1 trade before the limits-hits. Each row represents an average for each stock for which there is at least one limit hit.

SZSE B Lower									
46.50	32.00	46.50	41.50	41.50	41.50	38.00	36.50	41.50	36.50
5.29	5.43	5.71	5.29	5.29	6.14	4.86	3.86	3.14	2.71
3.57	3.71	3.43	3.29	3.14	2.86	2.43	1.86	2.29	2.43
5.50	5.50	5.75	6.25	4.50	4.00	4.00	2.75	3.00	2.00
7.83	8.00	8.33	7.67	7.33	7.33	5.50	6.17	7.50	3.83
8.40	9.00	8.20	7.40	8.00	6.80	5.00	4.80	4.20	3.80
96.00	96.00	90.00	96.00	92.00	92.00	92.00	92.00	91.00	91.00
12.00	7.50	7.50	7.00	6.50	5.50	5.50	3.50	3.00	1.50
6.00	6.00	6.00	5.00	9.00	4.00	4.00	4.00	4.00	4.00
6.00	5.67	6.33	6.00	5.67	4.67	3.67	3.00	1.33	1.33
8.88	8.50	8.88	8.88	7.00	6.63	4.63	2.63	1.75	1.63
1.00	1.00	2.50	1.50	1.00	2.00	1.00	1.50	1.00	1.00
23.00	24.00	22.33	22.33	20.67	19.33	19.00	19.00	17.33	1.67
2.33	2.11	2.33	1.89	1.89	1.89	2.00	1.67	1.67	1.44
7.23	8.77	9.69	9.31	8.54	8.54	8.23	7.31	9.31	5.62
7.67	8.42	7.08	8.58	6.83	6.00	4.25	4.17	3.83	2.75
58.67	65.67	66.00	65.33	64.67	62.67	49.00	48.67	60.67	3.33
5.12	4.94	5.24	4.94	4.65	4.47	3.76	4.47	4.24	3.82
55.00	55.00	54.00	54.00	54.00	55.00	54.00	54.00	55.00	5.00
6.00	6.00	5.42	5.83	5.08	5.00	2.00	1.92	1.75	2.00
3.50	3.75	4.75	4.00	3.50	2.75	2.75	2.25	1.75	1.25
13.00	13.33	13.33	11.67	11.33	8.33	10.00	9.67	11.00	10.00
33.00	33.00	33.00	35.00	33.00	33.00	33.00	22.00	4.00	22.00
10.00	9.00	10.67	2.67	5.33	1.67	1.33	1.67	1.00	1.00
2.25	2.25	2.25	2.00	2.25	1.75	1.25	1.50	1.25	1.50
1.20	1.60	1.20	1.00	1.20	1.20	1.00	1.00	1.00	1.00
7.00	6.00	5.00	5.00	5.00	5.00	5.00	1.00	1.00	1.00

Chapter 4

The Effect of Price Limits on Liquidity

4.1 Introduction

The price behaviour and volatility of a stock play a pivotal role in the investment decision. Whether the trade can be executed without substantial financial and opportunity costs largely depends on the liquidity of the market. In practice, a market is deemed as liquid when shares can be easily and quickly converted into cash without incurring considerable transaction costs. In previous literature, liquidity has been referred to four dimensions: immediacy, width/breadth, depth and resiliency, which are linked with the trading time, transaction cost, size of the trade and price impact, respectively. Price impact refers to how an incoming order would affect the price change. Hence, a sound liquidity measure should take all the dimensions into account. In previous studies, there is no such a measure, which can capture all the dimensions simultaneously. This is mainly due to the interdependence among dimensions. For example, a required immediacy is sometimes at the expense of width. In other words, an immediate sale of a stock may be fulfilled at a very large discount. The existing liquidity measures in the literature in general can be categorised into three groups: volume, price and a combination of volume and price. Measures like the trading volume, turnover ratio are in the volume group; various spreads like quoted spread and effective spread belong to the price group; the well-known Amihud measure is a representative of the third group.

The implementation of price limits may have an effect on liquidity. Kim and Rhee (1997) propose the trading interference hypothesis that a share that hits the price limits on day t will experience more trading on the subsequent day. In other words, an increase in trading volume in the following day is due to the restricted trading on the day of price-limit-hit. If trading volumes are a proxy for liquidity, price limits interfere with liquidity. The rationale behind the trading interference hypothesis is that the price limits prevent investors from buying their desired shares at a relatively higher price or selling their unwanted shares at a relatively lower price on the day of price-limit-hit. The investors can only delay their trading.

The purpose of this study is to examine the change in liquidity from the day of price limit-hit to the following day. The existing literature on the effect of price limits on liquidity focuses on the change of turnover ratio or order imbalance only. As mentioned before, a reliable measure should consider as many dimensions of liquidity as possible. Most of the liquidity measures used in the literature are single dimensional, although composite liquidity, quote slope, log quote slope and realised spread[23] are exceptions. The dimensions of width, depth and resiliency are covered by composite liquidity, quote slope and log quote slope. Realised spread considers the dimensions of immediacy and width. The log quote slope is similar to composite liquidity and quote slope, but is considered to be superior to quote slope and composite liquidity because of its better statistical property (Hasbrouck and Seppi, 2001). The realised spread measures the buyer and seller's trading costs within a certain time interval. For a comparison purpose to previous studies, two single-dimensional measures, turnover ratio and order imbalance, are also included in the study. To summarise, turnover ratio, order imbalance, log quote slope and realised spread are used in this chapter.

The existing studies on the effects of price limits (for example, Kim and Rhee, 1997; Chen, Rui and Wang, 2005; Bildik and Gülay, 2006,) only compare a single dimensional liquidity measure (for example turnover ratio) between price-limit-hit stock and near-price-limit-hit stock. That is, they compare the change of turnover ratio of price-limit-hit stocks with the change of turnover ratio of 90% price-limit-hit stocks. This study incorporates the price limits and near-price-limits dummy variables in an ARMA model. In the literature, modelling liquidity for an individual stock has shown poor goodness of fit; a consistently low values of adjusted R-squared. Specifically, market liquidity, industry liquidity and

[23] Composite liquidity: $\frac{(P_A-P_B)/P_M}{(Q_A P_A+Q_B P_B)/2}$; quote slope: $\frac{P_A-P_B}{\ln(Q_A)+\ln(Q_B)}$; log quote slope: $\frac{\ln(P_A/P_B)}{\ln(Q_A)+\ln(Q_B)}$; realised spread: $\begin{Bmatrix} 2(\ln(P_t)-\ln(P_{t+5}))\ when\ the\ t\_th\ trade\ is\ a\ buy \\ 2(\ln(P_{t+5})-\ln(P_t))\ when\ the\ t\_th\ trade\ is\ a\ sell \end{Bmatrix}$. A detail information is presented in the literature review.

variables like volatility, volume and price levels do not have strong explanatory power in models for individual stock liquidity. It is not considered desirable to spend time searching for explanatory variables just for the purpose of improving the degree of goodness of fit without any theoretical support. As stated by Brooks (2008, p.194, p.206), "*such a model would closely fit the sample of data at hand, but could fail miserably when applied to other samples if it is not based soundly on theory*" and "*time series models may be useful when a structural model is inappropriate*". Thus, an ARMA(p,q) models is implemented to study the effect of price limits on liquidity. Following standard practice, the (p,q) lag structure is determined using either the AIC or BIC criteria. Moreover, ARCH effects are included in the models because the residuals of ARMA model are heterogeneous. Before ARMA modelling, the stationarity tests are applied to these four liquidity measures. It is found that realised spread is not trend stationary. Therefore, the liquidity measures applied in the model are turnover ratio, order imbalance and log quote slope. This allows us to explore whether the choice of liquidity measure would influence the conclusion on the effect of price limits on liquidity.

In addition, this study also explores the difference between the effect of price limits on liquidity between A- and B-shares. A- and B-shares are issued by the same company, but B-shares are traded at a large discount due to their illiquidity. Chen, Kim and Rui (2005) show that B-shares has a wide spread than A-shares. It is well-known that domestic investors have information advantage on the local assets than foreign investors (Chan, Menkveld and Yang, 2008). Thus, it is important to see whether price limits aggravate illiquidity of B-shares.

The empirical results reported in this chapter show that there is no significant difference in the effect of price limits on liquidity between Shanghai Stock Exchange (SSE) and Shenzhen Stock Exchange (SZSE) despite the use of different liquidity measures. A significant difference, however, is found between upper and lower price-limit-hits. Specifically, when the liquidity is measured by turnover ratio, price limits interfere with trading after upper price-limit-hits. The interference after upper price-limit-hits is weaker when the liquidity measure is the log quote slope. Price limits almost have no effect on liquidity if it is measured by the order imbalance. After the lower price-limit-hits, there is almost no trading interference regardless of liquidity measures. A similar result is found in B-shares, but the number of shares that show trading interference decreases to a certain extent. That is to say, price limits do not aggravate the illiquidity of B-shares. In conclusion, the level of interference depends on the choice of liquidity measures. In other words, any suggestions about the rejection of the trading interference hypothesis require careful consideration because the conclusion based on only one measure may overstate or understate the effect of price limits. Finally, according to the average results, price limits interfere with trading.

The remainder of the chapter is organised as follows. Section 4.2 reviews the existing literature with theoretical background and empirical evidence, it also discusses the goodness of fit from liquidity modelling. Section 4.3 describes the data and Section 4.4 presents the methodology with the choices of liquidity measures and ARMA modelling. Section 4.5 discusses the empirical results and Section 4.6 concludes.

4.2 Literature Review

The main objective of this section is to conduct a comprehensive literature review and critically discuss the empirical work done on the effect of price limits on volatility. Section 4.2.1 defines liquidity. Section 4.2.2 reviews the liquidity measures. Section 4.2.3 reviews the empirical findings of the effect of price limits on liquidity. Section 4.2.4 presents the empirical results of modelling liquidity.

4.2.1 Definitions of Liquidity

An early definition of liquidity is given by Keynes (1930, p.67), who claims that an asset is more liquid if it is "*more certainly realisable at short notice without loss*". In other words, the conversion of a liquid asset into cash can be incurred without considerable financial and opportunity costs. To delineate liquidity in the stock market, Black (1971) states that a liquid stock should be differentiated from others by showing four characteristics. First, the quotes for investors to trade small amounts of stock immediately exist. Secondly, the small spread is common. Thirdly, there is no significant price impact on the current market price when a large amount of stock is expected to be traded by uninformed investors over a long period of time. Fourthly, to trade a large block of stock immediately is at a cost of premium or discount which is positively correlated with the size of the block. Harris (2003) categories liquidity into four dimensions: immediacy, width/breadth, depth and resiliency. *"Immediacy refers to how quickly trades of a given size can be arranged at a given cost; width refers to the cost of doing a trade of a given size; depth refers to the size of a trade that can be arranged at a given cost" (*Harris, 2003, p.398*). "Resiliency refers to* how *quickly prices convert to former levels after they change in response to large order flow imbalances initiated by uninformed traders" (*Harris, 2003, p.400*).*

It is important to note that these four dimensions are interdependent. For example, a required immediacy is at the expense of width if the overall market is dominated by the supply or demand side. Another case concerns width and depth. A sizeable amount of depth may not be fulfilled due to the prevailing width. Moreover, a desired width or depth may result in losing immediacy. Furthermore, a good resiliency suggests a balanced relationship between supply and demand, which improves immediacy. It is clear that their interdependence poses difficulties when measuring liquidity.

4.2.2 Liquidity Measures

Aitken and Comerton-Forde (2003) point out that liquidity is easy to define but hard to measure reliably, because the choice of liquidity measures would have a great impact on the research results. They distinguish liquidity measures from two aspects: trade-based measures and order-based measures. The trade-based measures are fundamentally similar to the dimensions of width and depth. For example, the measures are trading volume, turnover, the number of trades and the ratio of turnover to market value. Due to the availability of the order book, order-based measures include bid-ask spread and trading time, which reflects the dimensions of immediacy and width. Different from Aitken and Comerton-Ford (2003), Goyenko, Holden and Trzcinka (2009) categorise liquidity into low-frequency and high-frequency. As the names suggest, low-frequency data, such as a summary of daily and monthly trading, or a high-frequency data, like details of intraday trading, are used to estimate liquidity. Regardless of how the name is given, a convincing measure should take all the dimensions into consideration according to the definition of liquidity (Harris, 2003). It is, however, not feasible in reality. The following literature demonstrates this point.

Demsetz (1968) proposes that the bid-ask spread and the brokerage commissions form the cost of an immediate round-trip transaction. The brokerage commissions normally are not taken into account because the fees are independent of the time required to settle a transaction. Roll (1984), however, argues that the real trading data show that transactions usually happen within the bid-ask spread. In other words, the bid-ask spread may overestimate the cost. In the same paper, Roll develops the effective spread which depends on negative first order serial covariance of price changes. The idea behind the effective spread is that an efficient market suggests no serial covariance of price changes if there are no transaction costs, while a negative serial covariance implies transaction costs.

In several works, due to the availability of rich intraday data, various bid-ask spreads have been computed to measure liquidity (Huang and Stoll, 1996; Chordia, Roll and Subrahmanyam, 2000; Chordia, Roll and Subrahmanyam, 2001; Hasbrouck and Seppi, 2001). Details of the measures are shown in Table 4.1 and 4.2. Hasbrouck (2009) implements the Gibbs sampler estimate of Roll's model and computationally derivea the effective costs based on daily closing prices. Corwin and Schultz (2012) argue that stocks are traded within the daily high prices (buy-side) and low prices (sell-side), thus they derive a High-Low spread estimator. Hasbrouck (2009) and Corwin and Schultz (2012) show that their measures are highly correlated with the measures computed from the intraday data.

[Insert Tables 4.1 and 4.2 about here]

In addition to the spread measure, trading volume is prevalent in the literature. Bagehot (1971) describes that a market is composed of three types of investors; market makers, informed traders and liquidity-motivated investors. Copeland and Galai (1983) propose that the bid-ask spread is highly correlated with market activity due to these three market participants. An informed trader with special information can time the trade, whereas a liquidity-motivated investor is willing to pay an extra fee to obtain the stock immediately. Therefore, the market maker maximises profits by setting a bid-ask spread to attract more trading from both trader and investor. In the subsequent research, the trading volume has been improved to take the return and firm size into account. The Amivest measure (3) considers the trading volumes per unit of return (Cooper, Groth and Avera, 1985). Thus, a 1% price change in a more liquid market would bring about a larger trading volume than an illiquid market.

The reciprocal of the Amivest measure with minor adjustment, the Amihud measure (18), is also one of the most important measures but it emphasises illiquidity (Amihud, 2002). It is obvious that trading volume differs in terms of firm sizes. Datar, Naik and Radcliffe (1998) use the ratio of trading volume to shares outstanding as the liquidity measure which is known as the turnover ratio (5). A higher ratio suggests that one unit of market value in a more liquid market gives risk to a large trading volume than an illiquid market. Chordia, Roll and Subrahmanyam (2002), however, argue that the trading volume could be a misleading measure. This is because a sizeable volume may be initiated by few informed traders solely. This causes order imbalance and market makers will then revise the quote. To quote from Chordia *et al.* (2002, p.111), "*order imbalance in either direction, excess buy or sell orders, reduce liquidity*".

There are also other popular measures. Lesmond, Ogden and Trzcinka (1999) present a model called LOT (6), which is based on the application of Tobin's (1958) limited dependent variable procedure. The logic behind the LOT model is that informed traders will only trade when the value of accumulated information is greater than the trading costs. Hence, the percentage of the zero-return days during a period can be a proxy for liquidity. A large proportion of the zero return days indicate a longer time for the investors to accumulate information, which means the market is illiquid. Lesmond (2005) shows that the LOT model is useful by studying 31 emerging markets. A modified zero-return (21) study which takes the consecutive zero-return days into account is conducted by Bekaert, Harvey and Lundblad (2007) in 19 countries. Bekaert *et al.* (2007) show that the market is more illiquid if zero-returns are consecutive. Campbell, Grossman and Wang (1993) attribute a negative volume and return relationship to liquidity. As mentioned before, Amihud (2002) measures market illiquidity through the return per unit of trading volume. This is sometime called price impact measure. Pástor and Stambaugh (2003) introduce a gamma estimator (20), a coefficient that shows how the dependent variable return is explained by the volume in a regression model.

4.2.3 The Effect of Price Limits on Liquidity

This section reviews the empirical findings of the effect of price limits on liquidity. The findings are presented in terms of global stock exchanges which apply price limits. This is because liquidity can be quite different from each other in different stock exchanges (Brockman, Chung and Pérignon, 2009). A review based on different stock exchanges provides a clear picture of effect of price limits on liquidity.

4.2.3.1 Israel

The Tel-Aviv Stock Exchange (TASE) implements not only price limits but also trading halts, which may be triggered by price limits if there is extreme trading behaviour. Lauterbach and Ben-Zion (1993) use daily data of stocks on TASE from the period 13th October 1987 to 28th October 1987. This particular period allows them to test the effectiveness of price limits around the so-called Black Monday on 19 October 1987[24]. There is a three-stage trading mechanism on the TASE: pre-auction, auction and post-auction. Three types of stocks are identified under the trading mechanisms: 'Mishtanim stocks' that are traded throughout the auction and post-auction periods; 'non-Mishtanim stocks' that are traded in auction period only; 'non-traded stocks' (trading halts stocks) that are determined in pre-auction period. Lauterbach and Ben-Zion (1993) show that there was a significant amount of supply of all types of stocks on the crash day. In other words, there was a significant order-imbalance on the crash day. On the day after Black Monday, the

[24] Due to time zone, TASE response to Black Monday on 20 October 1987.

amount of order-imbalance decreased for all types of stocks, especially for 'Mishtanim stocks' and 'Non-Mishtanim stocks'. This was due to the fact that 'non-traded stocks' were prohibited to trade in the auction and post-auction period on the crash day and thus some unwanted stocks could only be sold on the subsequent day. Therefore, price limits with trading halts do not reduce order-imbalance.

4.2.3.2 Japan and Turkey

In the absence of price limits, investors can obtain (dispose) their desired (undesired) shares at potentially high costs. When a market applies price limits, however, potential trading price that lies outside the pre-specified level is prohibited. Kim and Rhee (1997) argue that if investors cannot buy or sell the shares on the day of price-limit-hits, they will buy or sell on the following day. This will then result in more intense trading. They call this as the trading interference hypothesis. To test the hypothesis, they measure the trading activity using the turnover ratio and measure the percentage change of turnover ratio from the previous day. If the trading interference hypothesis holds, there should be no intense trading on the following day for the groups of stocks that reaches at least 80% or 90% of the limits but do not hit the limits. Stocks that reach at least 80% of the limits but or 90% of the limits are denoted by *Stock80* and *Stock90* respectively. Stocks that hit the limits are denoted by *StockH*. Kim and Rhee (1997) use daily data for stocks on the Tokyo stock exchange (TSE) from 1989 to 1992. They report that there is a significant positive percentage change of turnover ratio for the group *StockH* at the 1% level, while it is negative for the groups *Stock90* and *Stock80*. This suggests that stocks which hit price limits give rise to intense trading on the following day and the trading interference hypothesis is not rejected. Similar to Kim and Rhee (1997), Bildik and Gülay (2006) use daily data for stocks on the Istanbul stock exchange over the period 1998-2002 and examine the trading interference hypothesis. Instead of estimating turnover ratio, Bildik and Gülay (2006) use actual trading volume. Similar to Kim and Rhee (1997), they also show that trading volume increases on the day after price-limit-hit, especially for the group of stocks hitting the lower limit.

4.2.3.3 Taiwan

Aitken and Comerton-Forde (2003) suggest that there are two types of liquidity measures: trade-based measures such as the turnover ratio and order-based measures such as the costs of trading. If liquidity measurement only focuses on one type of measure, any conclusions based on it may be biased. Lee and Chou (2004) use transaction data for 100 stocks on the Taiwan stock market from 30th June 1997 to 31st December 1997 and assert that liquid stocks are the stocks which have higher trading volumes and a lower level of volatility. Based on intraday data, a liquidity index similar to the Martin liquidity index is used to explore liquidity surrounding the price-limit-hits (Martin, 1975, cited in Lee and Chou, 2004). The measurement is defined as follows

$$\hat{\lambda}_i = \frac{\hat{\sigma}_i}{CVOL_i} \quad ,$$

where $\hat{\sigma}_i$ is the estimated return variance of stock *i* before (after) the events. $CVOL_i$ is cumulative trading volume during pre-event period (post-event period). An event is identified by stock price that either reaches or is close to price limits (for example 90% of price limits), which is similar to Kim and Rhee (1997). $\hat{\lambda}_i$ is a pre-event (post-event) liquidity measure; the higher the value of $\hat{\lambda}_i$, the lower liquidity for stock *i*.

According to Lee and Chou (2004), the post-event liquidity measures are on average statistically larger than pre-event measures in both price limit stocks and near-price limit stocks at the 1% significance level using the Wilcoxon signed rank test. They also run a cross-sectional regression to investigate which types of stocks have strong influence on the change of liquidity. They find that price limits neither increase nor decrease liquidity

Information asymmetry results in wider bid-ask spreads, which increases the trading costs and then decreases liquidity. If, however, price limits reduce information asymmetry, the adverse selection risk which is confronted by liquidity providers is reduced. In other words, they will reduce bid-ask spreads. Kim and Yang (2008) use transaction data of stocks on the Taiwan stock market in 2000 and argue that only consecutive price-limit-hits can mitigate the degree of information asymmetry. This is because a single price-limit-hit does not have adequate time to disseminate information. Then, they compute the proportional quoted spread, measure (9) in Table 4.1. According to their results, single price-limit-hits and closing price-limit-hits do not have a positive effect on information asymmetry; they do not reduce the proportional quoted spread. However, the spread increases (remains unchanged) after upper (lower) consecutive price-limit-hits. This implies that information asymmetry is further aggravated by upper consecutive price-limit-hits.

4.2.3.4 Mainland China

Similar to Kim and Rhee (1997), Chen, Rui and Wang (2005) use daily data of stocks on the Chinese stock exchanges from 1996 to 2003 and test the trading interference hypothesis. Their also measure liquidity as the turnover ratio, but show opposite findings to Kim and Rhee. No matter the bullish period (1996-2000) or bearish period (2001-2003) in the Shanghai (SSE) and Shenzhen (SZSE) stock exchanges, trading activities do not increase but decrease significantly after price-limit-hits. As stated by Chordia, Roll and Subrahmanyam (2002, p.111), "*order imbalances in either direction, excess buy or sell orders, reduce liquidity*". Seasholes and Wu (2007) use transaction data of A-shares on the SSE from 2001 to 2003 and show that negative order imbalance on the day of upper price-limit-hits is followed by positive order imbalance on the next day, but the absolute value of negative order imbalance is greater than the value of positive order imbalance.

Would the liquid and illiquid stocks response differently to price limits? As discussed in Chapter 2, A-shares are denominated in RMB and were initially traded by domestic citizens, but then also by Qualified Foreign Institutional Investors (QFII) after 2002. B-shares are denominated in USD on the SSE and HKD on the SZSE and were initially traded by foreign investors and then by local citizens after 2000. Moreover, domestic investors who are permitted to trade B-shares are subject to strict foreign currency regulations. These properties make B-shares less liquid in practice. From the summary statistics shown in Tables 2.1 and 2.2 of Chapter 2, the turnover ratio of A-shares is about twice as large as that for B-shares, 0.0099 against 0.0057 on the SSE and 0.0113 against 0.0061 on the SZSE.

To investigate how A and B-shares response to price limits, Chen, Kim and Rui (2005) use daily stock data for AB-shares from 1999 to 2002 and compute the proportional quoted spread (9). They find that the spread of B-shares is significantly larger than that of the A-shares at the 1% level.

4.2.3.5 Spain

Kim, Yagüe and Yang (2008, p.200) state that it is difficult to evaluate the effectiveness of price limits. They state that "*To date, the effectiveness of trading halts and price limits remains a subject of regulatory and academic debate. Because there is no way to know what would have happened without the circuit breakers, it is extremely difficult to examine their effectiveness empirically*". However, they argue that it is possible to compare the performance between price limits and trading halts, provided that a stock exchange implements both mechanisms. As discussed in Chapter 3, they have shown that trading halts perform better than price limits in terms of controlling volatility. In addition, they also investigate the effects of price limits and trading halts on liquidity. Their liquidity measures are decomposed into two parts, the effective spread and depth, measures (11) and (10) in Table 4.1, respectively. Kim, Yagüe and Yang (2008) show that there is a narrower (wider) spread and stronger (weaker) depth after trading halts (price-limit-hits). This indicates that trading halts perform better than price limits. Similar to the causes of upper and lower price-limit-hits, trading halts are triggered as a result of either good news or bad news. They reveal that trading halts only improve liquidity when they are triggered as a result of good news. Moreover, liquidity is reduced after both upper and lower price-limit-hits, but it is further reduced by lower price-limit-hits. Overall, trading halts perform relatively better than price limits by showing augmented liquidity after good news and stable liquidity after bad news.

4.2.3.6 Malaysia

Chan, Kim and Rhee (2005) conduct research on the Kuala Lumpur stock exchange (KLSE) which implements a 30% price limits rate. The transaction data for stocks on the KLSE during 1995-1996 are adopted. They argue that price limits lead to order imbalance.

According to them, investors would frantically increase buy (sell) orders when price approaches upper (lower) limits. Moreover, they also argue that investors cannot immediately correct their trading from buy (sell) to sell (buy). The correction is transferred to the next day which will bring about a reversed order imbalance. Similar to Kim and Rhee (1997), they compare the performance between price-limit-hit stocks and near-price-limit-hit stocks. Noticeably, Chan, Kim and Rhee (2005) only include upper price-limit-hits in the study as there are only a few lower price-limit-hits in their dataset. According to their results, buy orders dominate sell orders before the hits for the price-limit-hit stocks, but the situation is reversed after the hits. For near-price-limit-hit stocks, however, sell orders are the main driver of the order imbalance in both periods. The results confirm that price limits prevent immediate correction of order imbalance.

4.2.4 Modelling Liquidity

As it can be seen from the literature, there is no superior liquidity measure which captures all dimensions. This indicates that the research outcomes may depend on the choice of liquidity measures. When a liquidity measure is chosen as a dependent variable, it is often desired to see that it is well explained by a set of explanatory variables. This, however, does not seem to be the case in individual stock liquidity modelling in finance. This section reviews modelling liquidity in terms of individual stocks and portfolios, which lays the foundation for modelling liquidity in the methodology section of this chapter.

4.2.4.1 Individual Stock Liquidity

Chordia *et al*. (2000) investigate the commonality in liquidity; that is, how the liquidity of an individual stock co-moves with the liquidity of the market and industry sectors in the New York stock exchange (NYSE). Their liquidity measures are quoted spread (8), proportional quoted spread (9), quoted depth (10), effective spread (11) and proportional effective spread (12). In addition to market and industry liquidity, explanatory variables such as volatility, volume, and price level are also included in time-series regressions. The adjusted R-squareds, nevertheless, are only 2%, 2.1%, 5%, 3.1% and 3.2% for the quoted spread (8), proportional quoted spread (9), depth (10), effective spread (11) and proportional effective spread (12), respectively. Brockman and Chung (2002) study individual firm liquidity of stocks in the Hong Kong stock exchange (HKSE) which, being an order-driven, does not have market makers as the main liquidity provider. Similar to the liquidity measures and the methods of Chordia *et al.* (2000), the adjusted R-squared are also low; 1.4% for quoted spread (8), 2.8% for proportional quoted spread (9) and 2.1% for depth (10). The results indicate marketwide liquidity does not have strong explanatory power for individual stocks.

Kempf and Mayston (2008) support Brockman and Chung by examining the DAX30 in the Frankfurt Stock Exchange and reveal that on average only 3.7% and 2.1% of the individual spread and depth are explained by market liquidity. Instead of spread and depth, Kamara, Lou and Sadka (2008) apply the Amihud measure in the NYSE and produce detailed results based on years and firm sizes. They show that individual stock liquidity is still not well explained by marketwide liquidity. However, there is a trend for large firms to co-move with market. Specifically, the adjusted R-squared gradually increases from 3.1% in the sub-period of 1963-1967 to 10.6% in the sub-period of 2003-2005 for the large firms. The values for small firms, nevertheless, are about 2.5% on average. Brockman, Chung and Pérignon (2009) extends their previous study discussed above to include 47 stock exchanges. According to the spread results, the maximum and minimum adjusted R-squared values in main Europe, North America, Pacific, Emerging-Asia, Emerging-Europe MEA and Emerging-Latin America is shown below.

Virt-X[25] and Frankfurt stock exchange	6.4% and -0.3%
American stock exchange and NYSE	4.9% and 2.4%
Tokyo stock exchange and New Zealand exchange	5.6% and 1.8%
Taiwan stock exchange and Philippine stock exchange	14.7% and 1.2%
Istanbul stock exchange and Johannesburg stock exchange	6.2% and 0.3%
Buenos Aires stock exchange and Santiago stock exchange	2.9% and 0.5%

Reproduced from Brockman, Chung and Pérignon (2009)

Similar low values are also discovered for the depth results.

[25] Virt-X was owned by Swiss Exchange, but the trading is ceased now. Details refer to http://www.six-group.com/about/en/home/corporate/history/swx-group.html

4.2.4.2 Portfolio Liquidity

The liquidity of individual stocks is not well explained by market or industry liquidity (Chordia *et al*., 2000). This, however, may not be the case for a portfolio. They apply the same method but substitute portfolios for individual stocks. Portfolios are constructed according to size quintile; thus, five size groups. In their study of US stocks, the adjusted R-squared vary significantly across liquidity measures and are 15.2%, 55.2%, 81.1%, 3.6% and 3.9% on average for the quoted spread (8), proportional quoted spread (9), depth (10), effective spread (11) and proportional effective spread (12), respectively. Chordia *et al*. (2001) explore the determinants of market liquidity and trading activity on the NYSE. A market portfolio that comprises equal-weighted stocks is constructed and its liquidity proxies are quoted spread, effective spread, depth and composite liquidity (13). The measures of trading activity are volume and number of trades. A number of explanatory variables, Federal funds rate, term spread, market returns, holiday dummies, weekday dummies, GDP, CPI and unemployment rate are used as control variables in a regression model. The market portfolio's liquidity and trading activity are explained by the selected variables to a certain extent. The adjusted R-squareds are 32.5%, 34.2%, 23.2%, 29.8%, 16.4% and 17.5% for the quoted spread, effective spread, depth, composite liquidity, volume and number of trades, respectively.

Amihud (2002) runs a simple regression of his liquidity measure on the lag of the measure. The regression generates a high value of R-squared that is 53%. As described in the previous sub-section, Chordia *et al*. (2002) show that a marketwide order imbalance can be a proxy for liquidity and there are strong autocorrelations. Then, the marketwide order imbalance is regressed with weekday dummies, past market returns and past orders imbalance, which produces an R-squared equal to 47.7%. Different from most of the studies, Bailey, Cai, Cheung and Wang (2009) use a unique dataset which allows them to identify individual investors, institutional investors (ordinary, listed and insurance firms) and proprietary investors (brokerage firms and mutual funds and qualified foreign institutional investors) on the Shanghai stock exchange. Bailey *et al.* (2009) show that the order imbalance of a portfolio from individual investors co-moves with a marketwide order imbalance and the model reveals a 27.9% R-squared. The portfolios of institutional and proprietary investors, however, do not suggest that stronger co-movement with only about 0.2 and 0.7% R-squared. Bailey *et al.* (2009, p.17)," *clearly, other factors, or noise, largely determine the daily order imbalances of institutional and proprietary investors*".

4.2.4.3 Implications

There are three conclusions that can be drawn in this section. First, modelling individual stock liquidity has illustrated consistently low values of R-squared across different stock exchanges; that is, for example, 2.4% and 5.6% in the NYSE and Tokyo stock exchange respectively. Secondly, portfolio liquidity tends to have a better model fit than individual stock liquidity. It is expected to see an increase in the R-squared for a portfolio because the diversification effect. R-squared is low if the residual variance is high. The residual variance of a diversified portfolio will be lower and so the R-squared will be higher. When there is lack of diversification, a multiple variables regression model does not have strong explanatory power in modelling individual stock liquidity, instead a time-series regression model produces a better estimation result. Thirdly, the choice of liquidity measures does indeed have an effect on liquidity modelling.

Why does modelling liquidity in individual stock have such poor explanatory power? Lang and Maffett (2011) argue that a firm with greater transparency has lower correlations with marketwide liquidity and returns. A transparent company adheres to a sound accounting standards, selects independent auditors and has good earnings management. All of these facilitate analysts' forecasts and thus improve their forecasting accuracy. In other words, "*transparent firms are less likely to be illiquid at inopportune times, such as when market liquidity is low and market returns are negative*" (Lang and Maffett, 2011, p.103). Applying Amihud's liquidity measure (18) in 37 countries, Lang and Maffett find that there are low correlations between the transparent firms and the marketwide liquidity. Lee, Lin, Lee and Tsao (2006) study Taiwan's OTC stock market. Compared with the stocks traded on Taiwan stock exchange, the listing standards are less strict. In other words, OTC stocks are less transparent than those of the main market. Following the method of Chordia *et al.* (2000), the adjusted R-squared in Lee *et al.* (2006) are 21.6%, 26.7%, 25%, 20.5% and 34.4% for the quoted spread (8), proportional quoted spread (9), depth (10), effective spread (11) and proportional effective spread (12). These figures are much greater than the figures revealed by Chordia *et al.* (2000) in the NYSE in the previous section. The higher values of adjusted R-squared in OTC market confirm that the less transparent stocks are correlated with overall market performance, whereas those transparent firms listed in the main market are less correlated with overall market performance.

4.3 Data

To examine the effect of price limits on liquidity, this study employs intraday data to compute measures of liquidity. As reported in the literature, some important elements such as trade prices and bid-ask spreads are only available from intraday data. The data covers the period from 4th January 2010 to 31st December 2012[26]. During this period, 44 (42) companies issued both A and B-shares on the SSE (SZSE). Due to the fact that some A or B-shares (i) do not experience price-limit-hits; or (ii) they are traded as ST-shares which are subject to difference price limit rates[27], a final dataset of 37 (32) companies on the SSE (SZSE) are used. The data includes trading prices, volume, time, ask price, bid price, ask size, bid size, buyer or seller-initiated trade. For example, at time 9:30:50, one buy order is executed at the trading price of 10 RMB and volumes of 600 shares. The remaining unexecuted buy and sell orders with their intended volumes are displayed through the bid and ask prices with their sizes. After cleaning the data, for example removing zero trading price, the minimum, mean and maximum number of trades are shown below.

	SSE A	SSE B	SZSE A	SZSE B
minimum	47,253	10,879	397,702	40,948
Mean	725,990	141,910	876,620	150,910
maximum	1,359,422	306,018	2,112,518	499,830

[26] The data cleaning process is described in Chapter 3.
[27] 5% limits on the SZSE, 10% limits on the SSE.

A summary of trading volume measured as the number of share for morning and afternoon sessions is shown in Table 4.3. The trading volume for A-shares on the SZSE with a cross-sectional mean of about 5,898K (that is, 5,898,000) shares in the morning session (5,252K in the afternoon) is greater than that on the SSE with a value of 3,308K (3,000K) in morning (afternoon) trading session. A similar pattern is found for B-shares, although the trading volumes are significantly decreased to 583K (604K) on the SZSE and 469K (455K) on the SSE in the morning (afternoon) trading session. This suggests that the AB- shares on the SZSE are relatively more liquid than AB-shares on the SSE in terms of trading volume. In addition, according to panel B of Table 4.3, trading volumes in the morning session are about 10-12% greater than the afternoon trading volumes for A-shares on both exchanges. It is important to note that a large standard deviation and a wide range between the minimum and maximum value, for example the standard deviation of 2,887K and the range of 14,490K (= 14,873 - 383) for the SSE A-shares, indicates that some shares are attractive to investors to trade but some are not. According to median value reported in panel C of Table 4.3, the maximum trading volumes come from transportation (leasing and commerce service) and manufacturing (utilities) industry for A and B shares on the SSE (SZSE), respectively, while information technology service and wholesale and retail industry show the minimum trading volumes on the SSE and SZSE, respectively

[Insert Table 4.3 about here]

Standard t-tests are conducted to examine the difference in the morning and afternoon trading session, as well as between A and B- shares' trading volume. The results are reported in Table 4.4. Out of 37 SSE A-shares, the trading volume in the morning session for 7 shares are significantly greater at the 1% level than that in the afternoon, while there is no significant difference in the B-shares. For the SZSE, similar results are found for A-shares. However, the trading volume for 7 B-shares in the morning session is significantly less than that in the afternoon session. It is clear to see that all the trading volume of A-shares are significantly greater than that of B-shares regardless of stock exchanges or trading sessions. As mentioned before, it is normal to see relatively small volume of B-shares due to the trading only being available to foreign investors and local investors who are allocated only a limited amount of foreign currency. Furthermore, Table 4.5 shows that there is a high correlation between trading volume in the morning and volume in the afternoon. The cross-sectional means are 0.6930, 0.6733, 0.6923 and 0.6892 for SSE A, SSE B, SZSE A and SZSE B, respectively. Trading volume is also correlated with the market value. Specifically, about 33 (35) out of 37 A (B) shares on the SSE and 25 (26) out of 32 A (B) shares on the SZSE present positive correlation coefficients, which are significantly greater than zero at the 1% level.

[Insert Tables 4.4 and 4.5 about here]

4.4 Methodology

This section first discusses the choices of liquidity measures. It then outlines the ARMA model used to investigate the effect of price limits on liquidity.

4.4.1 The Choices of Liquidity Measures

The purpose of this chapter is to test the trading interference hypothesis. The trading interference hypothesis states that stocks which hit price limits on day *t* will experience higher trading volume on day *t+1* owing to the restricted trading on day *t* (Kim and Rhee, 1997). If trading volume is a proxy for liquidity, price limits interfere with liquidity. As Table 4.1 and 4.2 show there is a large number of liquidity measures reported in the literature. These liquidity measures are the major measures in the literature. According to Wyss (2004), there are still some other measures in the stock market, but these other measures are either similar to those reported in Tables 4.1 and 4.2 or have high correlations among each other. For example, the natural log of depth is just another form of the depth (10) and the correlation between them is 0.93. Furthermore, the effect of price limits on liquidity may depend on the choice of measures. The trading interference hypothesis emphasises inter-day liquidity. Therefore, the frequency of the liquidity measure should be daily. In Table 4.1 and 4.2, there are 13 liquidity measures meeting such a requirement and available to test the hypothesis. These are realised spread (4), quoted spread (8), proportional quoted spread (9), depth (10) effective spread (11), proportional effective spread (12), composite liquidity (13), order imbalance (19), log spread (14), log size (15), quote slope (16), log quote slope (17) and turnover ratio (5). A detailed discussion of the feasibility of the liquidity measures is presented in Table 4.6 and a summary of these 13 measures is shown in Table 4.7.

[Insert Tables 4.6 and 4.7 about here]

The existing literature on the effect of price limits on liquidity only uses turnover ratio, effective spread, depth and order imbalance. Among these measures, some could be dismissed from further consideration for the models if they are highly correlated. According to Table 4.8, turnover ratio is positively correlated with depth and order imbalance, but negatively correlated with effective spread. Specifically, there are 35 (30) stocks showing positive correlation significant at the 1% level between turnover ratio and depth (order imbalance), while 14 (27) stocks present significant negative correlation between turnover ratio and effective spread (proportional effective spread) from the SSE A-shares. More discussion on these correlations is presented below.

It is important to note that to compare a spread between stocks of high price and low price generates a biased conclusion. For example, suppose that stock XYZ trades at 20 RMB with a daily average spread 0.1 and stock YZX trades at 9.8 RMB with a daily average spread 0.05. It is hard to say stock YZX has a lower spread than stock XYZ. To avoid biases due to different price scales, a standardised (proportional) spread: 0.005 (0.1/20) and 0.051 (0.05/9.8) is used to make a comparison. The positive and negative correlations are expected from theoretical considerations since large turnover ratio means more trades, which suggests a large depth and a low spread. If the trades are dominated by the buyers or sellers, there is order imbalance. From the SSE B-shares, about 27 stocks' turnover ratios are positively and significantly correlated with depth and order imbalance, while 22 stocks reveal negative and significant correlation between turnover ratio and effective spread. Similar results are found for the SSE B, SZSE A and SZSE B in Table 4.9, 4.10 and 4.11 respectively.

[Insert Tables 4.8, 4.9, 4.10 and 4.11 about here]

As mentioned above, liquidity is a multi-dimensional measure according to its definition. It is obvious that turnover ratio (5), depth (10), log size (15) and order imbalance (22) only consider the dimension of depth, while quoted spread (8), proportional quoted spread (9), effective spread (11), proportional effective spread (12) and log spread (14) only take the dimension of width into account. The dimensions of width, depth and resiliency, however, are covered by composite liquidity (13), quote slope (16) and log quote slope (17). The realised spread (4) considers the dimensions of immediacy and width. According to Huang and Stoll (1996), the time interval for the realised spread cannot be too short or too long, otherwise the model would be invalid. From the practical point, the number of observations will be reduced in a longer time interval, especially in an exchange with short trading hours. A typical case concerns the SSE or SZSE whose continuous trading hours are from 9:30-11:30 and 13:00-15:00. Final observations, therefore, are at time 11:25 and 14:55.

Composite liquidity (13), quote slope (16), log quote slope (17) and realised spread (4) are better than other measures because they capture more than one dimension from the theoretical point as mentioned above. Moreover, empirical findings also shown that these four measures are highly correlated with other measures. For example, log quote slope is highly correlated with other 11 measures except the realised spread in Table 4.8. As shown in Table 4.8, there are significant and positive correlations among composite liquidity (*CmpLiq*), quote slope (*Qslp*) and log quote slope (*LogQslp*). The values are 0.60, 0.80 and 0.73 for *CmpLiq* and *Qslp, CmpLiq* and *LogQslp*, *Qslp* and *LogQslp*, respectively. Moreover, the correlations for all shares are significant at the 1% level. In addition, the realised spread (*Rsp*) is also positively correlated with *CmpLiq* (0.10), *Qslp* (0.27) and *LogQslp* (0.14), but the number of significant shares decreases to 20, 35 and 22. Similar results are discovered for the SSE B-shares, SZSE A and B shares in Table 4.9, 4.10 and 4.11 respetively.

In contrast to *CmpLiq* and *Qslp*, *LogQslp* has better statistical properties, which make it more suitable to use in subsequent analyses and modelling (Hasbrouck and Seppi, 2001)[28]. Therefore, *LogQslp* will be selected from *CmpLiq*, *Qslp* and *LogQslp*. The turnover ratio (*Tor*) and order imbalance (*OdImb*) will also be employed in the model described below as they are widely used in examining the effect of price limits on liquidity. Realised spread, *Rsp* is also included as it considers the dimensions of immediacy as well as width. In summary, a total of four liquidity measures, *Tor, OdImb, LogQslp* and *Rsp* are used in this study. As the purpose of the study is to examine the change of liquidity, the final variables of interest used in the models described below are $\ln(Tor_{t+1}/Tor_t)$, $\ln(OdImb_{t+1}/OdImb_t)$, $\ln(LogQslp_{t+1}/LogQslp_t)$ and $\ln(Rsp_{t+1}/Rsp_t)$. In the following sections, the standard notation Δ is used to represent the change.

A summary of *Tor, OdImb, LogQslp* and *Rsp* is presented in Table 4.12. *Tor* and *OdImb* of A-shares are about 3-4 times greater than those of B-shares on both exchanges. *LogQslp* of A-shares is smaller than that of B-shares on both exchanges. This suggests that there is a lot of trading dominated by one-side, either buy or sell in A-shares. *Rsp* of A-share is greater than that of B-shares on the SSE, but not on the SZSE.

[Insert Table 4.12 about here]

4.4.2 Model

The previous studies reported above only compare liquidity measures between two groups of stocks: price-limit-hit group and almost-hit group. The implicit assumption behind this methodology is that firm characteristics are not an issue. Thus, any difference between the groups is only due to the effect of price limits. Firm characteristics, however, can indeed generate different results (Fama and French, 1993). This implies, therefore, that a multiple regression model or time-series model would be a better choice. a standard multiple regression model, however, is not a useful model to model liquidity. As mentioned in

[28] It is well known that the logarithm of a positive random variable often has a variance that is independent of the variable's level and its distribution is generally closer to normality.

Section 4.2.4, very low values of adjusted R-squared are typically reported in modelling individual stock liquidity. For example, Chordia *et al*. (2000) show that only 2%-3.2% variation of liquidity is explained by the multiple regression model in the NYSE. This implies that most of the independent variables have low explanatory power for an individual stock's liquidity. However, it is not considered wise to spend time searching for explanatory variables just for the purpose of improving the coefficient of determination in a regression model without any theoretical support. Repeating the quotation from Brooks (2008, p.194, p.206), "*such a model would closely fit the sample of data at hand, but could fail miserably when applied to other samples if it is not based soundly on theory*" and "*time series models may be useful when a structural model is inappropriate*".

In addition, a standard multiple regression model is subject to assumptions that (i) the expected errors are zero; (ii) variance is constant; (iii) autocorrelation is not presented; (iv) independent variables are non-stochastic; (v) the errors are normal distributed. It has been demonstrated in the literature that some or all of these assumptions do not hold for applications in finance. For example, there is well-documented ARCH effect (Engle, 1982; Bollerslev, 1986). DeFusco, McLeavey, Pinto, Runkle and Anson (2007) state that it is unrealistic to assume that independent variables are not random, for instance it is not true to say monthly return of S&P500 are not random. In contrast with a multiple regression model, the time-series model depends mainly on the stationarity of the time-series data. Therefore, a time-series model, ARMA(*p*,*q*), with price limits dummy variables are implemented in the study. The model is as follows

$$\Delta\mathrm{LM}_t = \mu_t + \sum_{i=1}^{p} \emptyset_i \Delta\mathrm{LM}_{t-i} + \sum_{j=0}^{q} \psi_j \varepsilon_{t-j} \tag{4.1}$$

with

$$\mu_t = \beta_0 + \beta_1 \mathrm{U}_{\mathrm{t-1}} + \beta_2 90\%\mathrm{U}_{\mathrm{t-1}} + \beta_3 \mathrm{L}_{\mathrm{t-1}} + \beta_4 90\%\mathrm{L}_{\mathrm{t-1}}\ ,$$

where $\Delta\mathrm{LM}_t$ is the change of liquidity measure, ΔTor, $\Delta OdImb$, $\Delta LogQslp$ or ΔRsp described above $\mathrm{U}_{\mathrm{t-1}}$ and $\mathrm{L}_{\mathrm{t-1}}$ are price limit dummy variables, taking a value of 1 if the price hits the upper and lower limits on day *t-1*, respectively, 0 otherwise. $90\%\mathrm{U}_{t-1}$ and $90\%\mathrm{L}_{t-1}$ are 90% price limits dummy variables, taking value 1 if the price hits the 90% of upper and lower limits on day *t-1* but not hits the limits, respectively, 0 otherwise. If the data presents ARCH effects, the ARMA(*p*,*q*) model may be extended. In such cases, following standard practice in empirical finance research a GARCH(*1*,*1*) models is used.

If trading interference hypothesis hold and $\Delta\mathrm{LM}_t = \Delta\mathrm{Tor}$, then

for upper limits hit: $\beta_1 > \beta_2 \& \beta_1 > 0$;

for lower limits hit: $\beta_3 > \beta_4 \& \beta_3 > 0$;

If trading interference hypothesis hold and $\Delta\mathrm{LM}_t = \Delta\mathrm{OdImb}, \Delta\mathrm{LogQslp}$ or $\Delta\mathrm{Rsp}$, then

for upper limits hit: $\beta_1 < \beta_2 \& \beta_1 < 0$;

for lower limits hit: $\beta_3 < \beta_4 \& \beta_3 < 0$;

Before estimating the model (4.1), Engle's ARCH and LBQ tests are conducted to examine heteroscedasticity. 20-lags and log(T)-lags for Engle's and the LBQ test are adopted[29]. The null hypothesis is that there is no ARCH effect. The shares reject the null hypothesis of Engle's ARCH and LBQ tests simultaneously are reported in Appendix 4.1 and summarised below.

SSE	Δ*Tor*	Δ*LogQslp*	Δ*OdImb*	Δ*Rsp*	SZSE	Δ*Tor*	Δ*LogQslp*	Δ*OdImb*	Δ*Rsp*
A	5	16	0	7	A	3	11	1	4
B	2	1	0	3	B	2	4	1	0

There is only a small number of shares that show ARCH effect in all liquidity measures. To be specific, only 5 (3) A-shares and 2 (2) B-shares present ARCH effect in Δ*Tor* on the SSE (SZSE). Moreover, no shares have ARCH effect in Δ*OdImb* on the SSE and only 1 A and B-share have ARCH effect in Δ*OdImb* on the SZSE. The number of shares, however, show ARCH effect in Δ*LogQslp* are 16 (11) and 1 (4) for SSE (SZSE) A and B, respectively.

[29] A 20-lags LBQ^2 test is adopted by Box, Jenkins and Reinsel (2008). A Log(T)-lags LBQ^2 test is suggested by Tsay (2010). T is the number of observations.

A similar result is also found in ΔRsp. The tests of ARCH effect in these four liquidity measures suggest that the ARCH effect is not very prevalent in liquidity, even if it is very obvious in return. In addition, the ARCH effect also depends on the choice of liquidity measures.

To construct an ARMA model, it is normal practice to check the stationarity of the time-series data. Thus, the Augmented Dickey-Fuller(ADF) and Kwiatkowski–Phillips–Schmidt–Shin (KPSS) tests are applied. The null hypothesis of the ADF test is that the time-series data has a unit root, while the null hypothesis of the KPSS test is that the time-series is trend stationary. Brooks (2008) suggests that a valid stationarity test should reject (do not reject) the null hypothesis of the ADF test, but do not reject (reject) the null hypothesis of the KPSS test. From the results in Table 4.13, the two tests reveal the time series data for $\Delta Tor,\ \Delta OdImb$ and $\Delta LogQslp$ are stationary time-series for almost all stocks on both exchanges. For ΔRsp, however, the test reveals some conflicting results. For example, there are 16, 1, 21 and 4 shares that indicate the rejection of a unit root, whereas the trend stationary are not rejected in all shares. Therefore, the final time-series used in the ARMA model are $\Delta Tor,\ \Delta OdImb,\ \Delta LogQslp$. Taking the second difference of *Rsp* may transform the data into a trend stationary data, however, it is not the required form to test the trading interference hypothesis. As discussed above, the hypothesis emphasises the first difference of liquidity measure[30].

[Insert Table 4.13 about here]

Finally, the AIC and BIC statistics are used to decide the appropriate lag structure of the ARMA model. These are defined respectively as

$$AIC=-2l+2k,\ BIC=-2l+k\log(T),$$

[30] The dependent variable in equation (4.1) is $\Delta LM_t = LM_t - LM_{t-1}$, and the second difference $^2\Delta LM_t = LM_t - LM_{t-1} - (LM_{t-1} - LM_{t-2}) = LM_t - 2LM_{t-1} - LM_{t-2}$, which is not in the required form to test the trading interference hypothesis.

where T denotes the sample size and k the number of parameters in the model and where l is the value of log-likelihood function evaluated at its estimated maximum. For ARMA models, the number of lags under the BIC will always be equal to or smaller than the number of lags for the AIC. This is due to the penalization of the additional parameters through the function of sample size in the BIC. In this chapter, ARMA models with maximum orders p, $q = 5$ are considered. This reflects the paper of Bali, Peng, Shen and Tang (2014) who model liquidity using an ARMA(*1*,*1*) model and show that increasing the number of lags make little difference in the results. It also reflects the fact that there is a heavy computational burden; for example, p, $q = 5$ leads to a 36-by-36 Fisher information matrix[31]. Based on the AIC and BIC, the ARMA(p,q) model with the highest adjusted R-squared is selected. The results of this exercise are shown in Table 4.14. As the table shows, the lag selection is different for different stocks and liquidity measures.

[Insert Table 4.14 about here]

4.5 Empirical Results

Tables 4.15 summarises the empirical results using the model at equation (4.1). The table has two panels. Panel A tabulates results for each AB-shares in each market. Panel A has two vertical sections, which report results at the 5% and 1% level of significance, respectively. Panel B of the table reports the cross-sectional means of the adjusted R-squareds from each model and their standard errors. As can be seen from Panel A of Table 4.15, 26 (2) A-shares and 9 (3) B-shares on the SSE show that price limits interfere with trading significantly at the 1% level when price hits the upper (lower) limit and the liquidity is measured by turnover ratio. A similar result has been found on the SZSE, for example, 21 (0) A-shares and 8 (2) B-shares for upper (lower) price-limit-hit. However, the number of significant shares decreases to 7 (0) A-shares and 2 (0) B-shares on the SSE for the upper (lower) price-limit-hits when the liquidity measure is log quote slope. Moreover, price

[31] 2664 (37*2*36 for SSE) and 2304 (32*2*36 for SZSE) sets of estimations are required to decide the lag structure.

limits almost do not affect trading if the liquidity proxy is order imbalance, for instance, there are 0 (1) A-share and 3 (2) B-shares for the upper (lower) price-limit-hits on the SSE. For log quote slope and order imbalance, the findings of SZSE are similar to the SSE.

[Insert Table 4.15 about here]

The trading interference emerged after upper price-limits-hits, especially for A-shares. There are 26 (9) and 21 (8) A (B)-shares showing higher turnover ratio for upper limits on the SSE and SZSE at the 1% the significance level, respectively. By contrast with upper limits, only 2 (3) and 0 (2) A (B)-shares showing higher turnover ratio after lower limits. As suggested by the trading interference hypothesis, stocks which hit price limits on day *t* will experience an intense trading on day *t+1*. The large trading volume is only found after upper price-limit-hits, which implies that investors believe the continuation of upward price movement. The continuation of downward price movement, however, is not likely to happen. Overall, the results of SSE A-shares are similar to those of SZSE A-shares. The same conclusion applies to their B-shares. There are, however, some differences between A- and B-shares on both exchanges, especially for the measure of turnover ratio

The goodness of fit for liquidity modelling is discussed in Section 4.2.4. Low R-squared values are typically found in modelling liquidity for individual stocks. Using the model at Equation (4.1), the adjusted R-squared values reported in Panel B of Table 4.15 imply a better model fit. The adjusted R-squared values, 0.177, 0.312 and 0.484 for the turnover ratio, log quote slope and order imbalance respectively are larger than those reported in liquidity modeling and show small standard deviations 0.035, 0.041 and 0.026, respectively. Similar to Section 4.2.4, however, the choice of liquidity measures indeed has an influence on the adjusted R-squared values. The detailed results are shown in the Appendix 4.3. In order to show the estimation which is not affected by the ARCH effect, an ARMA(p,q) model without GARCH error has also been implemented. The results which are reported in Appendix 4.4 are almost identical to the results that are reported in Table 4.15.

To sum up, the trading interference hypothesis is not rejected when the turnover ratio is applied, which is consistent with the outcome of a previous study on the Tokyo stock exchange (Kim and Rhee, 1997) and on the Istanbul stock exchange (Bildik and Gülay, 2006). This, however, is not the case for the study on the Shanghai and Shenzhen stock exchanges (Chen, Rui and Wang, 2005). Chen, Rui and Wang use the daily data of stock during 1996-2003 and do not find that price limits interfere with trading activity. As mentioned in Chapter 1, there was significant change in the Chinese stock market after 2003. In order to align with international capital markets, Chinese A-shares can be traded by qualified foreign institutional investors since July 2003. Thus, it we might expect to see similar findings with other markets in this study.

In addition to turnover ratio, when the order-imbalance is applied there is no evidence to suggest that the order-imbalance is increased after price limits. This finding is consistent with Chan, Kim and Rhee (2005) and Seasholes and Wu (2007). They find that there is a reverse of order-imbalance after price limits. This study, however, suggests that the change of order-imbalance is not statistically different from zero at the 1% level after price limits. As discussed before, turnover ratio and order-imbalance are widely used in the literature, However, these are single dimension liquidity measure. By contrast, log quote slop is a multi-dimensional liquidity measure. According to the results, A-shares show similar findings with turnover ratio that a total of 14 A-shares do not reject trading interference hypothesis, whereas B-shares show similar findings with order-imbalance that only 4 B-shares do not reject the hypothesis. The results suggest that the effect of price limits on liquidity is inconclusive due to the choice of liquidity measures.

4.6 Conclusion

Liquidity plays a vital role in an efficient market. In a liquid market, the conversion of an asset into cash can be incurred without considerable financial and opportunity costs. To investigate whether the price limits have a positive effect or negative effect on liquidity, Kim and Rhee (1997) test the trading interference hypothesis. If the hypothesis holds, stocks which hit price limits on day *t* will experience more trading on day *t+1*.The rationale behind this hypothesis is that investors cannot acquire their desired shares at a relatively higher price or dispose their unwanted shares at a relatively lower price on the day of price limits hits. Then, the investors can only obtain or sell those shares on the subsequent day. In other words, price limits reduce liquidity on the day of price limits hits.

From the existing literature, popular liquidity measures are trading volume, turnover ratio, various spreads (quoted spread, effective spread and so on) and the price impact measure (Amihud measure, log quote slope and others). From Table 4.1 and 4.2, there are 23 liquidity measures. It is important to note that not all of those 23 measures meet the requirement of the study. The purpose of this study is to test the trading interference hypothesis that emphasises the change of liquidity from the day of price limits hits to the following day. Therefore, 13 liquidity measures are available to test the hypothesis, which are summarised in Table 4.7. After some discussion and conducting tests, three liquidity measures, turnover ratio, log quote slope and order imbalance are selected to study the effect of price limits on liquidity.

The overall results on the SSE and SZSE do not show significant difference. When the liquidity measure is turnover ratio, the results suggest that the trading interference hypothesis is not rejected, which is consistent with the findings of previous studies on the Tokyo stock exchange (Kim and Rhee, 1997) and Istanbul stock exchange (Bildik and Gülay ,2006). To be specific, A-shares on both exchanges indicate that trading is interfered with after upper price-limit-hits, whereas there is almost no effect on turnover ratio after lower price-limit-hits. A similar result is found for B-shares, but the number of shares that support the trading interference hypothesis decreases to a certain degree. On the other hand, price limits have a weak effect if the measure is the log quote slope. Moreover, there is almost no effect if the measure is the order imbalance. In conclusion, price limits interfere with trading in terms of the average results.

Table 4.1 Liquidity Measures 1968-2001

This table summarises liquidity measures published between 1968 and 2001. Those published after 2001 are in Table 2. There are 23 liquidity measures in total.

Author	Market and Data Type	Measure	
Demsets (1968)	New York Stock Exchange (NYSE) Intraday data	Bid-Ask spread	(1)
Roll (1984)	NYSE and American Stock Exchange (AMEX) Daily data	Effective spread: $2\sqrt{-Cov(R_t, R_{t-1})}$, R: return	(2)
Cooper *et al*. (1985)	NYSE, AMEX and NASDAQ Daily data	$Amivest = \frac{\sum_{t=1}^{T} P_t V_t}{\sum_{t=1}^{T} \|R_t\|}$, P: Daily closing price; V: Daily share volume; R: Daily return	(3)
Huang and Stoll (1996)	NYSE and NASDAQ Intraday data	Realised spread: $\begin{cases} 2(\ln(P_t) - \ln(P_{t+m})) \text{ when the trade at time 't' is a buy} \\ 2(\ln(P_{t+m}) - \ln(P_t)) \text{ when the trade at time 't' is a sell} \end{cases}$, m: m-minutes interval	(4)
Datar *et al*. (1998)	NYSE Monthly data	$Tor = \frac{Volume}{Share\ outstanding} = \frac{PV}{MV}$ Tor: Turnover ratio; PV: Turnover; MV: Market value	(5)
Lesmond *et al*.(1999) **Lesmond (2005)**	NYSE and AMEX Daily data, and 31 Emerging markets Daily data	1. LOT: $R_{jt}^* = \beta_j R_{mt} + \epsilon_{jt}$, where $R_{jt} = R_{jt}^* - \alpha_{1j}$ if $R_{jt}^* < \alpha_{1j}$ and $\alpha_{1j} < 0$ $R_{jt} = 0$ if $\alpha_{1j} \leq R_{jt}^* \leq \alpha_{2j}$ $R_{jt} = R_{jt}^* - \alpha_{2j}$ if $R_{jt}^* > \alpha_{2j}$ and $\alpha_{2j} > 0$ R_{jt}^*: Unobservable true returns for firm j on day t; R_{mt}: Market return; R_{jt}: Stock return; α_{1j}: sell-side cost; α_{2j}: buy-side cost; $\alpha_{2j} - \alpha_{1j}$: transaction cost 2. Zero-returns: %Zero-returns = (Number of days with zero returns)/T, T: the number of trading days	(6) (7)
Chordia *et al*.(2000)	NYSE Intraday data	1. Quoted spread: $P_A - P_B$ 2. Proportional quoted spread: $(P_A - P_B)/P_M$ 3. Depth: $\frac{1}{2}(Q_A + Q_B)$ 4. Effective spread: $2\|P_t - P_M\|$ 5. Proportional effective spread: $2\|P_t - P_M\|/P_t$ P_A: Best ask price; P_B: Best bid price; P_M: Middle point of ask and bid price; P_t: Trade price; Q_A: Size of ask price; Q_B: Size of bid price	(8) (9) (10) (11) (12)
Chordia *et al*.(2001)	NYSE Intraday data	Similar to Chordia *et al*.(2000), and Composite liquidity: $\frac{(P_A - P_B)/P_M}{(Q_A P_A + Q_B P_B)/2}$	(13)
Hasbrouck and Seppi (2001)	NYSE, AMEX and NASDAQ Intraday data	1. Quoted spread: $P_A - P_B$ 2. Log spread: $\ln(P_A/P_B)$ 3. Log size: $\ln(Q_A) + \ln(Q_B)$ 4. Quote slope: $\frac{P_A - P_B}{\ln(Q_A) + \ln(Q_B)}$ 5. Log quote slope: $\frac{\ln(P_A/P_B)}{\ln(Q_A) + \ln(Q_B)}$	 (14) (15) (16) (17)

Table 4.2 Liquidity Measures 2002-2012

This table summarises liquidity measures published between 2002 and 2012. Those published before 2001 are in Table 1. There are 23 liquidity measures in total.

Amihud (2002)	NYSE Daily data	$\boldsymbol{ILLIQ_{iy}} = \frac{1}{D_{iy}}\sum_{i=1}^{D_{iy}}\frac{\lvert R_{iyd}\rvert}{P_{iyd}V_{iyd}}$, $\boldsymbol{ILLIQ_{iy}}$: Illiquidity for stock *i* in year *y*; $\boldsymbol{D_{iy}}$: Number of days for stock *i* in year *y*, $\boldsymbol{R_{iyd}}$: Return on stock *i* on day *d* of year *y*; $\boldsymbol{P_{iyd}V_{iyd}}$: Daily trading turnover	(18)
Chordia *et al.*(2002)	NYSE Intraday data	OdImb= abs(NoB-NoS) NoB:Number of Buy Orders ; NoS: Number of Sell Orders ; abs: absolute value	(19)
Pástor and Stambaugh (2003)	NYSE and AMEX Daily data	Gamma measure: $r^e_{i,d+1,t} = \theta_{i,t} + \emptyset_{i,t} r_{i,d,t} + \gamma_{i,t}\text{sign}(r^e_{i,d,t})v_{i,d,t} + \epsilon_{i,d+1,t}$, *d* = 1, …, *D*, $r_{i,d,t}$: Return on stock *i* on day *d* in month *t;* $r^e_{i,d,t}$=$r_{i,d,t} - r_{i,m,t}$; $r_{i,m,t}$: Market return; $v_{i,d,t}$: The dollar volume $\gamma_{i,t}$: gamma measure (price impact)	(20)
Bekaert *et al.*(2007)	19 Emerging markets Monthly data	Modified Zero-returns (Price Pressure): $PP_{i,t} = \frac{\sum_{j=1}^{N} w_j \delta_{j,t}\lvert r_{j,t,\tau}\rvert}{\sum_{j=1}^{N} w_j\lvert r_{j,t,\tau}\rvert}$, $\delta_{j,t} = \begin{cases}1, & \text{if } r_{j,t} \text{ or } r_{j,t-1} = 0\\ 0, & otherwise\end{cases}$, $r_{j,t,\tau} = \begin{cases} r_{j,t} & \text{if } r_{j,t-1} \neq 0 \\ \prod_{k=0}^{\tau-1}(1 + r_{i,t-k}) - 1 & \text{if } r_{j,t-1} = 0\end{cases}$, $PP_{i,t}$, price pressure for country *i* in month *t*; w_j: the weight of the stock *j* in the index; $\delta_{j,t}$: non-trade days or zero-return days; $r_{i,t-k}$: Volume-weighted market return; τ: The number of non-trade days; $r_{j,t,\tau}$: Expected return if the stock has have been traded	(21)
Hasbrouck (2009)	NYSE Daily data	Gibbs sampler estimate of Roll's model	(22)
Corwin and Schultz (2012)	NYSE, AMEX and NASDAQ Daily data	HL spread: $HL = \frac{2(e^{\alpha}-1)}{1+e^{\alpha}}$, $\alpha = \frac{\sqrt{2\beta}-\sqrt{\beta}}{3-2\sqrt{2}} - \sqrt{\frac{\gamma}{3-2\sqrt{2}}}$, $\beta = [\ln\left(\frac{H_t}{H_t}\right)]^2 + [\ln\left(\frac{H_{t+1}}{H_{t+1}}\right)]^2$, $\gamma = [\ln\left(\frac{H_{t,t+1}}{H_{t,t+1}}\right)]^2$ *H*: High price; *L:* Low price, $H_{t,t+1}$: High price of a two consecutive days $L_{t,t+1}$: Low price of a two consecutive days	(23)

Table 4.3 Summary Statistics

Panel A summarises the morning and afternoon trading volumes measured as the number of shares. Panel B compares trading volumes in the morning and afternoon sessions. Panel C reports the number of AB-shares in each sector of Chinese industry and their trading volumes.

Panel A - Trading volume (Unit: thousands of shares)

	AM				PM			
	Min	Max	Mean	Std	Min	Max	Mean	Std
SSE A	383	14,873	3,308	2,887	357	13,011	3,000	2,497
SSE B	134	1,307	469	301	130	1,319	455	276

	AM				PM			
	Min	Max	Mean	Std	Min	Max	Mean	Std
SZSE A	503	45,487	5,898	9,803	429	38,625	5,252	8,332
SZSE B	70	2,400	583	636	87	2,457	604	644

Panel B - Trading volume AM vs PM[1]

	A-share	B-share
SSE	10%	3%
SZSE	12%	-4%

Panel C - Industry

Exchanges	SSE	SZSE
Information technology service[2]	1 (A: 739,543 ; B: 291,935)[3]	0
Leasing and commerce service	0	1 (A: 9,014,148 ; B: 1,501,020)
Manufacturing	23 (A: 4,465,550 ; B: 862,469)	20 (A: 5,500,932 ; B: 814,607)
Real estate	5 (A: 4,124,103 ; B: 809,217)	4 (A: 7,994,597 ; B: 633,138)
Transportation	3 (A: 8,757,639 ; B: 647,999)	2 (A: 3,271,268 ; B: 536,143)
Utilities	1 (A: 6,092,406 ; B: 783,200)	2 (A: 5,033,281 ; B: 1,201,875)
Wholesale and retail	4 (A: 4,332,076 ; B: 486,298)	3 (A: 2,426,464 ; B: 260, 576)

1.(Mean AM- Mean PM)/Mean PM

2.Full name: Information transmission、software and information technology service

3.The number of companies and median trading volumes are reported for A and B-shares; thus, there is 1 company with AB-share in the information technology services sector on the SSE, but none on the SZSE. A-shares and B-shares' trading volumes on the SSE are 739,543 and 291,935, respectively.

Table 4.4 Standard t-test for Trading Volume

This table reports the results of t-tests to examine the difference between morning and afternoon trading volumes. The difference between A and B-shares' trading volumes is also tested. The significant number of shares are displayed.

SSE											
AM versus PM - A						AM versus PM - B					
AM<PM		AM≠PM		AM>PM		AM<PM		AM≠PM		AM>PM	
1%	5%	1%	5%	1%	5%	1%	5%	1%	5%	1%	5%
0	0	5	11	7	13	1	1	0	2	0	7
A versus B - AM						A versus B - PM					
A<B		A≠B		A>B		A<B		A≠B		A>B	
1%	5%	1%	5%	1%	5%	1%	5%	1%	5%	1%	5%
0	0	37	37	37	37	0	0	37	37	37	37

SZSE											
AM versus PM - A						AM versus PM - B					
AM<PM		AM≠PM		AM>PM		AM<PM		AM≠PM		AM>PM	
1%	5%	1%	5%	1%	5%	1%	5%	1%	5%	1%	5%
0	0	6	10	7	12	7	12	6	9	0	0
A versus B - AM						A versus B - PM					
A<B		A≠B		A>B		A<B		A≠B		A>B	
1%	5%	1%	5%	1%	5%	1%	5%	1%	5%	1%	5%
0	0	32	32	32	32	0	0	32	32	32	32

Table 4.5 Correlation Matrix – Trading Volume

This table displays the correlation among morning trading volumes (TvAm), afternoon trading morning (TvPm) and market value (MV). The number of shares that show statistically significant positive or negative correlations are shown in round parentheses under the respective correlations.

SSE A	TvAm	TvPm	MV	SSE B	TvAm	TvPm	MV
TvAm	1	0.6930	0.3822	TvAm	1	0.6733	0.3908
		(37+ ; 0-)	(33+ ; 4-)			(37+ ; 0-)	(35+ ; 0-)
TvPm		1	0.3916	TvPm		1	0.3825
			(32+ ; 4-)				(34+ ; 0-)
MV			1	MV			1

SZSE A	TvAm	TvPm	MV	SZSE B	TvAm	TvPm	MV
TvAm	1	0.6923	0.2892	TvAm	1	0.6892	0.2811
		(32+ ; 0-)	(25+ ; 2-)			(32+ ; 0-)	(26+ ; 2-)
TvPm		1	0.3013	TvPm		1	0.2870
			(24+ ; 2-)				(26+ ; 2-)
MV			1	MV			1

Note: 1% significance level at two-tails.

Table 4.6 The Choices of Liquidity Measure

The trading interference hypothesis focuses on the change of liquidity between days. This table lists the measures and whether or not they can be applied to the study – the trading interference hypothesis.

Author	Liquidity measured on a daily basis ?	Reason
Amihud (2002)	No	If the return is 0, then the change of measure is not meaningful.
Bekaert *et al.* (2007)	No	This is a marketwide liquidity measure rather than an individual stock liquidity measure.
Chordia *et al.* (2000)	Yes	The daily spreads can be computed using intraday data.
Chordia *et al.* (2001)	Yes	The daily spreads can be computed using intraday data.
Chordia *et al* (2002)	Yes	The imbalance can be computed using intraday data.
Corwin and Schultz (2012)	No	It measures a 2-day period spread.
Datar *et al.* (1998)	Yes	The turnover ratio can be computed from daily volume and share outstanding data.
Cooper *et al. (*1985)	No	Same reasons as Amihud's measures.
Hasbrouck and Seppo (2001)	Yes	The daily spread can be computed using intraday data.
Hasbrouck (2009)	No	It measures liquidity over a time period, for example, yearly
Huang and Stoll (1996)	Yes	The spreads can be computed using intraday data
Lesmond *et al.* (1999,RFS)	No	It measures liquidity over a time period, for example proportion of zero returns in a year.
Pastor and Stambaugh (2003)	No	According to the model, $\gamma_{i,t}$measures the monthly liquidity.
Roll (1984)	No	According to the method, it measures liquidity over a time period, for example yearly effective spread.

Table 4.7 Feasible Liquidity Measure

This table summarises those 13 feasible liquidity measures in Table 4.1 and 4.2.

1.Turnover ratio(Tor):	$\frac{V_T}{DSO_T}$
2.Quoted spread (QS):	$P_A - P_B$
3.Proportional quoted spread(PQS):	$(P_A - P_B)/P_M$
4.Depth(Dep):	$\frac{1}{2}(Q_A + Q_B)$
5.Effective spread (ESP):	$2\|P_t - P_M\|$
6.Proportional spread (PESP):	$2\|P_t - P_M\|/P_t$
7.Composite liquidity (CmpLiq):	$\frac{(P_A - P_B)/P_M}{(Q_A P_A + Q_B P_B)/2}$
8.Log spread (LogQS):	$\ln(P_A/P_B)$
9.LogSize:	$\ln(Q_A) + \ln(Q_B)$
10.Quote slope (Qslp):	$\frac{P_A - P_B}{\ln(Q_A) + \ln(Q_B)}$
11.Log quote slope (LogQslp):	$\frac{\ln(P_A/P_B)}{\ln(Q_A) + \ln(Q_B)}$
12.Order imbalance (OdImb):	$\|B_T - S_T\|$
13.Realised spread (Rsp):	$\begin{Bmatrix} 2(\ln(P_t) - \ln(P_{t+m}))\ when\ the\ t\_th\ trade\ is\ a\ buy \\ 2(\ln(P_{t+m}) - \ln(P_t))\ when\ the\ t\_th\ trade\ is\ a\ sell \end{Bmatrix}$, *m*-mins interval

where V_T is daily volume. DSO_T is daily share outstanding. P_A is ask price. P_B is bid price. P_M is middle point of ask and bid price. P_t is trade price at time *t*. Q_A is the size of ask price. Q_B is the size of bid price. B_T is the number of buy orders on day *T*. S_T is the number of sell orders on day *T*. Note: 2-13 are volume weighted average figures, for example

$$QS = \sum_{i=1}^{n} \frac{V_t}{V_T} * QS_t ,$$

where V_t is volume at time *t*. V_T is volume on day *T*. QS_t is the quoted spread at time *t*.

Table 4.8 Correlation Matrix – Liquidity Measures in the SSE A

This table displays the correlation among those 13 liquidity measures on the SSE A-shares. The number of shares that show statistically significant positive or negative correlations are shown in round parentheses under the respective correlations.

SSE A	Tor	QS	PQS	Dep	ESP	PESP	CmpLiq	LogQS	LogSize	Qslp	LogQslp	OdImb	Rsp
Tor	1.00	0.05	-0.28	0.38	-0.07	-0.14	-0.31	-0.28	0.30	0.00	-0.30	0.27	0.39
	(37+ ; 0-)	(12+ ; 5-)	(0+ ; 36-)	(35+ ; 0-)	(2+ ; 14-)	(0+ ; 27-)	(0+ ; 35-)	(0+ ; 36-)	(32+ ; 1-)	(7+ ; 10-)	(0+ ; 35-)	(30+ ; 0-)	(37+ ; 0-)
QS		1.00	0.70	-0.12	0.65	0.59	0.53	0.70	-0.37	0.98	0.73	0.00	0.28
		(37+ ; 0-)	(36+ ; 0-)	(2+ ; 22-)	(37+ ; 0-)	(37+ ; 0-)	(37+ ; 0-)	(36+ ; 0-)	(0+ ; 36-)	(37+ ; 0-)	(37+ ; 0-)	(2+ ; 3-)	(36+ ; 0-)
PQS			1.00	-0.10	0.56	0.66	0.72	1.00	-0.21	0.68	0.99	-0.11	0.13
			(37+ ; 0-)	(5+ ; 24-)	(37+ ; 0-)	(37+ ; 0-)	(37+ ; 0-)	(37+ ; 0-)	(5+ ; 28-)	(36+ ; 0-)	(37+ ; 0-)	(1+ ; 24-)	(22+ ; 1-)
Dep				1.00	-0.05	-0.05	-0.35	-0.10	0.74	-0.22	-0.19	0.15	0.08
				(37+ ; 0-)	(3+ ; 12-)	(3+ ; 12-)	(0+ ; 36-)	(5+ ; 24-)	(37+ ; 0-)	(1+ ; 31-)	(1+ ; 29-)	(26+ ; 0-)	(16+ ; 1-)
ESP					1.00	0.96	0.37	0.56	-0.17	0.62	0.57	0.13	0.09
					(37+ ; 0-)	(37+ ; 0-)	(37+ ; 0-)	(37+ ; 0-)	(0+ ; 29-)	(37+ ; 0-)	(37+ ; 0-)	(22+ ; 0-)	(16+ ; 0-)
PESP						1.00	0.44	0.66	-0.14	0.56	0.65	0.10	0.07
						(37+ ; 0-)	(37+ ; 0-)	(37+ ; 0-)	(0+ ; 24-)	(37+ ; 0-)	(37+ ; 0-)	(15+ ; 1-)	(13+ ; 1-)
CmpLiq							1.00	0.72	-0.56	0.60	0.80	-0.12	0.10
							(37+ ; 0-)	(37+ ; 0-)	(0+ ; 37-)	(37+ ; 0-)	(37+ ; 0-)	(1+ ; 23-)	(20+ ; 0-)
LogQS								1.00	-0.21	0.68	0.99	-0.11	0.13
								(37+ ; 0-)	(5+ ; 28-)	(36+ ; 0-)	(37+ ; 0-)	(1+ ; 24-)	(22+ ; 1-)
LogSize									1.00	-0.49	-0.33	0.09	-0.04
									(37+ ; 0-)	(0+ ; 37-)	(0+ ; 31-)	(14+ ; 0-)	(1+ ; 6-)
Qslp										1.00	0.73	-0.01	0.27
										(37+ ; 0-)	(37+ ; 0-)	(2+ ; 3-)	(35+ ; 0-)
LogQslp											1.00	-0.12	0.14
											(37+ ; 0-)	(1+ ; 25-)	(22+ ; 0-)
OdImb												1.00	0.09
												(37+ ; 0-)	(13+ ; 1-)
Rsp													1.00
													(37+ ; 0-)

Note: 1% significance level

Table 4.9 Correlation Matrix – Liquidity Measures in the SSE B

This table displays the correlation among those 13 liquidity measures on the SSE B-shares. The number of shares that show statistically significant positive or negative correlations are shown in round parentheses under the respective correlations.

SSE B	Tor	QS	PQS	Dep	ESP	PESP	CmpLiq	LogQS	LogSize	Qslp	LogQslp	OdImb	Rsp
Tor	1.00	-0.11	-0.26	0.37	-0.12	-0.16	-0.26	-0.26	0.34	-0.14	-0.28	0.52	0.18
	(37+ ; 0-)	(0+ ; 21-)	(0+ ; 35-)	(36+ ; 0-)	(0+ ; 22-)	(0+ ; 32-)	(0+ ; 36-)	(0+ ; 35-)	(36+ ; 0-)	(0+ ; 26-)	(0+ ; 36-)	(37+ ; 0-)	(28+ ; 0-)
QS		1.00	0.88	-0.26	0.72	0.69	0.56	0.88	-0.35	0.99	0.88	-0.06	0.18
		(37+ ; 0-)	(37+ ; 0-)	(0+ ; 34-)	(37+ ; 0-)	(37+ ; 0-)	(37+ ; 0-)	(37+ ; 0-)	(0+ ; 35-)	(37+ ; 0-)	(37+ ; 0-)	(0+ ; 8-)	(33+ ; 0-)
PQS			1.00	-0.27	0.67	0.73	0.70	1.00	-0.35	0.87	0.99	-0.14	0.17
			(37+ ; 0-)	(0+ ; 31-)	(37+ ; 0-)	(37+ ; 0-)	(37+ ; 0-)	(37+ ; 0-)	(0+ ; 35-)	(37+ ; 0-)	(37+ ; 0-)	(0+ ; 30-)	(29+ ; 0-)
Dep				1.00	-0.14	-0.15	-0.41	-0.27	0.79	-0.33	-0.34	0.19	0.00
				(37+ ; 0-)	(1+ ; 29-)	(0+ ; 28-)	(0+ ; 37-)	(0+ ; 31-)	(37+ ; 0-)	(0+ ; 35-)	(0+ ; 35-)	(32+ ; 0-)	(1+ ; 2-)
ESP					1.00	0.97	0.39	0.67	-0.19	0.70	0.65	0.08	0.03
					(37+ ; 0-)	(37+ ; 0-)	(36+ ; 0-)	(37+ ; 0-)	(0+ ; 33-)	(37+ ; 0-)	(37+ ; 0-)	(16+ ; 0-)	(9+ ; 2-)
PESP						1.00	0.45	0.73	-0.19	0.67	0.71	0.04	0.03
						(37+ ; 0-)	(36+ ; 0-)	(37+ ; 0-)	(0+ ; 31-)	(37+ ; 0-)	(37+ ; 0-)	(4+ ; 1-)	(8+ ; 2-)
CmpLiq							1.00	0.70	-0.61	0.64	0.77	-0.14	0.12
							(37+ ; 0-)	(37+ ; 0-)	(0+ ; 37-)	(37+ ; 0-)	(37+ ; 0-)	(0+ ; 32-)	(21+ ; 0-)
LogQS								1.00	-0.35	0.87	0.99	-0.14	0.17
								(37+ ; 0-)	(0+ ; 35-)	(37+ ; 0-)	(37+ ; 0-)	(0+ ; 30-)	(29+ ; 0-)
LogSize									1.00	-0.46	-0.45	0.17	-0.06
									(37+ ; 0-)	(0+ ; 37-)	(0+ ; 37-)	(31+ ; 0-)	(0+ ; 10-)
Qslp										1.00	0.89	-0.07	0.18
										(37+ ; 0-)	(37+ ; 0-)	(0+ ; 11-)	(33+ ; 0-)
LogQslp											1.00	-0.15	0.17
											(37+ ; 0-)	(0+ ; 31-)	(30+ ; 0-)
OdImb												1.00	0.07
												(37+ ; 0-)	(9+ ; 0-)
Rsp													1.00
													(37+ ; 0-)

Note: 1% significance level

Table 4.10 Correlation Matrix – Liquidity Measures in the SZSE A

This table displays the correlation among those 13 liquidity measures on the SZSE A-shares. The number of shares that show statistically significant positive or negative correlations are shown in round parentheses under the respective correlations.

SZSE A	Tor	QS	PQS	Dep	ESP	PESP	CmpLiq	LogQS	LogSize	Qslp	LogQslp	OdImb	Rsp
Tor	1.00	0.00	-0.33	0.35	-0.09	-0.16	-0.31	-0.33	0.29	-0.04	-0.36	0.24	0.36
	(32+ ; 0-)	(10+ ; 10-)	(0+ ; 31-)	(27+ ; 1-)	(0+ ; 16-)	(0+ ; 28-)	(0+ ; 32-)	(0+ ; 31-)	(26+ ; 2-)	(7+ ; 14-)	(0+ ; 32-)	(26+ ; 1-)	(32+ ; 0-)
QS		1.00	0.56	-0.24	0.59	0.50	0.50	0.56	-0.46	0.97	0.61	-0.01	0.29
		(32+ ; 0-)	(27+ ; 1-)	(1+ ; 25-)	(32+ ; 0-)	(31+ ; 0-)	(32+ ; 0-)	(27+ ; 1-)	(0+ ; 32-)	(32+ ; 0-)	(29+ ; 1-)	(1+ ; 4-)	(31+ ; 0-)
PQS			1.00	-0.08	0.48	0.60	0.66	1.00	-0.12	0.51	0.98	-0.08	0.14
			(32+ ; 0-)	(5+ ; 15-)	(32+ ; 0-)	(32+ ; 0-)	(31+ ; 1-)	(32+ ; 0-)	(7+ ; 21-)	(26+ ; 4-)	(32+ ; 0-)	(2+ ; 16-)	(19+ ; 2-)
Dep				1.00	-0.07	-0.04	-0.37	-0.08	0.79	-0.35	-0.18	0.12	0.01
				(32+ ; 0-)	(2+ ; 13-)	(2+ ; 11-)	(0+ ; 32-)	(5+ ; 15-)	(32+ ; 0-)	(0+ ; 31-)	(3+ ; 25-)	(20+ ; 0-)	(5+ ; 2-)
ESP					1.00	0.95	0.33	0.48	-0.17	0.55	0.49	0.16	0.07
					(32+ ; 0-)	(32+ ; 0-)	(30+ ; 0-)	(32+ ; 0-)	(0+ ; 25-)	(31+ ; 0-)	(32+ ; 0-)	(20+ ; 0-)	(10+ ; 1-)
PESP						1.00	0.40	0.60	-0.11	0.46	0.60	0.14	0.05
						(32+ ; 0-)	(30+ ; 0-)	(32+ ; 0-)	(3+ ; 20-)	(29+ ; 1-)	(32+ ; 0-)	(17+ ; 0-)	(8+ ; 3-)
CmpLiq							1.00	0.66	-0.53	0.58	0.75	-0.10	0.14
							(32+ ; 0-)	(31+ ; 1-)	(0+ ; 32-)	(32+ ; 0-)	(31+ ; 0-)	(1+ ; 19-)	(21+ ; 0-)
LogQS								1.00	-0.12	0.51	0.98	-0.08	0.14
								(32+ ; 0-)	(7+ ; 21-)	(26+ ; 4-)	(32+ ; 0-)	(2+ ; 16-)	(19+ ; 2-)
LogSize									1.00	-0.60	-0.26	0.09	-0.10
									(32+ ; 0-)	(0+ ; 32-)	(5+ ; 25-)	(15+ ; 1-)	(0+ ; 16-)
Qslp										1.00	0.59	-0.03	0.29
										(32+ ; 0-)	(27+ ; 1-)	(1+ ; 4-)	(31+ ; 0-)
LogQslp											1.00	-0.09	0.16
											(32+ ; 0-)	(2+ ; 18-)	(19+ ; 1-)
OdImb												1.00	0.06
												(32+ ; 0-)	(10+ ; 1-)
Rsp													1.00
													(32+ ; 0-)

Note: 1% significance level

Table 4.11 Correlation Matrix – Liquidity Measures in the SZSE B

This table displays the correlation among those 13 liquidity measures on the SZSE B-shares. The number of shares that show statistically significant positive or negative correlations are shown in round parentheses under the respective correlations.

SZSE B	Tor	QS	PQS	Dep	ESP	PESP	CmpLiq	LogQS	LogSize	Qslp	LogQslp	OdImb	Rsp
Tor	1.00	-0.14	-0.28	0.41	-0.13	-0.17	-0.28	-0.28	0.40	-0.18	-0.31	0.49	0.11
	(32+ ; 0-)	(1+ ; 19-)	(0+ ; 29-)	(32+ ; 0-)	(0+ ; 21-)	(0+ ; 27-)	(0+ ; 32-)	(0+ ; 29-)	(31+ ; 0-)	(1+ ; 26-)	(0+ ; 31-)	(32+ ; 0-)	(18+ ; 0-)
QS		1.00	0.79	-0.28	0.72	0.66	0.53	0.79	-0.41	0.98	0.80	-0.09	0.20
		(32+ ; 0-)	(31+ ; 0-)	(0+ ; 32-)	(32+ ; 0-)	(32+ ; 0-)	(32+ ; 0-)	(31+ ; 0-)	(0+ ; 32-)	(32+ ; 0-)	(32+ ; 0-)	(0+ ; 14-)	(27+ ; 0-)
PQS			1.00	-0.22	0.63	0.72	0.68	1.00	-0.30	0.77	0.99	-0.18	0.19
			(32+ ; 0-)	(1+ ; 26-)	(32+ ; 0-)	(32+ ; 0-)	(32+ ; 0-)	(32+ ; 0-)	(1+ ; 28-)	(31+ ; 0-)	(32+ ; 0-)	(0+ ; 26-)	(27+ ; 0-)
Dep				1.00	-0.13	-0.12	-0.37	-0.22	0.79	-0.37	-0.29	0.20	-0.04
				(32+ ; 0-)	(0+ ; 24-)	(1+ ; 20-)	(0+ ; 32-)	(1+ ; 26-)	(32+ ; 0-)	(0+ ; 32-)	(1+ ; 31-)	(28+ ; 0-)	(0+ ; 5-)
ESP					1.00	0.96	0.37	0.63	-0.20	0.69	0.62	0.05	0.08
					(32+ ; 0-)	(32+ ; 0-)	(32+ ; 0-)	(32+ ; 0-)	(0+ ; 30-)	(32+ ; 0-)	(32+ ; 0-)	(9+ ; 2-)	(11+ ; 0-)
PESP						1.00	0.44	0.72	-0.18	0.64	0.71	0.01	0.08
						(32+ ; 0-)	(32+ ; 0-)	(32+ ; 0-)	(1+ ; 25-)	(32+ ; 0-)	(32+ ; 0-)	(4+ ; 3-)	(11+ ; 0-)
CmpLiq							1.00	0.68	-0.56	0.61	0.76	-0.16	0.17
							(32+ ; 0-)	(32+ ; 0-)	(0+ ; 32-)	(32+ ; 0-)	(32+ ; 0-)	(0+ ; 27-)	(24+ ; 0-)
LogQS								1.00	-0.30	0.77	0.99	-0.18	0.19
								(32+ ; 0-)	(1+ ; 28-)	(31+ ; 0-)	(32+ ; 0-)	(0+ ; 26-)	(27+ ; 0-)
LogSize									1.00	-0.53	-0.41	0.19	-0.08
									(32+ ; 0-)	(0+ ; 32-)	(1+ ; 31-)	(28+ ; 0-)	(0+ ; 10-)
Qslp										1.00	0.81	-0.11	0.20
										(32+ ; 0-)	(31+ ; 0-)	(0+ ; 19-)	(26+ ; 0-)
LogQslp											1.00	-0.19	0.20
											(32+ ; 0-)	(0+ ; 28-)	(28+ ; 0-)
OdImb												1.00	0.03
												(32+ ; 0-)	(1+ ; 0-)
Rsp													1.00
													(32+ ; 0-)

Note: 1% significance level

Table 4.12 Summary of the Liquidity Measures

Panels A and B reports the summary statistics for the liquidity measures on the SSE and SZSE. Panel C compares the cross-sectional mean of the measures. The measures shown in the table are turnover ratio (*Tor*), order imbalance (*OdImb*), log quote slope (*LogQslp*) and realised spread *(Rsp)*. Individual liquidity measures are shown in Appendix 4.2.

Panel A	SSE A				SSE B			
	Tor	*OdImb*	*LogQslp*	*Rsp*	*Tor*	*OdImb*	*LogQslp*	*Rsp*
Min	0.00224	55.76871	0.00008	0.00131	0.00153	16.51880	0.00012	0.00119
Median	0.01130	86.28342	0.00012	0.00181	0.00411	28.52812	0.00022	0.00152
Mean	0.01447	93.49923	0.00012	0.00177	0.00415	29.32954	0.00022	0.00155
Max	0.03966	216.9110	0.00016	0.00228	0.01135	51.24599	0.00037	0.00206
SD	0.00977	32.83833	0.00002	0.00027	0.00179	8.60282	0.00006	0.00021

Panel B	SZSE A				SZSE B			
	Tor	*OdImb*	*LogQslp*	*Rsp*	*Tor*	*OdImb*	*LogQslp*	*Rsp*
Min	0.00326	56.95824	0.00006	0.00118	0.00062	10.46025	0.00011	0.00114
Median	0.01298	97.23403	0.00011	0.00164	0.00420	26.82254	0.00025	0.00158
Mean	0.01635	117.0701	0.00011	0.00166	0.00437	32.72970	0.00027	0.00162
Max	0.05832	304.5960	0.00015	0.00210	0.01105	110.5949	0.00055	0.00291
SD	0.01183	57.96982	0.00003	0.00021	0.00210	21.11316	0.00011	0.00039

Panel C	SSE				SZSE			
	Tor	*OdImb*	*LogQslp*	*Rsp*	*Tor*	*OdImb*	*LogQslp*	*Rsp*
A	0.01447	93.49923	0.00012	0.00177	0.01635	117.07016	0.00011	0.00166
	∨	∨	∧	∨	∨	∨	∧	=
B	0.00415	29.32954	0.00022	0.00155	0.00437	32.72970	0.00027	0.00162

Note: ∨, ∧ or = suggests that the measure of A-shares is greater, smaller or equal to the measure of B-shares at the 1 % significance level.

Table 4.13 Stationary Test

This table shows the results of stationary test for the time-series data: the change of turnover ratio *(ΔTor*), log quote slope *(ΔLogQslp*), order imbalance *(ΔOdImb*) and realized spread *(ΔRsp*). All the results are based on 1% significance level. The explanation of the table entries is as follows. For example, 37 means 37 shares reject the null hypothesis of ADF, while 0 means no share rejects null hypothesis of KPSS.

Stationary test				
ADF(KPSS)	ΔTor	ΔLogQslp	ΔOdImb	ΔRsp
SSE A	37 (0)	37 (0)	37 (0)	16 (0)
SSE B	37 (0)	37 (0)	36 (0)	1 (0)
SZSE A	32 (0)	32 (0)	32 (0)	21 (0)
SZSE B	32 (0)	32 (0)	31 (0)	4 (0)

ADF, H_0 = the time series data have a unit root; KPSS, H_0 = the time series data are trend stationary

Table 4.14 Lags selection: AIC and BIC

The table has four panels. Panel (i) shows the ARMA lag structure selection for each of the three liquidity measures for SSE AB-shares. Panel (ii) gives a summary of the selection selection criteria used. For example, in panel (i) there are 4 SSE A-shares with a (1,1) lag structure and in panel (ii) the lag structure is selected using the AIC for 31 stocks out of 37. Panels (iii) and (iv) report the corresponding results for SZSE.

(i) SSE - Lag structure selection

ΔTor

SSE A	q=0	q=1	q=2	q=3	q=4	q=5	SSE B	q=0	q=1	q=2	q=3	q=4	q=5
p=0	0	1	0	0	0	0	p=0	0	1	0	0	0	0
p=1	0	4	0	0	0	0	p=1	0	2	2	1	0	0
p=2	0	1	0	2	0	1	p=2	0	1	0	2	2	2
p=3	0	0	0	3	3	0	p=3	0	2	0	2	1	2
p=4	0	0	1	4	1	3	p=4	0	0	0	1	2	4
p=5	0	2	2	6	0	3	p=5	0	0	0	0	1	9

ΔLogQslp

SSE A	q=0	q=1	q=2	q=3	q=4	q=5	SSE B	q=0	q=1	q=2	q=3	q=4	q=5
p=0	0	8	0	0	0	0	p=0	0	16	0	0	0	0
p=1	0	3	5	1	0	0	p=1	0	2	0	0	0	0
p=2	0	0	0	1	0	0	p=2	0	1	0	0	1	0
p=3	0	1	0	0	3	2	p=3	0	0	0	3	2	1
p=4	0	1	0	0	3	3	p=4	0	0	0	1	3	3
p=5	0	0	1	0	0	5	p=5	0	0	0	0	2	2

ΔOdImb

SSE A	q=0	q=1	q=2	q=3	q=4	q=5	SSE B	q=0	q=1	q=2	q=3	q=4	q=5
p=0	0	12	0	0	0	0	p=0	0	18	0	0	1	0
p=1	0	0	1	1	0	0	p=1	0	0	2	0	0	0
p=2	0	0	1	2	0	0	p=2	0	0	1	4	0	0
p=3	0	0	1	0	3	3	p=3	0	0	0	0	3	0
p=4	0	0	0	1	2	6	p=4	0	0	0	1	1	2
p=5	0	0	0	0	2	2	p=5	0	0	0	0	0	4

(ii) SSE - Summary of results from AIC and BIC

	ΔTor				*ΔLogQslp*				*ΔOdImb*		
	AIC	BIC	AIC=BIC		AIC	BIC	AIC=BIC		AIC	BIC	AIC=BIC
SSE A	31	7	1	SSE A	21	19	3	SSE A	24	17	4
SSE B	34	5	2	SSE B	19	19	1	SSE B	19	20	2

(i) SZSE - Lag structure selection

ΔTor

SZSE A	q=0	q=1	q=2	q=3	q=4	q=5	SZSE B	q=0	q=1	q=2	q=3	q=4	q=5
p=0	0	0	1	0	0	0	p=0	0	2	0	0	0	0
p=1	0	2	3	1	0	0	p=1	0	6	2	0	0	0
p=2	0	0	0	0	1	0	p=2	0	0	0	0	0	1
p=3	0	0	0	1	3	1	p=3	0	0	0	4	1	5
p=4	0	0	0	1	1	4	p=4	0	0	1	0	0	2
P=5	0	0	1	2	2	8	p=5	0	1	2	1	1	3

ΔLogQslp

SZSE A	q=0	q=1	q=2	q=3	q=4	q=5	SZSE B	q=0	q=1	q=2	q=3	q=4	q=5
p=0	0	8	1	0	0	0	p=0	0	14	1	0	0	0
p=1	0	1	3	1	0	0	p=1	0	4	0	0	0	0
p=2	0	0	1	1	1	1	p=2	0	0	0	0	2	1
p=3	0	0	1	0	4	2	p=3	0	0	0	0	2	1
p=4	0	0	0	0	0	1	p=4	0	0	0	0	1	4
P=5	0	0	1	0	2	3	p=5	0	0	0	0	0	2

ΔOdImb

SZSE A	q=0	q=1	q=2	q=3	q=4	q=5	SZSE B	q=0	q=1	q=2	q=3	q=4	q=5
p=0	0	12	0	0	0	0	p=0	0	12	0	0	0	0
p=1	0	0	5	0	0	0	p=1	0	0	1	1	2	0
p=2	0	0	2	6	0	0	p=2	0	1	0	0	0	0
p=3	0	0	0	0	3	1	p=3	0	0	0	0	2	3
p=4	0	0	0	1	0	0	p=4	0	0	0	0	1	5
p=5	0	0	0	0	0	2	p=5	0	0	0	1	1	2

(ii) SZSE - Summary of results from AIC and BIC

	ΔTor				*ΔLogQslp*				*ΔOdImb*		
	AIC	BIC	AIC=BIC		AIC	BIC	AIC=BIC		AIC	BIC	AIC=BIC
SZSE A	27	6	1	SZSE A	19	13	0	SZSE A	13	24	5
SZSE B	23	11	2	SZSE B	15	19	2	SZSE B	19	15	2

Table 4.15 Empirical Results

Panel A reports the number of shares that support the trading interference hypothesis in terms of three liquidity measures: the turnover ratio (*Tor*), log quote slope (*LogQslp*) and order imbalance (*OdImb*). Panel B reveals the cross-sectional mean of adjusted R-squared values. Standard deviation is also reported in round parentheses.

Panel A		5%			1%	
SSE A	*Tor*	*LogQslp*	*OdImb*	*Tor*	*LogQslp*	*OdImb*
Up	25	10	0	26	7	0
Lower	3	0	3	2	0	1
		5%			1%	
SSE B	*Tor*	*LogQslp*	*OdImb*	*Tor*	*LogQslp*	*OdImb*
Up	10	3	3	9	2	3
Lower	3	1	4	3	0	2
		5%			1%	
SZSE A	*Tor*	*LogQslp*	*OdImb*	*Tor*	*LogQslp*	*OdImb*
Up	25	8	0	21	6	0
Lower	0	1	2	0	1	0
		5%			1%	
SZSE B	*Tor*	*LogQslp*	*OdImb*	*Tor*	*LogQslp*	*OdImb*
Up	8	3	0	8	1	0
Lower	2	2	0	2	1	1

Panel B			
SSE	*Tor*	*LogQslp*	*OdImb*
A	0.177 (0.035)	0.312 (0.041)	0.484 (0.026)
B	0.263 (0.023)	0.358 (0.028)	0.484 (0.020)
SZSE	*Tor*	*LogQslp*	*OdImb*
A	0.198 (0.037)	0.300 (0.054)	0.478 (0.023)
B	0.271 (0.039)	0.356 (0.030)	0.478 (0.032)

Appendix 4.1 ARCH Test

This table presents the shares showing ARCH effects in terms of four liquidity measures at the 1% significance level. As showed before, each row represents a stock. For simplicity, row identifier rather than stock code is reported.

	SSE A	SSE B	SZSE A	SZSE B
ΔTor	4 14 23 24 36	17 26	14 15 31	8 18
$\Delta LogQslp$	3 6 11 13 15 17 19 20 21 22 26 27 31 33 34 36	33	2 5 8 9 11 13 19 21 23 31 32	4 8 21 26
$\Delta OdImb$	none	none	7	2
ΔRsp	3 5 11 14 15 28 36	24 25 29	11 13 14 20	none

Appendix 4.2 Summary of Liquidity Measures

SSE								SZSE							
A				B				A				B			
Tor	OdImb	LogQslp	Rsp	Tor	OdImb	LogQslp	Rsp	Tor	OdImb	LogQslp	Rsp	Tor	OdImb	LogQslp	Rsp
0.03966	91.67900	0.00014	0.00226	0.00629	31.53992	0.00025	0.00168	0.00716	304.59603	0.00006	0.00150	0.00215	110.59491	0.00014	0.00153
0.00400	76.47236	0.00015	0.00137	0.00290	21.43266	0.00023	0.00139	0.05832	113.08558	0.00009	0.00191	0.01105	29.80340	0.00024	0.00166
0.00824	174.22609	0.00009	0.00183	0.00316	27.38513	0.00026	0.00180	0.02269	170.42329	0.00006	0.00183	0.00646	74.20126	0.00011	0.00135
0.03482	84.22563	0.00010	0.00195	0.00529	19.75717	0.00026	0.00153	0.02226	116.87402	0.00013	0.00162	0.00394	27.67838	0.00024	0.00142
0.02410	104.06787	0.00008	0.00162	0.00448	51.24599	0.00013	0.00154	0.02252	74.26237	0.00014	0.00198	0.00758	13.85590	0.00050	0.00221
0.00490	159.68325	0.00010	0.00133	0.00303	48.27816	0.00015	0.00140	0.04460	66.76028	0.00013	0.00172	0.00488	18.98892	0.00033	0.00163
0.00962	86.30713	0.00013	0.00156	0.00250	22.10100	0.00026	0.00169	0.00438	72.07443	0.00010	0.00130	0.00110	19.20098	0.00027	0.00122
0.01095	91.30554	0.00011	0.00162	0.00294	27.37243	0.00022	0.00152	0.01011	56.95824	0.00015	0.00190	0.00572	10.46025	0.00055	0.00182
0.00787	85.72256	0.00015	0.00206	0.00470	28.52812	0.00023	0.00177	0.02262	94.90703	0.00012	0.00166	0.00564	24.08364	0.00028	0.00177
0.00973	94.25224	0.00009	0.00135	0.00222	33.29803	0.00016	0.00125	0.00804	90.88385	0.00014	0.00180	0.00418	19.02505	0.00033	0.00170
0.01841	111.89047	0.00009	0.00152	0.00534	46.45421	0.00012	0.00123	0.01001	67.96581	0.00015	0.00150	0.00193	15.64639	0.00035	0.00190
0.02633	68.43792	0.00012	0.00203	0.00602	18.97616	0.00033	0.00174	0.01108	168.80366	0.00006	0.00160	0.00141	70.45801	0.00011	0.00129
0.03233	216.91102	0.00012	0.00228	0.01135	38.13493	0.00021	0.00174	0.01130	69.74418	0.00014	0.00190	0.00520	14.94327	0.00045	0.00174
0.01130	103.32514	0.00009	0.00208	0.00485	40.59390	0.00017	0.00144	0.02751	95.61525	0.00011	0.00167	0.00553	30.35309	0.00023	0.00162
0.01236	74.57248	0.00012	0.00182	0.00411	30.87156	0.00017	0.00137	0.02303	83.19839	0.00012	0.00210	0.00373	20.12177	0.00040	0.00262
0.00382	77.74459	0.00011	0.00179	0.00425	31.52454	0.00018	0.00144	0.01644	106.89347	0.00011	0.00168	0.00604	28.21349	0.00024	0.00161
0.00633	75.35809	0.00011	0.00159	0.00207	21.50136	0.00021	0.00146	0.01268	77.62610	0.00014	0.00200	0.00663	23.19535	0.00038	0.00291
0.01351	65.75345	0.00013	0.00173	0.00237	21.73663	0.00024	0.00146	0.01513	128.11489	0.00010	0.00158	0.00182	21.07290	0.00037	0.00174
0.00224	93.96814	0.00008	0.00131	0.00153	34.09268	0.00014	0.00121	0.00954	66.24607	0.00015	0.00135	0.00249	21.41461	0.00022	0.00120
0.02350	75.14079	0.00013	0.00220	0.00414	22.65277	0.00028	0.00184	0.01768	140.79052	0.00009	0.00118	0.00387	40.80495	0.00014	0.00116
0.03505	70.51883	0.00014	0.00191	0.00361	18.67447	0.00027	0.00152	0.02108	103.07667	0.00010	0.00147	0.00501	22.65261	0.00026	0.00158
0.01895	66.14952	0.00014	0.00187	0.00552	16.51880	0.00037	0.00206	0.02849	98.85281	0.00011	0.00168	0.00401	21.11942	0.00028	0.00156
0.01811	79.95571	0.00012	0.00187	0.00437	30.21811	0.00022	0.00148	0.00326	148.33896	0.00011	0.00143	0.00283	35.35003	0.00017	0.00114
0.00824	86.28342	0.00016	0.00144	0.00181	23.53666	0.00024	0.00143	0.02138	121.51771	0.00007	0.00161	0.00414	32.53917	0.00017	0.00133
0.01112	95.45509	0.00011	0.00175	0.00423	30.36323	0.00020	0.00148	0.00357	130.51518	0.00012	0.00148	0.00062	28.17184	0.00026	0.00137
0.01887	112.03823	0.00008	0.00190	0.00228	33.71719	0.00022	0.00170	0.01504	94.30642	0.00010	0.00163	0.00422	24.46654	0.00024	0.00147
0.01306	72.59630	0.00013	0.00194	0.00571	21.17714	0.00027	0.00151	0.01273	94.14944	0.00010	0.00157	0.00460	25.96671	0.00025	0.00158
0.00509	70.90930	0.00013	0.00198	0.00329	23.08052	0.00029	0.00196	0.01135	164.82602	0.00009	0.00173	0.00493	36.65105	0.00021	0.00161
0.01417	86.44804	0.00011	0.00167	0.00535	22.67854	0.00026	0.00158	0.00370	94.66074	0.00014	0.00171	0.00365	37.05769	0.00026	0.00158
0.00809	129.48141	0.00009	0.00152	0.00284	34.33724	0.00019	0.00142	0.00906	184.81321	0.00009	0.00160	0.00632	67.15957	0.00014	0.00138
0.00748	114.98553	0.00008	0.00136	0.00386	34.60727	0.00014	0.00119	0.01323	284.03656	0.00014	0.00182	0.00383	49.49221	0.00030	0.00184
0.00357	57.76666	0.00016	0.00177	0.00342	29.17734	0.00020	0.00134	0.00334	61.32787	0.00014	0.00153	0.00438	32.60716	0.00019	0.00117
0.01107	66.37843	0.00015	0.00181	0.00401	26.69797	0.00023	0.00165								
0.01607	103.52523	0.00008	0.00193	0.00614	37.28380	0.00020	0.00174								
0.00535	55.76871	0.00016	0.00148	0.00295	22.33860	0.00020	0.00121								
0.01167	69.99683	0.00012	0.00184	0.00536	23.69714	0.00027	0.00170								
0.02558	110.17047	0.00009	0.00202	0.00508	39.61164	0.00018	0.00170								

Appendix 4.3a Detailed Estimation Results

The first column [0,1] means that the estimation model is ARMA (0,1). The '[]' in the estimation results mean that the respective variables are not part of the model estimation.

SSE A	ARMA											Price Limits Dummy				GARCH			
ΔTor	[p,q]											Up	Up9	Lo	Lo9	C	P	Q	R-squared
[0,1]	-0.02	-0.43***	[]	[]	[]	[]	[]	[]	[]	[]	[]	0.61***	0.16	-0.49	-0.66	[]	[]	[]	0.18
[4,5]	0.00	-0.71	-0.41	0.52***	0.16	0.31	0.01	-0.86***	-0.13	0.02	[]	0.36***	-0.05	0.19	[]	[]	[]	[]	0.15
[2,5]	-0.01	-0.77***	-0.35	0.36	-0.10	-0.39***	-0.20**	-0.07	[]	[]	[]	0.48***	-0.05	0.14	-0.30	[]	[]	[]	0.18
[2,3]	-0.01	0.26***	-0.28**	-0.65***	0.34**	-0.16***	[]	[]	[]	[]	[]	0.76***	0.36***	0.00	-0.45	0.05**	0.61***	0.12***	0.20
[1,1]	0.00	0.37***	-0.77***	[]	[]	[]	[]	[]	[]	[]	[]	0.11	0.10	-0.54	-0.22	[]	[]	[]	0.16
[5,1]	0.00	0.46***	0.06	0.14***	0.07	0.09**	-0.98***	[]	[]	[]	[]	1.32***	-1.33***	[]	[]	[]	[]	[]	0.24
[5,1]	-0.02	-0.53***	-0.37***	-0.23***	-0.21***	-0.07	0.04	[]	[]	[]	[]	1.24***	0.31	-0.34	-0.01	[]	[]	[]	0.25
[5,3]	-0.01	-0.14	-0.34	0.12	-0.05	-0.07	-0.18	0.11	-0.29	[]	[]	0.57***	0.04	-0.20	0.06	[]	[]	[]	0.12
[1,1]	0.00	0.55***	-1.00***	[]	[]	[]	[]	[]	[]	[]	[]	0.53	-0.01	-0.20	-0.25	[]	[]	[]	0.18
[5,3]	-0.01	0.13	-0.58***	0.25***	-0.05	0.05	-0.51***	0.42***	-0.46***	[]	[]	1.09***	1.23	[]	[]	[]	[]	[]	0.18
[1,1]	0.00	0.39***	-0.87***	[]	[]	[]	[]	[]	[]	[]	[]	0.20***	-0.22	-0.04	-0.08	[]	[]	[]	0.20
[3,4]	-0.02	-0.53***	-0.20	-0.12	0.15	-0.09	-0.07	-0.07	[]	[]	[]	0.71***	0.01	0.01	-0.23	[]	[]	[]	0.17
[5,5]	-0.01	-0.14	-0.60***	0.04	-0.52***	0.17	-0.17	0.47***	-0.31***	0.47***	-0.38***	0.40***	0.34***	0.38***	-0.33	[]	[]	[]	0.13
[4,3]	-0.01	-0.64***	-0.11	0.37***	0.02	0.31***	-0.24***	-0.61***	[]	[]	[]	0.31***	0.14	-0.07	-0.96**	0.16***	0.00	0.19***	0.13
[5,3]	-0.01	0.80***	-0.71***	0.20***	-0.09	0.00	-1.23***	0.98***	-0.45***	[]	[]	0.61***	0.36***	-0.22	-0.54	[]	[]	[]	0.22
[5,3]	-0.01	-0.10	-0.11	0.29**	-0.02	-0.02	-0.23	-0.10	-0.44**	[]	[]	0.43***	-0.09	-0.32	-0.11	[]	[]	[]	0.13
[4,3]	0.00	0.63***	-0.69***	0.27***	0.13***	-1.09***	0.84***	-0.60***	[]	[]	[]	0.93***	-0.07	[]	[]	[]	[]	[]	0.21
[5,5]	-0.01	0.07	-0.50***	0.02	-0.60***	0.56***	-0.38***	0.41***	-0.20***	0.49***	-0.83***	0.22***	0.32***	0.14**	[]	[]	[]	[]	0.12
[2,3]	0.00	-0.56**	-0.07	0.10	-0.31	-0.07	[]	[]	[]	[]	[]	0.82***	0.03	[]	[]	[]	[]	[]	0.18
[4,4]	-0.02**	-0.33**	-0.16	0.00	0.09	0.00	-0.07	-0.22	-0.26**	[]	[]	0.56***	0.24***	-0.35	-0.12	[]	[]	[]	0.16
[5,2]	-0.02**	0.27	-0.03	-0.13***	0.03	-0.06	-0.55***	-0.04	[]	[]	[]	0.56***	0.62***	-0.15	-0.62	[]	[]	[]	0.15
[4,3]	-0.02	-0.34**	-0.05	0.10	-0.04	-0.04	-0.21	-0.24	[]	[]	[]	0.86***	-0.16	0.01	-0.28	[]	[]	[]	0.17
[3,3]	0.00	0.69**	-0.44	0.26**	-1.09***	0.47	-0.30	[]	[]	[]	[]	0.19***	-0.06	-0.24**	-0.33**	0.18***	0.00	0.21***	0.18
[4,3]	-0.01	-0.13	-0.37***	0.22**	0.00	-0.30***	0.22**	-0.54***	[]	[]	[]	0.37***	1.09***	0.52	0.73	0.13***	0.08	0.31***	0.18
[5,3]	-0.01	-0.26	-0.24	-0.22**	-0.17***	-0.06	-0.19	0.06	-0.01	[]	[]	0.76***	0.01	-0.36	-0.29	[]	[]	[]	0.20
[5,5]	-0.01	-1.21***	-1.07***	-0.71***	-0.21**	0.37***	0.85***	0.47***	-0.04	-0.46***	-0.78***	0.10**	0.17***	0.37***	-0.23	[]	[]	[]	0.19
[3,3]	-0.01	0.19	-0.59***	0.30***	-0.63***	0.54***	-0.61***	[]	[]	[]	[]	0.54***	-0.09	-0.15	-0.57	[]	[]	[]	0.20
[4,2]	0.00	-0.15	0.39***	0.06	0.06	-0.24	-0.63***	[]	[]	[]	[]	0.04	-0.18	-0.50**	-0.06	[]	[]	[]	0.17
[5,2]	0.00	0.06	0.29	0.02	0.02	0.10**	-0.38	-0.47**	[]	[]	[]	0.26***	-0.19	-0.34**	-0.07	[]	[]	[]	0.13
[2,1]	0.00	0.39***	0.16***	-0.93***	[]	[]	[]	[]	[]	[]	[]	-0.01	0.04	[]	[]	[]	[]	[]	0.23
[1,1]	0.00	0.35***	-0.83***	[]	[]	[]	[]	[]	[]	[]	[]	0.26	-0.08	[]	[]	[]	[]	[]	0.20
[4,5]	-0.01**	-0.19	-0.21	-0.03	0.23	-0.23	-0.05	-0.18	-0.31**	-0.01	[]	0.94***	0.17	-0.43***	-1.01**	[]	[]	[]	0.21
[4,5]	0.00	0.10	0.15	-0.26	0.51***	-0.44	-0.25	0.22	-0.61***	0.14**	[]	0.06	-0.08	-0.17	-0.38**	[]	[]	[]	0.13
[3,4]	0.00	-0.39***	0.00	0.69***	-0.09	-0.26***	-0.79***	0.26***	[]	[]	[]	0.05	-0.08	0.03	-0.18	[]	[]	[]	0.20
[3,3]	-0.01	0.33***	-0.81***	0.30***	-0.68***	0.83***	-0.65***	[]	[]	[]	[]	0.47***	0.87**	-1.01***	0.18	[]	[]	[]	0.16
[3,4]	-0.01	-0.70***	-0.08	0.31***	0.43**	-0.32**	-0.58***	-0.06	[]	[]	[]	0.47***	[]	-0.68	-0.05	0.23***	0.00	0.06***	0.12
[5,3]	-0.01	0.30**	-0.48***	0.07	-0.01	-0.04	-0.80***	0.56***	-0.35***	[]	[]	0.59***	-0.26**	0.29	-0.31	[]	[]	[]	0.22

Appendix 4.3b Detailed Estimation Results

The first column [0,1] means that the estimation model is ARMA (0,1). The '[]' in the estimation results mean that the respective variables are not part of the model estimation.

SSE A	ARMA											Price Limits Dummy				GARCH			
ΔLogQslp	[p,q]											Up	Up9	Lo	Lo9	C	P	Q	R-squared
[1,1]	0.01***	0.27***	-1.00***	[]	[]	[]	[]	[]	[]	[]	[]	-0.06**	-0.12**	-0.03	-0.04	[]	[]	[]	0.37
[4,4]	0.00	-0.11	0.21	0.03	0.09	-0.63	-0.33	0.05	0.02	[]	[]	0.03	0.01	-0.13	[]	[]	[]	[]	0.36
[0,1]	0.00	-0.67***	[]	[]	[]	[]	[]	[]	[]	[]	[]	-0.11***	0.04	0.00	0.01	0.00***	0.80***	0.18***	0.31
[1,3]	0.00	0.82***	-1.43***	0.34***	0.09**	[]	[]	[]	[]	[]	[]	-0.01	-0.01	0.02	0.02	[]	[]	[]	0.28
[2,3]	0.00	-1.07***	-0.68***	0.33	-0.08	-0.44***	[]	[]	[]	[]	[]	0.18	0.01	0.23	-0.22	[]	[]	[]	0.36
[3,5]	0.00	-0.15	-0.22	0.68***	-0.45***	0.05	-0.85***	0.42***	0.00	[]	[]	-0.02	-0.07	[]	[]	0.00***	0.90***	0.07***	0.27
[4,5]	0.00***	-0.06	-0.20***	-0.22***	0.71***	-0.60***	0.11***	0.09***	-1.00***	0.47***	[]	-0.07***	0.00	0.01	0.10	[]	[]	[]	0.36
[4,5]	0.00	0.64***	-1.06***	0.28	-0.18	-1.27***	1.43***	-1.00**	0.39	-0.24	[]	-0.01	0.22***	-0.02	0.01	[]	[]	[]	0.29
[5,5]	0.01	-0.93**	-0.35	-0.15	0.09	0.29	0.59	-0.53	-0.46	-0.15	-0.45	-0.03	-0.15	0.10	-0.31	[]	[]	[]	0.33
[5,5]	0.00	-0.76***	0.10	-0.21	-0.29	0.06	0.10	-0.67**	0.19	0.12	-0.32	-0.08	0.58**	[]	[]	[]	[]	[]	0.32
[0,1]	0.00	-0.76***	[]	[]	[]	[]	[]	[]	[]	[]	[]	0.05	0.04	-0.04	0.26***	0.01***	0.76***	0.10***	0.36
[1,1]	0.00	0.26***	-0.83***	[]	[]	[]	[]	[]	[]	[]	[]	-0.05**	0.04	0.02	-0.15**	[]	[]	[]	0.27
[3,5]	0.00	-0.45	0.56**	0.07	-0.01	-0.92***	0.14	0.05	0.00	[]	[]	-0.04	-0.03	0.07**	-0.12**	0.00	0.88***	0.11***	0.21
[0,1]	0.00	-0.73***	[]	[]	[]	[]	[]	[]	[]	[]	[]	-0.06***	-0.10**	-0.01	0.19	[]	[]	[]	0.35
[5,5]	0.00	1.15**	-0.85	0.47	-0.24	0.12	-1.79***	1.50	-0.97	0.39	-0.10	-0.05**	0.01	0.09	-0.05	0.00	0.90***	0.06***	0.30
[1,2]	0.00***	0.67***	-1.35***	0.35***	[]	[]	[]	[]	[]	[]	[]	-0.03***	0.00	0.04**	0.05	[]	[]	[]	0.33
[1,2]	0.00***	0.79***	-1.37***	0.37***	[]	[]	[]	[]	[]	[]	[]	-0.04	-0.01	[]	[]	0.00**	0.84***	0.11***	0.26
[3,4]	0.00	-0.38***	-0.11	0.73***	-0.19**	-0.21***	-0.89***	0.41***	[]	[]	[]	0.02	-0.17***	0.03	[]	[]	[]	[]	0.29
[4,4]	0.00	-0.55***	-0.75***	-0.55***	0.16**	-0.01	0.32**	0.02	-0.64***	[]	[]	0.22***	0.05	[]	[]	0.02***	0.31	0.19***	0.26
[3,4]	0.00	-0.03	0.07	0.49***	-0.55***	-0.27**	-0.45***	0.33***	[]	[]	[]	-0.04**	-0.01	0.00	0.01	0.01***	0.72***	0.19***	0.27
[1,2]	0.00***	0.76***	-1.36***	0.38***	[]	[]	[]	[]	[]	[]	[]	-0.03**	-0.07**	0.02	0.17***	0.01***	0.71***	0.19***	0.27
[1,1]	0.00	0.15***	-0.81***	[]	[]	[]	[]	[]	[]	[]	[]	-0.06	-0.01	-0.03	-0.35	0.00	0.92***	0.06***	0.31
[0,1]	0.00	-0.77***	[]	[]	[]	[]	[]	[]	[]	[]	[]	-0.02	0.03	0.11**	0.08	[]	[]	[]	0.37
[4,1]	0.00**	0.29***	0.20***	0.02	0.22***	-0.98***	[]	[]	[]	[]	[]	-0.03***	-0.03	0.04	0.05**	[]	[]	[]	0.34
[4,4]	0.00***	-0.74***	0.42***	0.50***	0.08	0.06	-0.99***	-0.21	0.14	[]	[]	-0.07***	0.07	0.10***	0.03	[]	[]	[]	0.34
[0,1]	0.00	-0.68***	[]	[]	[]	[]	[]	[]	[]	[]	[]	-0.02	-0.06	-0.10	-0.09	0.00**	0.90***	0.07***	0.31
[1,2]	0.00	-0.28	-0.34	-0.25	[]	[]	[]	[]	[]	[]	[]	0.24***	0.30	0.15	-0.37	0.00***	0.88***	0.11***	0.27
[1,2]	0.00	0.77***	-1.46***	0.47***	[]	[]	[]	[]	[]	[]	[]	-0.02	0.01	0.02	-0.02	[]	[]	[]	0.32
[5,5]	0.00	0.25	-0.23	-0.11	0.54	-0.09	-0.87**	0.29	-0.07	-0.68	0.40	-0.09	0.00	-0.02	0.09	[]	[]	[]	0.28
[5,5]	0.00	-0.21***	-0.11***	-0.35***	-0.77***	0.14***	-0.47***	-0.21***	0.26***	0.56***	-0.78***	0.26***	-0.09	[]	[]	[]	[]	[]	0.36
[0,1]	0.00	-0.81***	[]	[]	[]	[]	[]	[]	[]	[]	[]	-0.18**	-0.07	[]	[]	0.00**	0.87***	0.10***	0.39
[5,2]	0.00***	-0.47***	0.29***	0.13***	0.04	0.06	-0.20	-0.74***	[]	[]	[]	-0.22***	-0.18	0.06	0.06	[]	[]	[]	0.32
[4,5]	0.01	-0.84***	-1.19***	-0.74***	-0.36***	0.18	0.62***	-0.16	-0.18	-0.44***	[]	0.00	-0.05	0.08	-0.28**	0.01**	0.76***	0.13***	0.33
[3,4]	0.00	-1.72***	-1.17***	-0.27	1.07***	-0.03	-0.71***	-0.32***	[]	[]	[]	-0.04	0.05	0.23***	0.02	0.00**	0.88***	0.07***	0.32
[0,1]	0.00	-0.68***	[]	[]	[]	[]	[]	[]	[]	[]	[]	-0.07	-0.09	0.26	0.30	[]	[]	[]	0.31
[3,1]	0.00**	0.38***	0.12***	0.17***	-0.95***	[]	[]	[]	[]	[]	[]	-0.05	[]	0.21	-0.14	0.02***	0.57***	0.15***	0.25
[0,1]	0.00	-0.69***	[]	[]	[]	[]	[]	[]	[]	[]	[]	-0.03	0.06***	-0.05	-0.07	[]	[]	[]	0.32

Appendix 4.3c Detailed Estimation Results

The first column [0,1] means that the estimation model is ARMA (0,1). The '[]' in the estimation results mean that the respective variables are not part of the model estimation.

SSE A	ARMA											Price Limits Dummy				GARCH			
ΔOdImb	[p,q]											Up	Up9	Lo	Lo9	C	P	Q	R-squared
[3,4]	-0.01***	0.35***	0.57	-0.24	-1.53***	-0.20	1.00	-0.27	[]	[]	[]	0.11***	0.02	0.04	0.25***	[]	[]	[]	0.55
[0,1]	0.00	-0.94***	[]	[]	[]	[]	[]	[]	[]	[]	[]	0.84	0.13	-1.57	[]	[]	[]	[]	0.47
[4,5]	0.00	0.59***	0.21	-0.63***	0.26	-1.55***	0.32	0.91***	-1.00***	0.32**	[]	0.04	-0.17**	-0.08	0.19***	[]	[]	[]	0.48
[5,4]	0.00	-1.10***	0.08	0.33***	0.11**	0.05	0.08	-1.21***	-0.19	0.32***	[]	0.06	0.57***	-0.30**	-0.12	[]	[]	[]	0.51
[3,5]	0.00	-0.37***	-0.21***	0.59***	-0.59***	-0.18***	-0.86***	0.64***	-0.01	[]	[]	-0.06	0.21	0.25	0.38	[]	[]	[]	0.50
[2,2]	0.00	-0.53**	0.11***	-0.35	-0.62***	[]	[]	[]	[]	[]	[]	1.98**	-2.34***	[]	[]	[]	[]	[]	0.44
[3,4]	-0.00***	-1.01***	0.35***	0.71***	0.04	-1.39***	-0.41***	0.75***	[]	[]	[]	0.05	0.10	-0.08	0.27	[]	[]	[]	0.51
[3,2]	0.00	0.48***	0.02	-0.02	-1.49***	0.49***	[]	[]	[]	[]	[]	-0.06	-0.05	-0.01	0.08	[]	[]	[]	0.50
[5,5]	-0.02	-0.37**	-0.46***	-0.40***	-0.74***	0.18	-0.54***	0.03	-0.03	0.54***	-1.00***	1.93**	-1.22***	0.11	-1.36	[]	[]	[]	0.52
[4,4]	0.00	-1.23***	-1.24***	-0.74***	-0.02	0.26***	0.05	-0.42***	-0.77***	[]	[]	0.17	-2.20***	[]	[]	[]	[]	[]	0.50
[2,3]	0.00	-0.30***	0.68***	-0.58***	-0.97***	0.55***	[]	[]	[]	[]	[]	-0.02	-0.05	0.10	-0.17	[]	[]	[]	0.44
[3,5]	0.00	-0.38***	-0.19**	0.54***	-0.53***	-0.19***	-0.76***	0.57***	-0.09**	[]	[]	0.07**	-0.10	0.16	-0.21	[]	[]	[]	0.47
[4,5]	0.00	-0.64***	-0.22***	0.27***	0.81***	-0.13**	-0.32***	-0.48***	-0.67***	0.62***	[]	-0.11	-0.41**	0.24	0.64**	[]	[]	[]	0.41
[4,5]	0.00	-0.11	0.73	-0.15	-0.19	-0.93**	-0.76	0.80**	0.08	-0.19	[]	0.03	0.01	-0.02	0.03	[]	[]	[]	0.53
[4,5]	-0.00***	0.46	-0.28	-0.03	0.11	-1.47***	0.81	-0.22	-0.26	0.14	[]	0.21***	-0.03	-0.02	0.33	[]	[]	[]	0.51
[3,5]	-0.00**	0.17	-0.42***	0.61***	-1.18***	0.59***	-1.00***	0.58***	0.01	[]	[]	0.07**	-0.08	0.04	-0.21	[]	[]	[]	0.50
[4,5]	0.00	0.20	-0.28	-0.27**	0.64***	-1.14***	0.47	0.00	-0.95***	0.63***	[]	0.47	0.10	[]	[]	[]	[]	[]	0.47
[2,3]	0.00	-0.28***	0.64***	-0.64***	-0.94***	0.58***	[]	[]	[]	[]	[]	0.05	-0.18	-0.20**	[]	[]	[]	[]	0.46
[3,4]	-0.00***	-0.44***	0.07	0.81***	-0.50***	-0.48***	-0.79***	0.77***	[]	[]	[]	0.18	0.10	[]	[]	[]	[]	[]	0.48
[1,2]	-0.00***	0.55***	-1.50***	0.50***	[]	[]	[]	[]	[]	[]	[]	0.02	0.02	0.03	0.12	[]	[]	[]	0.47
[0,1]	-0.01	-0.93***	[]	[]	[]	[]	[]	[]	[]	[]	[]	0.17	0.25	-0.03	-0.55	[]	[]	[]	0.46
[0,1]	-0.01**	-0.97***	[]	[]	[]	[]	[]	[]	[]	[]	[]	0.14	0.16	0.05	-0.03	[]	[]	[]	0.48
[4,5]	0.00	-0.45***	0.85***	0.24***	-0.59***	-0.50***	-1.31***	0.61***	0.82***	-0.62***	[]	0.09	-0.16	0.21**	-0.13	[]	[]	[]	0.51
[0,1]	0.00	-0.96***	[]	[]	[]	[]	[]	[]	[]	[]	[]	0.10	0.54	0.31	-0.39	[]	[]	[]	0.48
[1,3]	-0.00**	0.50***	-1.47***	0.47***	0.00	[]	[]	[]	[]	[]	[]	0.04	-0.03	-0.02	0.00	[]	[]	[]	0.48
[0,1]	0.00	-0.99***	[]	[]	[]	[]	[]	[]	[]	[]	[]	0.09**	0.11	0.04	-0.01	[]	[]	[]	0.49
[0,1]	0.00	-0.96***	[]	[]	[]	[]	[]	[]	[]	[]	[]	0.03	0.25	0.14	-0.34	[]	[]	[]	0.48
[0,1]	0.00	-0.98***	[]	[]	[]	[]	[]	[]	[]	[]	[]	0.00	0.17	-0.46***	-0.03	[]	[]	[]	0.49
[4,3]	0.00	0.00	0.71**	0.02	0.00	-0.94***	-0.68	0.63	[]	[]	[]	0.01	0.09	-0.03	0.01	[]	[]	[]	0.46
[0,1]	0.00***	-1.00***	[]	[]	[]	[]	[]	[]	[]	[]	[]	0.39**	-0.09	[]	[]	[]	[]	[]	0.50
[5,4]	0.00	-0.83***	-0.54	-0.37	0.13**	0.11***	-0.15	-0.21	-0.13	-0.46	[]	0.53	-0.22	[]	[]	[]	[]	[]	0.49
[4,4]	-0.01***	-0.34**	-0.45***	-0.57***	0.08**	-0.59***	0.15	0.07	-0.63***	[]	[]	0.64***	0.10	0.06	-1.25***	[]	[]	[]	0.46
[0,1]	0.00	-0.98***	[]	[]	[]	[]	[]	[]	[]	[]	[]	0.21**	0.20	-0.06	-0.25	[]	[]	[]	0.49
[0,1]	0.00	-0.98***	[]	[]	[]	[]	[]	[]	[]	[]	[]	0.01	0.06	0.06	-0.10	[]	[]	[]	0.49
[5,5]	-0.01	-1.40***	-0.69	0.24	0.05	-0.05	0.55***	-0.54**	-1.00***	0.03	0.05	0.46***	-0.40	0.11	0.77**	[]	[]	[]	0.45
[0,1]	0.00	-0.97***	[]	[]	[]	[]	[]	[]	[]	[]	[]	0.06	[]	0.02	-0.22	[]	[]	[]	0.48
[0,1]	0.00	-1.00***	[]	[]	[]	[]	[]	[]	[]	[]	[]	0.00	0.17**	-0.10	-0.12	[]	[]	[]	0.50

Appendix 4.3d Detailed Estimation Results

The first column [0,1] means that the estimation model is ARMA (0,1). The '[]' in the estimation results mean that the respective variables are not part of the model estimation.

SSE B ΔTor	ARMA [p,q]											Price Limits Dummy Up	Up9	Lo	Lo9	GARCH C	P	Q	R-squared
[0,1]	-0.01	-0.56***	[]	[]	[]	[]	[]	[]	[]	[]	[]	0.98**	[]	0.24	-0.29	[]	[]	[]	0.24
[4,3]	0.00	-0.88***	-0.43***	0.28***	0.03	0.36***	-0.19***	-0.75***	[]	[]	[]	0.96	0.72	0.06	[]	[]	[]	[]	0.24
[1,1]	0.00	0.51***	-0.94***	[]	[]	[]	[]	[]	[]	[]	[]	-0.05	-0.04	-0.18**	-0.36	[]	[]	[]	0.20
[5,5]	0.00	-1.00***	-0.45***	-0.70***	-0.38***	0.32***	0.55***	-0.18***	0.30***	-0.07	-0.71***	[]	[]	0.46***	-0.08	[]	[]	[]	0.23
[2,5]	0.00	0.08	-0.28	-0.67**	0.20	-0.16	-0.02	-0.10***	[]	[]	[]	0.45	0.70	0.06	-0.12	[]	[]	[]	0.26
[4,5]	0.00	-0.58	-0.80***	-0.58	-0.01	0.00	0.36	0.06	-0.49**	-0.11	[]	0.82	0.22	0.09	-0.20	[]	[]	[]	0.26
[3,1]	0.00	0.30***	0.00	0.10**	-0.86***	[]	[]	[]	[]	[]	[]	0.57***	0.23	-0.03	-0.28	[]	[]	[]	0.25
[1,3]	0.00	0.82***	-1.36***	0.26***	0.10**	[]	[]	[]	[]	[]	[]	0.06	[]	-0.02	-0.10***	[]	[]	[]	0.24
[4,5]	0.00	1.46**	-0.44	-0.49***	0.25	-2.00***	0.91	0.85**	-0.82	0.16	[]	0.46***	[]	[]	[]	[]	[]	[]	0.26
[2,1]	0.00	0.28***	0.09**	-0.90***	[]	[]	[]	[]	[]	[]	[]	-0.13	0.09	[]	[]	[]	[]	[]	0.28
[4,5]	0.00	-0.29	-0.29**	0.61***	0.46	-0.24	0.01	-0.84***	-0.21	0.28	[]	0.00	-0.17	-0.06	[]	[]	[]	[]	0.24
[5,5]	-0.01	-0.01	-0.13	-0.41***	-0.02	0.11	-0.55***	-0.02	0.35**	-0.36**	-0.14	1.87***	0.43	0.39	-0.74	[]	[]	[]	0.28
[3,4]	-0.01	-0.24	-0.36**	-0.04	-0.36	0.15	-0.23	-0.02	[]	[]	[]	1.20***	0.87***	0.79***	-0.44	[]	[]	[]	0.27
[5,5]	0.00	-0.82***	-0.27***	-0.88***	-0.53***	0.27***	0.30***	-0.29***	0.59***	-0.03	-0.82***	-0.15	0.90***	-0.01	0.08	[]	[]	[]	0.27
[4,5]	0.00	-0.05	-0.16**	-0.19**	0.79***	-0.51***	0.04	0.06	-0.95***	0.35***	[]	0.10	[]	-0.33***	-0.08	[]	[]	[]	0.26
[5,5]	0.00	-0.44	-0.38**	-0.59***	0.02	0.23***	-0.18	0.05	0.20	-0.42**	-0.32	0.54	0.39	0.60	-0.56**	[]	[]	[]	0.30
[5,4]	0.00	0.32	-0.89***	0.55**	-0.06	0.13***	-0.92***	0.90***	-1.00***	0.13	[]	1.34***	0.35	-0.15	-0.29	0.00	0.97***	0.03**	0.28
[3,3]	0.00	-0.94	-0.15	0.13	0.39	-0.51***	-0.43	[]	[]	[]	[]	0.45	0.37	0.69	[]	[]	[]	[]	0.25
[3,1]	0.00	0.40***	0.08	0.12***	-0.94***	[]	[]	[]	[]	[]	[]	0.73	-0.12	-0.10	[]	[]	[]	[]	0.23
[2,3]	0.00	-0.18***	0.71***	-0.39***	-0.92***	0.37***	[]	[]	[]	[]	[]	-0.14	-0.13	-0.27**	-0.28	[]	[]	[]	0.27
[4,4]	-0.01	-0.45***	-0.70***	-0.48***	0.25***	-0.14	0.36**	-0.08	-0.64***	[]	[]	0.52	[]	0.44***	-0.58***	[]	[]	[]	0.29
[1,2]	0.00	0.85***	-1.46***	0.46***	[]	[]	[]	[]	[]	[]	[]	-0.06	0.08	-0.14***	0.02	[]	[]	[]	0.28
[1,1]	0.00	0.25***	-0.86***	[]	[]	[]	[]	[]	[]	[]	[]	0.52***	-0.13	-0.04	-0.52**	[]	[]	[]	0.29
[5,5]	0.00	-0.97**	-1.11***	-0.62	-0.05	0.20	0.39	0.41	-0.18	-0.53	-0.43	0.76	[]	0.16	[]	[]	[]	[]	0.27
[2,5]	-0.01	-1.20***	-0.76***	0.62***	0.00	-0.65***	-0.17***	-0.09**	[]	[]	[]	[]	[]	0.55	0.54	[]	[]	[]	0.25
[3,5]	0.00	-0.60***	0.21**	0.75***	0.07	-0.71***	-0.81***	0.38***	0.14***	[]	[]	0.12	-0.05	-0.06	[]	0.21***	0.27	0.12***	0.25
[2,4]	-0.01	-0.68***	-0.39**	0.09	-0.09	-0.44***	-0.11**	[]	[]	[]	[]	1.70***	[]	0.16	[]	[]	[]	[]	0.27
[1,2]	0.00	0.71***	-1.36***	0.40***	[]	[]	[]	[]	[]	[]	[]	0.06	-0.01	-0.12	-0.08	[]	[]	[]	0.30
[5,5]	0.00	-0.55	0.24	0.83***	0.34	-0.19	0.00	-0.68**	-0.81***	0.08	0.44	-0.21	0.32	-0.13	-0.17	[]	[]	[]	0.24
[2,3]	0.00	0.28	0.50***	-0.91***	-0.49	0.40***	[]	[]	[]	[]	[]	0.14	-0.45**	-0.16***	[]	[]	[]	[]	0.30
[3,5]	0.00	-0.36***	0.28***	0.80***	-0.22	-0.67***	-0.72***	0.46***	0.15***	[]	[]	0.03	0.18	-0.13	[]	[]	[]	[]	0.27
[3,3]	0.00	-1.04***	-0.37***	0.32***	0.51***	-0.32***	-0.70***	[]	[]	[]	[]	0.70	-0.24	-0.18	[]	[]	[]	[]	0.25
[4,4]	-0.01	-0.44**	-0.58***	-0.33**	0.10	-0.15	0.15	-0.01	-0.47***	[]	[]	0.93	[]	0.39	-0.17	[]	[]	[]	0.27
[5,5]	0.00	0.29	-0.59**	0.26	0.36	0.07	-0.83***	0.57	-0.50	-0.44	0.27	[]	[]	-0.06	-0.09	[]	[]	[]	0.27
[2,4]	0.00	0.04	0.56**	-0.64	-0.67	0.32***	0.08	[]	[]	[]	[]	[]	[]	-0.03	-0.38	[]	[]	[]	0.27
[5,5]	-0.01	-0.88***	-1.06***	-0.28	-0.33**	0.29***	0.30	0.40**	-0.50***	-0.01	-0.62***	0.73***	[]	-0.01	0.07	[]	[]	[]	0.31
[5,5]	-0.01	-0.40***	-0.32***	-0.42***	-0.50***	0.20***	-0.14	-0.05	0.20	0.18**	-0.56***	0.96***	0.96***	-0.02	[]	[]	[]	[]	0.25

Appendix 4.3e Detailed Estimation Results

The first column [0,1] means that the estimation model is ARMA (0,1). The ‘[]’ in the estimation results mean that the respective variables are not part of the model estimation.

SSE B	ARMA											Price Limits Dummy				GARCH			
ΔLogQslp	[p,q]											Up	Up9	Lo	Lo9	C	P	Q	R-squared
[5,4]	0.00	-0.21	0.04	-0.42***	0.40***	0.23***	-0.49**	-0.34**	0.49***	-0.66***	[]	-0.09	[]	0.32	-0.23	[]	[]	[]	0.38
[2,4]	0.00	-1.59***	-0.89***	0.91***	-0.30***	-0.82***	-0.10***	[]	[]	[]	[]	-0.11	-0.17	0.21	[]	[]	[]	[]	0.33
[1,1]	0.00	0.15***	-0.84***	[]	[]	[]	[]	[]	[]	[]	[]	0.02	0.00	0.03	-0.14	[]	[]	[]	0.33
[3,4]	0.00	0.12	-0.80***	0.45***	-0.78***	0.79***	-1.00***	0.19	[]	[]	[]	[]	[]	0.23**	0.03	[]	[]	[]	0.31
[4,4]	0.00	-0.04	-0.28	-0.62***	0.15***	-0.61***	0.19	0.39	-0.56***	[]	[]	0.03	0.47	0.33	0.08	[]	[]	[]	0.31
[3,3]	0.00	-1.29***	-0.52***	0.04	0.55***	-0.42***	-0.50***	[]	[]	[]	[]	0.11	-0.03	-0.06	0.36***	[]	[]	[]	0.38
[3,4]	0.00	-0.78***	-1.07***	-0.22	0.09	0.42***	-0.65***	-0.31**	[]	[]	[]	-0.19**	0.06	-0.01	0.13**	[]	[]	[]	0.37
[4,5]	0.00	-1.87***	-1.50	-0.82	-0.22	1.20**	0.12	-0.42	-0.50	-0.23	[]	0.02	[]	0.29	0.09	[]	[]	[]	0.31
[5,4]	0.00	0.51	-0.32	-0.28	0.12	-0.14	-1.30**	0.60	-0.09	-0.21	[]	-0.24***	[]	[]	[]	[]	[]	[]	0.35
[0,1]	0.00	-0.74***	[]	[]	[]	[]	[]	[]	[]	[]	[]	-0.15	-0.21	[]	[]	[]	[]	[]	0.35
[4,5]	0.00	-0.29**	-0.17***	0.45***	0.63***	-0.45***	-0.05	-0.61***	-0.40***	0.50***	[]	-0.10	-0.01	-0.10	[]	[]	[]	[]	0.36
[3,3]	0.00	-0.52***	-0.80***	0.19***	-0.17***	0.38***	-0.85***	[]	[]	[]	[]	-0.15	-0.21	0.08	-0.04	[]	[]	[]	0.34
[1,1]	0.00	0.14***	-0.82***	[]	[]	[]	[]	[]	[]	[]	[]	-0.05	-0.03	0.18**	0.17	[]	[]	[]	0.32
[0,1]	0.00	-0.77***	[]	[]	[]	[]	[]	[]	[]	[]	[]	0.00	0.14	-0.01	0.07	[]	[]	[]	0.37
[4,3]	0.00	-0.15	0.75***	0.03	0.12***	-0.57***	-0.95***	0.52***	[]	[]	[]	-0.05	[]	0.06	0.00	[]	[]	[]	0.36
[0,1]	0.00	-0.82***	[]	[]	[]	[]	[]	[]	[]	[]	[]	-0.09	0.26	0.13	0.02	[]	[]	[]	0.40
[5,5]	0.00	-1.23***	-0.10	0.54***	0.07	-0.02	0.54***	-0.84***	-0.79***	0.19	0.07	-0.22***	-0.23	-0.43**	0.19	[]	[]	[]	0.35
[0,1]	0.00	-0.79***	[]	[]	[]	[]	[]	[]	[]	[]	[]	-0.32	0.10	-0.44	[]	[]	[]	[]	0.38
[0,1]	0.00	-0.81***	[]	[]	[]	[]	[]	[]	[]	[]	[]	0.16	0.07	0.24	[]	[]	[]	[]	0.39
[0,1]	0.00	-0.75***	[]	[]	[]	[]	[]	[]	[]	[]	[]	-0.07	0.03	0.07	-0.19	[]	[]	[]	0.36
[0,1]	0.00	-0.76***	[]	[]	[]	[]	[]	[]	[]	[]	[]	0.10	[]	0.09	0.31	[]	[]	[]	0.36
[2,1]	0.00	0.21***	0.07	-0.92***	[]	[]	[]	[]	[]	[]	[]	0.01	0.02	0.06	-0.02	[]	[]	[]	0.33
[5,5]	0.00	-0.67***	-0.87***	-0.72***	-0.19	0.12	-0.07	0.47	0.00	-0.35	-0.36**	0.03	-0.27**	0.05	-0.07	[]	[]	[]	0.39
[0,1]	0.00	-0.78***	[]	[]	[]	[]	[]	[]	[]	[]	[]	0.00	[]	-0.06	[]	[]	[]	[]	0.38
[0,1]	0.00	-0.79***	[]	[]	[]	[]	[]	[]	[]	[]	[]	[]	[]	0.05	0.05	[]	[]	[]	0.38
[3,5]	0.00	-1.64***	-1.50***	-0.45	0.98**	0.30	-0.81***	-0.57	-0.11	[]	[]	0.00	0.11	0.01	[]	[]	[]	[]	0.32
[4,5]	0.00	-0.39***	0.12***	-0.38***	-0.93***	-0.42***	-0.41***	0.49***	0.65***	-0.79***	[]	-0.16	[]	0.16***	[]	[]	[]	[]	0.41
[0,1]	0.00	-0.76***	[]	[]	[]	[]	[]	[]	[]	[]	[]	-0.01	0.14	0.13	0.03	[]	[]	[]	0.36
[0,1]	0.00	-0.76***	[]	[]	[]	[]	[]	[]	[]	[]	[]	0.07	-0.06	0.23	0.02	[]	[]	[]	0.36
[0,1]	0.00	-0.76***	[]	[]	[]	[]	[]	[]	[]	[]	[]	-0.16	-0.09	0.20	[]	[]	[]	[]	0.36
[0,1]	0.00	-0.79***	[]	[]	[]	[]	[]	[]	[]	[]	[]	-0.08	0.05	0.00	[]	[]	[]	[]	0.38
[3,3]	0.00	-1.06***	-0.63***	0.20***	0.36***	-0.09**	-0.76***	[]	[]	[]	[]	0.06	-0.27	0.06	[]	[]	[]	[]	0.37
[0,1]	0.00	-0.78***	[]	[]	[]	[]	[]	[]	[]	[]	[]	-0.01	[]	0.09	-0.15	0.04**	0.47**	0.15**	0.38
[4,4]	0.00	-0.59**	-0.76***	-0.34	0.19**	-0.06	0.25	-0.28	-0.58**	[]	[]	[]	[]	0.08	0.44***	[]	[]	[]	0.31
[4,4]	0.00	-0.65***	-0.84***	-0.73***	0.06	-0.03	0.25***	0.09	-0.71***	[]	[]	[]	[]	0.03	-0.04	[]	[]	[]	0.34
[0,1]	0.00	-0.80***	[]	[]	[]	[]	[]	[]	[]	[]	[]	-0.12	[]	0.08	-0.22	[]	[]	[]	0.38
[0,1]	0.00	-0.80***	[]	[]	[]	[]	[]	[]	[]	[]	[]	-0.06	0.07	0.09	[]	[]	[]	[]	0.38

Appendix 4.3f Detailed Estimation Results

The first column [0,1] means that the estimation model is ARMA (0,1). The '[]' in the estimation results mean that the respective variables are not part of the model estimation.

SSE B	ARMA											Price Limits Dummy				GARCH			
ΔOdImb	[p,q]											Up	Up9	Lo	Lo9	C	P	Q	R-squared
[0,4]	-0.01**	-1.11***	0.30***	-0.30***	0.12	[]	[]	[]	[]	[]	[]	0.27	[]	0.25	0.25	[]	[]	[]	0.57
[0,1]	0.00	-0.96***	[]	[]	[]	[]	[]	[]	[]	[]	[]	-0.31	0.22	-0.44	[]	[]	[]	[]	0.48
[3,4]	0.00	-0.17***	-0.31***	0.64***	-0.73***	0.15***	-1.00***	0.59***	[]	[]	[]	-0.13	0.21	-0.06	-0.39	[]	[]	[]	0.45
[4,3]	0.00	0.66	-0.20	-0.06	-0.05	-1.65***	0.95	-0.27	[]	[]	[]	[]	[]	-0.12	-0.03	[]	[]	[]	0.50
[5,5]	0.00	0.37	0.25	-0.57**	0.36	0.03	-1.36***	0.12	0.92***	-1.00	0.32	-0.25	0.51**	0.08	-0.14	[]	[]	[]	0.49
[1,2]	0.00	0.27***	-1.26***	0.26***	[]	[]	[]	[]	[]	[]	[]	-0.08	-0.17	-0.07	-0.01	[]	[]	[]	0.49
[2,2]	0.00	0.01	0.10***	-0.98***	-0.02	[]	[]	[]	[]	[]	[]	0.47**	0.30**	-0.07	-0.42***	[]	[]	[]	0.48
[0,1]	-0.00**	-0.98***	[]	[]	[]	[]	[]	[]	[]	[]	[]	0.82***	[]	0.08	0.16	[]	[]	[]	0.49
[2,3]	0.00	0.19	0.31	-1.30	0.16	0.14	[]	[]	[]	[]	[]	1.37***	[]	[]	[]	[]	[]	[]	0.53
[0,1]	0.00	-0.97***	[]	[]	[]	[]	[]	[]	[]	[]	[]	0.22	-0.01	[]	[]	[]	[]	[]	0.48
[0,1]	0.00	-0.96***	[]	[]	[]	[]	[]	[]	[]	[]	[]	-0.14	-0.14	-0.03	[]	[]	[]	[]	0.48
[0,1]	-0.00***	-1.00***	[]	[]	[]	[]	[]	[]	[]	[]	[]	0.90***	0.47	0.26	-0.97***	[]	[]	[]	0.50
[0,1]	0.00	-0.96***	[]	[]	[]	[]	[]	[]	[]	[]	[]	0.15	0.11	0.03	-0.07	[]	[]	[]	0.47
[0,1]	0.00	-0.97***	[]	[]	[]	[]	[]	[]	[]	[]	[]	0.41	-0.47	-0.06	-0.08	[]	[]	[]	0.48
[0,1]	0.00	-0.96***	[]	[]	[]	[]	[]	[]	[]	[]	[]	0.14	[]	0.29	-0.03	[]	[]	[]	0.48
[0,1]	-0.00**	-0.97***	[]	[]	[]	[]	[]	[]	[]	[]	[]	0.48	0.08	0.09	0.23	[]	[]	[]	0.48
[0,1]	0.00	-0.96***	[]	[]	[]	[]	[]	[]	[]	[]	[]	-0.13***	0.04	-0.27	0.02	[]	[]	[]	0.48
[1,2]	0.00	0.78***	-1.72***	0.72***	[]	[]	[]	[]	[]	[]	[]	-0.04	-0.03	0.03	[]	[]	[]	[]	0.46
[4,4]	0.00	0.22	0.46	-0.20	0.09	-1.17***	-0.25	0.66	-0.21	[]	[]	1.10	-0.18	-0.11	[]	[]	[]	[]	0.47
[2,3]	0.00	-1.72***	-0.84***	0.81***	-0.75***	-0.78***	[]	[]	[]	[]	[]	-0.68	-1.71***	0.05	0.22	[]	[]	[]	0.48
[4,5]	0.00	-0.04	-0.11	-0.05	0.66***	-0.91***	0.12	-0.06	-0.78***	0.63***	[]	-0.21	[]	-0.12	0.17	[]	[]	[]	0.48
[0,1]	0.00	-0.96***	[]	[]	[]	[]	[]	[]	[]	[]	[]	0.44	0.24	0.39	-0.52**	[]	[]	[]	0.47
[3,4]	0.00	-0.25***	0.14***	0.89***	-0.73***	-0.38***	-0.80***	0.90***	[]	[]	[]	0.16***	-0.14	-0.02	0.00	[]	[]	[]	0.48
[5,5]	0.00	-0.63***	-0.87***	-0.68***	-0.75***	0.05	-0.34***	0.28**	-0.15	0.10	-0.77***	1.27	[]	-0.79**	[]	[]	[]	[]	0.49
[2,3]	-0.01	-1.48***	-0.54	0.56	-0.89***	-0.56	[]	[]	[]	[]	[]	[]	[]	0.14	0.42	[]	[]	[]	0.46
[0,1]	0.00	-0.96***	[]	[]	[]	[]	[]	[]	[]	[]	[]	0.29	0.18	-0.06	[]	[]	[]	[]	0.48
[0,1]	0.00	-0.94***	[]	[]	[]	[]	[]	[]	[]	[]	[]	0.60	[]	-0.29**	[]	[]	[]	[]	0.46
[5,5]	0.01	-1.64***	-1.32**	-0.71	-0.45	-0.03	0.75***	-0.26	-0.60***	-0.19	-0.36	-0.84***	-0.26	-1.00***	-0.35	[]	[]	[]	0.49
[4,5]	0.00	-0.93***	-0.98***	-1.00***	-0.64***	-0.02	0.12	0.11	-0.32**	-0.68***	[]	-0.47	-2.40***	-0.32	0.09	[]	[]	[]	0.48
[0,1]	0.00	-0.97***	[]	[]	[]	[]	[]	[]	[]	[]	[]	0.78***	-1.02**	-0.17	[]	[]	[]	[]	0.48
[0,1]	0.00	-0.98***	[]	[]	[]	[]	[]	[]	[]	[]	[]	0.24	0.04	-0.26	[]	[]	[]	[]	0.49
[3,4]	0.00	-0.51***	0.33**	0.62***	-0.46***	-0.74***	-0.34	0.53***	[]	[]	[]	-0.17	-0.39	-0.17	[]	[]	[]	[]	0.48
[2,3]	0.00	-1.68***	-0.75***	0.76***	-0.82***	-0.68***	[]	[]	[]	[]	[]	-0.99***	[]	-0.04	0.39	[]	[]	[]	0.48
[0,1]	0.00	-0.96***	[]	[]	[]	[]	[]	[]	[]	[]	[]	[]	[]	-0.07	-0.13	[]	[]	[]	0.48
[5,5]	0.00	-0.30	-0.77***	-0.60***	-0.57***	-0.07	-0.69***	0.50**	-0.12	-0.03	-0.54***	[]	[]	-0.12	-0.54**	[]	[]	[]	0.50
[0,1]	0.00	-0.98***	[]	[]	[]	[]	[]	[]	[]	[]	[]	0.23	[]	-0.45***	-0.22	[]	[]	[]	0.49
[0,1]	0.00	-0.95***	[]	[]	[]	[]	[]	[]	[]	[]	[]	0.09	0.10	0.09	[]	[]	[]	[]	0.47

Appendix 4.3g Detailed Estimation Results

The first column [0,1] means that the estimation model is ARMA (0,1). The '[]' in the estimation results mean that the respective variables are not part of the model estimation.

SZSE A	ARMA											Price Limits Dummy				GARCH			
ΔTor	[p,q]											Up	Up9	Lo	Lo9	C	P	Q	R-squared
[4,5]	0.00	-0.10	-0.18	0.03	0.65***	-0.49**	0.03	-0.22	-0.69***	0.43***	[]	-0.07	0.03	[]	[]	[]	[]	[]	0.27
[5,5]	0.00	0.32***	-0.51***	0.43***	-0.61***	0.34***	-0.68***	0.42***	-0.65***	0.68***	-0.60***	0.35***	-0.07	-0.43***	-0.28**	[]	[]	[]	0.18
[1,1]	0.00	0.42***	-0.83***	[]	[]	[]	[]	[]	[]	[]	[]	0.13**	-0.18	0.08	-0.09	[]	[]	[]	0.17
[5,2]	0.00	-0.33***	0.61***	-0.06	0.06	0.08**	0.05**	-0.95***	[]	[]	[]	0.03	-0.04	0.14	-0.11	[]	[]	[]	0.14
[4,5]	-0.01	0.47**	-0.19	-0.39	0.22	-0.80***	0.18	0.38	-0.44**	-0.06	[]	0.50***	0.01	-0.33**	-0.24	[]	[]	[]	0.14
[4,3]	-0.02**	0.15	-0.49***	0.25***	0.03	-0.54***	0.45***	-0.57***	[]	[]	[]	0.66***	0.33	-0.10	-0.35**	[]	[]	[]	0.18
[5,5]	0.00	-0.16***	-0.74***	-0.15***	-0.59***	0.43***	-0.27***	0.58***	-0.30***	0.40***	-0.80***	0.26***	[]	[]	[]	[]	[]	[]	0.21
[5,5]	-0.01**	0.43***	-0.55**	0.18	-0.24	0.10	-0.78***	0.56**	-0.42	0.20	-0.28	0.72***	0.43***	-0.15	-0.24	[]	[]	[]	0.18
[5,4]	0.00	-0.88***	-0.70***	-0.19	0.43***	0.12***	0.38***	0.18***	-0.28***	-0.74***	[]	0.71***	0.22	0.25	-0.37**	[]	[]	[]	0.24
[5,3]	-0.01**	-0.48***	0.18	0.29***	0.03	0.01	0.15	-0.57***	-0.41***	[]	[]	0.70***	-0.21	-0.23	-0.29	[]	[]	[]	0.18
[5,3]	-0.01	0.25**	-0.03	-0.06	-0.06	-0.02	-0.66***	0.00	0.07	[]	[]	0.80***	-0.19	-0.37	0.06	[]	[]	[]	0.19
[5,5]	0.00	-0.04	-0.41***	-0.25	-0.23	0.38***	-0.41**	0.25	0.07	-0.04	-0.51***	-0.12	-0.10	0.27	-0.25	[]	[]	[]	0.21
[5,5]	-0.01	-0.46***	-0.21	0.04	0.06	0.11	0.10	-0.10	-0.28	-0.19	-0.22	1.05***	-0.04	0.20	-0.32	[]	[]	[]	0.17
[1,2]	-0.01	-0.28	-0.10	-0.26***	[]	[]	[]	[]	[]	[]	[]	0.78***	-0.04	-0.27	-0.67	0.01***	0.86***	0.07***	0.16
[3,4]	-0.03	-0.69***	-0.05	-0.04	0.31	-0.34**	-0.14	-0.07	[]	[]	[]	0.66***	0.07	-0.03	0.04	0.09	0.47	0.03	0.20
[3,3]	-0.02	-0.41***	-0.28***	0.11	-0.06	-0.05	-0.36***	[]	[]	[]	[]	1.21***	-0.04	-0.13	-1.02	[]	[]	[]	0.30
[5,5]	-0.01	-0.08	-0.41**	0.49***	-0.31	0.18	-0.40	0.24	-0.70***	0.40	-0.31	0.51***	-0.07	-0.18	-0.25	[]	[]	[]	0.21
[2,4]	0.00	-1.41***	-0.50**	1.07***	-0.22	-0.60***	-0.21***	[]	[]	[]	[]	0.16**	0.16	[]	[]	[]	[]	[]	0.16
[1,3]	-0.00***	0.91***	-1.41***	0.31***	0.11**	[]	[]	[]	[]	[]	[]	0.03	0.04	[]	[]	[]	[]	[]	0.21
[3,4]	-0.01	-0.24	-0.24	0.11	-0.17	-0.07	-0.32***	0.05	[]	[]	[]	2.66***	[]	[]	[]	[]	[]	[]	0.23
[0,2]	0.00	-0.37***	-0.25***	[]	[]	[]	[]	[]	[]	[]	[]	0.63***	0.23	-0.59	-0.29	[]	[]	[]	0.16
[1,1]	-0.01	0.27***	-0.74***	[]	[]	[]	[]	[]	[]	[]	[]	0.50***	0.44	-0.15	0.03	[]	[]	[]	0.19
[5,5]	-0.01	0.22	-0.47	-0.01	-0.26	0.16**	-0.74***	0.55	-0.34	0.25	-0.30**	1.19***	[]	[]	[]	[]	[]	[]	0.24
[1,2]	0.00	0.90***	-1.42***	0.42***	[]	[]	[]	[]	[]	[]	[]	0.02**	-0.03	-0.05	-0.01	[]	[]	[]	0.21
[3,4]	0.00	-0.82***	0.44***	0.32	0.38	-0.93***	-0.34	0.05	[]	[]	[]	0.22	0.31**	-0.04	[]	[]	[]	[]	0.19
[4,5]	-0.02**	-0.07	-0.09	-0.33***	0.24**	-0.35***	-0.02	0.26**	-0.36***	-0.04	[]	0.83***	0.85***	0.01	[]	[]	[]	[]	0.21
[4,4]	-0.01	-0.59***	-0.42***	-0.10	0.37***	0.23**	0.03	-0.25***	-0.65***	[]	[]	0.59***	-0.02	-0.26	-0.76	[]	[]	[]	0.17
[1,2]	0.00	0.73***	-1.27***	0.30***	[]	[]	[]	[]	[]	[]	[]	0.00	0.17	-0.14	[]	[]	[]	[]	0.23
[5,5]	-0.01	-0.37	-0.50***	-0.53**	-0.01	0.10	-0.13	0.11	0.19	-0.44**	-0.21	0.45**	0.22	0.69	0.09	[]	[]	[]	0.23
[3,5]	-0.01	-0.70***	-0.79***	-0.66***	0.20	0.35**	0.16	-0.39***	-0.06	[]	[]	0.64***	-0.06	[]	[]	[]	[]	[]	0.21
[4,5]	-0.01	-0.39**	-0.24	-0.54***	0.09	-0.07	-0.09	0.37***	-0.42***	-0.08	[]	0.46***	0.10	0.49	1.21***	0.04	0.72**	0.03	0.20
[5,4]	-0.01	-0.57**	-0.29	-0.24	0.03	-0.02	0.20	-0.04	0.05	-0.17	[]	0.88***	-0.14	[]	[]	[]	[]	[]	0.14

Appendix 4.3h Detailed Estimation Results

The first column [0,1] means that the estimation model is ARMA (0,1). The '[]' in the estimation results mean that the respective variables are not part of the model estimation.

SZSE A ΔLogQslp	ARMA [p,q]											Price Limits Dummy Up	Up9	Lo	Lo9	GARCH C	P	Q	R-squared
[5,5]	0.00	-0.21***	-1.50***	0.04	-0.63***	0.21***	-0.33***	1.24***	-0.97***	0.42***	-0.70***	0.10**	0.06**	[]	[]	[]	[]	[]	0.27
[0,1]	0.00	-0.72***	[]	[]	[]	[]	[]	[]	[]	[]	[]	-0.03	0.03	-0.03	0.14***	0.00***	0.90***	0.05***	0.34
[5,4]	0.00***	-0.53***	0.83***	0.72***	-0.17***	0.00	-0.10**	-1.25***	-0.31***	0.66***	[]	-0.02	0.00	0.01	-0.01	[]	[]	[]	0.31
[0,1]	0.00	-0.73***	[]	[]	[]	[]	[]	[]	[]	[]	[]	-0.05	0.05	-0.01	0.16	[]	[]	[]	0.34
[0,1]	0.00	-0.68***	[]	[]	[]	[]	[]	[]	[]	[]	[]	-0.02	-0.09	0.03	-0.01	0.01***	0.85***	0.09***	0.31
[1,2]	0.00	-0.37	-0.35	-0.30	[]	[]	[]	[]	[]	[]	[]	0.07***	-0.10	0.03	0.21**	[]	[]	[]	0.34
[5,5]	0.00	-0.13	-0.07	0.54***	-0.28	0.21***	-0.59**	-0.07	-0.53***	0.64***	-0.39***	-0.05	[]	[]	[]	[]	[]	[]	0.36
[3,4]	0.00	0.13	-0.01	0.47***	-0.74***	-0.10	-0.36	0.20	[]	[]	[]	-0.07***	0.00	0.14***	0.10***	0.01***	0.75***	0.10***	0.29
[4,5]	0.00***	0.01	-0.05	-0.23***	0.78***	-0.66***	-0.05	0.16***	-0.95***	0.50***	[]	-0.14**	-0.08**	-0.19***	0.09***	0.01	0.86***	0.06**	0.31
[0,1]	0.00	-0.80***	[]	[]	[]	[]	[]	[]	[]	[]	[]	-0.08***	-0.08	0.10***	0.03	[]	[]	[]	0.39
[3,2]	0.00	-0.67***	0.02	-0.07	0.06	-0.57***	[]	[]	[]	[]	[]	-0.05	0.03	0.17***	0.11	0.00***	0.80***	0.13***	0.28
[5,5]	0.00	-0.48**	-0.25**	-0.80***	-0.25	0.11	-0.12	-0.16	0.60***	-0.21	-0.42**	-0.15	-0.04	0.02	0.25***	[]	[]	[]	0.29
[0,2]	0.00	-0.56***	-0.13***	[]	[]	[]	[]	[]	[]	[]	[]	-0.07	-0.13	0.01	-0.02	0.02***	0.65***	0.18***	0.24
[3,4]	0.00	-0.85***	0.47***	0.75***	0.26***	-1.04***	-0.62***	0.45***	[]	[]	[]	-0.03	0.02	-0.02	0.06**	[]	[]	[]	0.29
[0,1]	0.00	-0.74***	[]	[]	[]	[]	[]	[]	[]	[]	[]	-0.04	0.01	0.00	-0.18	[]	[]	[]	0.35
[0,1]	0.00	-0.61***	[]	[]	[]	[]	[]	[]	[]	[]	[]	-0.14***	-0.02	0.06	0.05	[]	[]	[]	0.29
[5,2]	0.00	-0.40	0.16**	0.08	-0.03	0.04	-0.24	-0.51***	[]	[]	[]	-0.17***	0.06	0.12**	0.05	[]	[]	[]	0.30
[2,2]	0.00	0.64***	0.16***	-1.35***	0.37***	[]	[]	[]	[]	[]	[]	0.00	-0.02	[]	[]	[]	[]	[]	0.34
[5,4]	0.00***	-0.77***	0.01	0.80***	0.20	0.12	0.12	-0.61***	-0.85***	0.34**	[]	-0.13***	-0.15***	[]	[]	0.00***	0.82***	0.14***	0.33
[0,1]	0.00	-0.66***	[]	[]	[]	[]	[]	[]	[]	[]	[]	-0.05	[]	[]	[]	[]	[]	[]	0.30
[3,4]	0.00	-0.12	-0.33***	0.74***	-0.45***	0.22***	-1.00***	0.37***	[]	[]	[]	-0.06***	-0.06**	0.12**	0.03	0.00***	0.76***	0.17***	0.28
[1,3]	0.00	-0.56	-0.08	-0.49	-0.08	[]	[]	[]	[]	[]	[]	0.00	-0.03	0.18**	0.20	[]	[]	[]	0.30
[2,5]	0.00	0.09	0.42	-0.66	-0.45	0.13	0.07	0.00	[]	[]	[]	-0.06	[]	[]	[]	0.00**	0.83***	0.13***	0.25
[3,4]	0.00	0.66***	-0.33	-0.22	-1.30***	0.62**	0.19	-0.31***	[]	[]	[]	0.04	-0.05	-0.07	-0.07	[]	[]	[]	0.31
[1,2]	0.00	0.85***	-1.53***	0.53***	[]	[]	[]	[]	[]	[]	[]	-0.03	0.02	0.04	[]	[]	[]	[]	0.32
[2,4]	0.00	0.31***	-0.96***	-0.93***	1.05***	-0.54***	-0.15***	[]	[]	[]	[]	-0.01	-0.03	0.02	[]	[]	[]	[]	0.30
[2,3]	0.00	-0.87***	-0.05	0.27	-0.63***	-0.18	[]	[]	[]	[]	[]	0.01	0.00	0.11	0.16	[]	[]	[]	0.27
[3,5]	0.00	-0.88***	0.20	0.66***	0.27**	-0.92***	-0.69***	0.42***	-0.01	[]	[]	-0.04	-0.17***	0.03	[]	[]	[]	[]	0.33
[0,1]	0.00	-0.78***	[]	[]	[]	[]	[]	[]	[]	[]	[]	0.04	0.00	-0.11	-0.11	[]	[]	[]	0.37
[1,2]	0.00	0.50***	-1.12***	0.24**	[]	[]	[]	[]	[]	[]	[]	-0.04	0.01	[]	[]	[]	[]	[]	0.28
[1,1]	0.00	0.43***	-0.70***	[]	[]	[]	[]	[]	[]	[]	[]	-0.03**	-0.02	-0.08	0.03	0.00***	0.90***	0.09***	0.08
[3,5]	0.00	-0.50	-1.01***	-0.05	-0.04	0.60***	-0.64***	-0.20	-0.06	[]	[]	-0.03***	-0.08	[]	[]	0.00***	0.76***	0.15***	0.24

Appendix 4.3i Detailed Estimation Results

The first column [0,1] means that the estimation model is ARMA (0,1). The '[]' in the estimation results mean that the respective variables are not part of the model estimation.

SZSE A	ARMA											Price Limits Dummy				GARCH			
ΔOdImb	[p,q]											Up	Up9	Lo	Lo9	C	P	Q	R-squared
[1,2]	0.00	0.36***	-1.21***	0.21***	[]	[]	[]	[]	[]	[]	[]	-0.07	0.16	[]	[]	[]	[]	[]	0.41
[0,1]	0.00	-1.00***	[]	[]	[]	[]	[]	[]	[]	[]	[]	0.13**	0.01	0.00	-0.21	[]	[]	[]	0.50
[0,1]	0.00	-0.97***	[]	[]	[]	[]	[]	[]	[]	[]	[]	0.04	-0.01	0.07	0.02	[]	[]	[]	0.48
[3,4]	-0.00**	-0.18***	0.02	0.73***	-0.83***	-0.20**	-0.71***	0.75***	[]	[]	[]	0.04	-0.01	-0.04	0.11	[]	[]	[]	0.52
[0,1]	0.00	-0.96***	[]	[]	[]	[]	[]	[]	[]	[]	[]	0.25**	0.20	-0.26**	0.25	[]	[]	[]	0.47
[2,2]	0.00	0.74***	0.02	-1.67***	0.67***	[]	[]	[]	[]	[]	[]	0.04**	0.00	-0.06	-0.04	[]	[]	[]	0.46
[1,2]	0.00	0.16***	-1.04***	0.04	[]	[]	[]	[]	[]	[]	[]	0.09	[]	[]	[]	0.08**	0.90***	0.04***	0.44
[0,1]	0.00	-0.97***	[]	[]	[]	[]	[]	[]	[]	[]	[]	0.36***	0.11	-0.43**	-0.15	[]	[]	[]	0.48
[0,1]	0.00	-0.94***	[]	[]	[]	[]	[]	[]	[]	[]	[]	0.55	0.56	0.41	-0.22	[]	[]	[]	0.47
[0,1]	-0.00***	-1.00***	[]	[]	[]	[]	[]	[]	[]	[]	[]	0.26***	-0.10	-0.05	-0.03	[]	[]	[]	0.50
[5,5]	-0.02***	-0.90***	-0.72***	-0.21	0.08	0.04	-0.04	-0.08	-0.45**	-0.32	-0.12	0.57***	0.48	0.89**	-3.10***	[]	[]	[]	0.48
[1,2]	0.00	0.20***	-1.21***	0.21***	[]	[]	[]	[]	[]	[]	[]	-0.16	0.02	0.10	0.14	[]	[]	[]	0.50
[0,1]	0.00	-0.97***	[]	[]	[]	[]	[]	[]	[]	[]	[]	0.26***	0.19	0.06	-0.41	[]	[]	[]	0.48
[3,4]	0.00	0.62***	-0.25***	-0.44***	-1.61***	0.87***	0.22	-0.48***	[]	[]	[]	0.25***	-0.29**	0.17	-0.12	[]	[]	[]	0.49
[0,1]	-0.01	-0.97***	[]	[]	[]	[]	[]	[]	[]	[]	[]	0.13**	0.01	-0.09	0.43	[]	[]	[]	0.48
[0,1]	-0.01	-0.93***	[]	[]	[]	[]	[]	[]	[]	[]	[]	0.10	0.05	0.47	-0.66	[]	[]	[]	0.46
[0,1]	0.00	-0.92***	[]	[]	[]	[]	[]	[]	[]	[]	[]	0.14	0.23	-0.15	-0.25	[]	[]	[]	0.45
[0,1]	0.00	-0.98***	[]	[]	[]	[]	[]	[]	[]	[]	[]	0.18	0.59***	[]	[]	[]	[]	[]	0.49
[2,3]	-0.00***	-0.05	0.53***	-0.98***	-0.47	0.45**	[]	[]	[]	[]	[]	-0.24	-0.02	[]	[]	[]	[]	[]	0.52
[3,4]	0.00	-0.76***	0.59***	0.84***	-0.21**	-1.28***	-0.29***	0.78***	[]	[]	[]	0.01	[]	[]	[]	[]	[]	[]	0.49
[0,1]	0.00	-0.95***	[]	[]	[]	[]	[]	[]	[]	[]	[]	-0.01	0.35	-0.10	-0.11	[]	[]	[]	0.47
[2,3]	-0.00***	-0.15	0.63***	-0.78***	-0.75***	0.53***	[]	[]	[]	[]	[]	0.09**	0.24	0.05	0.15	[]	[]	[]	0.46
[2,3]	0.00	-0.21	0.53***	-0.70***	-0.80***	0.52***	[]	[]	[]	[]	[]	0.12	[]	[]	[]	[]	[]	[]	0.45
[4,3]	0.00	-1.10***	-0.90***	0.07	0.10***	0.14***	-0.06***	-0.96***	[]	[]	[]	-0.17	-0.24**	-0.35	0.34**	[]	[]	[]	0.51
[2,2]	0.00	0.33***	0.07	-1.25***	0.25**	[]	[]	[]	[]	[]	[]	-0.01	0.09	-0.03	[]	[]	[]	[]	0.46
[1,2]	-0.00**	0.33***	-1.32***	0.32***	[]	[]	[]	[]	[]	[]	[]	0.18***	0.11	-0.05	[]	[]	[]	[]	0.49
[2,3]	0.00	-1.23***	-0.55***	0.31**	-0.62***	-0.57***	[]	[]	[]	[]	[]	0.50**	0.32	-0.33	-3.27***	[]	[]	[]	0.48
[1,2]	0.00**	0.53***	-1.52***	0.52***	[]	[]	[]	[]	[]	[]	[]	0.05	-0.12	-0.21	[]	[]	[]	[]	0.49
[5,5]	0.00	0.18	-0.29	-0.48***	0.14	0.12***	-1.14***	0.48**	0.21	-0.69**	0.14	0.12	-0.06	-0.05	-1.02	[]	[]	[]	0.48
[2,3]	0.00	-0.26***	0.72***	-0.72***	-0.96***	0.69***	[]	[]	[]	[]	[]	0.25***	0.25**	[]	[]	[]	[]	[]	0.49
[2,3]	0.00	-0.31**	0.56***	-0.70***	-0.85***	0.55***	[]	[]	[]	[]	[]	0.04	0.09	0.32	0.06	[]	[]	[]	0.50
[3,5]	-0.00***	-0.07	-0.28***	0.65***	-0.83***	0.19	-0.94***	0.55***	0.02	[]	[]	0.13	0.00	[]	[]	[]	[]	[]	0.45

Appendix 4.3j Detailed Estimation Results

The first column [0,1] means that the estimation model is ARMA (0,1). The '[]' in the estimation results mean that the respective variables are not part of the model estimation.

SZSE B	ARMA											Price Limits Dummy				GARCH			
ΔTor	[p,q]											Up	Up9	Lo	Lo9	C	P	Q	R-squared
[5,1]	0.00	0.37***	0.13***	-0.07	-0.02	0.18***	-1.00***	[]	[]	[]	[]	-0.11	0.10	-0.06	0.16**	[]	[]	[]	0.31
[5,4]	0.00	-0.11	-0.66***	-0.18	0.11	0.08	-0.47	0.45	-0.19	-0.42**	[]	0.47**	0.87***	0.05	-0.23	[]	[]	[]	0.27
[3,3]	0.00	0.00	-0.80***	0.29***	-0.54***	0.69***	-0.81***	[]	[]	[]	[]	[]	[]	0.02	0.21	[]	[]	[]	0.24
[3,5]	0.00	-1.88***	-1.16***	-0.26	1.34***	-0.10	-0.79***	-0.38**	-0.06	[]	[]	[]	[]	-0.02	0.04	[]	[]	[]	0.28
[3,4]	0.00	-0.36	0.02	-0.02	-0.23	-0.31	-0.05	0.00	[]	[]	[]	1.39***	-0.03	-0.53	-0.15	[]	[]	[]	0.27
[5,5]	0.00	0.26***	0.11	0.00	-0.78***	0.33***	-0.80***	-0.09	0.02	0.83***	-0.78***	0.45	0.31	0.00	-0.47**	[]	[]	[]	0.24
[0,1]	0.00	-0.70***	[]	[]	[]	[]	[]	[]	[]	[]	[]	-0.14	[]	-0.28	[]	[]	[]	[]	0.32
[1,1]	0.00	0.30***	-0.84***	[]	[]	[]	[]	[]	[]	[]	[]	-0.02	0.39	-0.02	-0.65	0.00	0.97***	0.03***	0.24
[5,2]	0.00	0.35**	0.16**	0.08	0.10**	0.06	-0.91***	-0.09	[]	[]	[]	0.01	[]	-0.04	0.00	[]	[]	[]	0.24
[5,5]	0.00	-0.62***	-0.18***	-0.59***	-0.50***	0.36***	0.13***	-0.29***	0.38***	0.12***	-0.85***	0.41**	0.63***	0.27	0.44***	[]	[]	[]	0.25
[4,5]	0.00	-0.04	-0.35***	0.69***	0.32	-0.52**	0.19	-0.91***	-0.04	0.28**	[]	-0.24	0.02	-0.19**	0.35**	[]	[]	[]	0.28
[4,2]	0.00	-0.33**	0.35***	0.24***	0.23***	-0.32**	-0.68***	[]	[]	[]	[]	[]	[]	-0.17	[]	[]	[]	[]	0.31
[3,5]	0.00	-0.68***	0.50***	0.67***	0.12	-1.03***	-0.53***	0.45***	0.04	[]	[]	0.33	0.19	0.04	-0.15	[]	[]	[]	0.25
[3,3]	-0.02	-0.61***	-0.17	0.13**	0.11	-0.34***	-0.31***	[]	[]	[]	[]	1.64***	1.43***	0.46	0.29	[]	[]	[]	0.26
[4,5]	0.00	-0.90***	-0.32***	0.43***	0.68***	0.36***	-0.36***	-0.63***	-0.51***	0.36***	[]	0.30***	-0.59**	0.04	-0.44**	[]	[]	[]	0.32
[3,3]	-0.01	-0.28	-0.52***	0.09	-0.48***	0.37**	-0.53***	[]	[]	[]	[]	-0.44	0.97**	2.10	[]	[]	[]	[]	0.40
[1,1]	0.00	0.24***	-0.80***	[]	[]	[]	[]	[]	[]	[]	[]	0.52***	-0.35	0.04	-0.37**	[]	[]	[]	0.26
[1,1]	0.00	0.24***	-0.85***	[]	[]	[]	[]	[]	[]	[]	[]	-0.24	[]	-0.07	-0.46	0.01	0.95***	0.03**	0.28
[3,5]	0.00	-1.38***	-0.64	-0.16	0.81**	-0.29	-0.45	-0.22	-0.05	[]	[]	[]	[]	1.83***	[]	[]	[]	[]	0.26
[1,1]	0.00	0.34***	-0.82***	[]	[]	[]	[]	[]	[]	[]	[]	0.59***	[]	[]	[]	[]	[]	[]	0.20
[5,3]	0.00	0.10	-0.94***	0.31***	-0.03	0.05	-0.62***	0.82***	-0.84***	[]	[]	0.08	0.16	-0.02	-0.34**	[]	[]	[]	0.25
[1,1]	0.00	0.27***	-0.82***	[]	[]	[]	[]	[]	[]	[]	[]	0.40	[]	0.28	-0.14	[]	[]	[]	0.24
[3,5]	0.00	0.15	-0.78***	0.49**	-0.69***	0.77***	-1.00***	0.16	0.00	[]	[]	0.25**	[]	[]	[]	[]	[]	[]	0.25
[0,1]	0.00	-0.66***	[]	[]	[]	[]	[]	[]	[]	[]	[]	-0.14	-0.23	-0.12	-0.69	[]	[]	[]	0.31
[5,2]	0.00	-0.29	0.33***	0.15***	0.15***	0.19***	-0.39**	-0.61***	[]	[]	[]	0.06	[]	0.13	[]	[]	[]	[]	0.32
[1,2]	-0.01	-0.36	-0.18	-0.31**	[]	[]	[]	[]	[]	[]	[]	1.99***	[]	0.34	0.75	[]	[]	[]	0.24
[2,5]	0.00	0.46***	-0.87***	-1.07***	1.11***	-0.58***	-0.05	-0.10**	[]	[]	[]	[]	[]	-0.01	-0.21	[]	[]	[]	0.28
[1,1]	0.00	0.32***	-0.90***	[]	[]	[]	[]	[]	[]	[]	[]	0.06	-0.18	-0.28	0.53**	[]	[]	[]	0.27
[1,2]	0.00	0.75***	-1.34***	0.34***	[]	[]	[]	[]	[]	[]	[]	-0.29***	-0.39***	-0.03	-0.05	[]	[]	[]	0.27
[5,5]	-0.01	-0.46***	-0.35**	-0.26	-0.22	0.10	-0.07	-0.05	-0.02	0.06	-0.30**	0.96***	2.00**	0.88	0.48	[]	[]	[]	0.25
[3,3]	-0.01	-0.75***	-0.44***	0.02	0.11	-0.17	-0.44***	[]	[]	[]	[]	1.44***	-0.23	0.52***	0.14	[]	[]	[]	0.31
[3,5]	0.00	0.24	0.69	-0.03	-0.71***	-0.79	0.35	0.12	0.03	[]	[]	[]	[]	0.00	[]	[]	[]	[]	0.20

Appendix 4.3k Detailed Estimation Results

The first column [0,1] means that the estimation model is ARMA (0,1). The '[]' in the estimation results mean that the respective variables are not part of the model estimation.

SZSE B	ARMA											Price Limits Dummy				GARCH			
ΔLogQslp	[p,q]											Up	Up9	Lo	Lo9	C	P	Q	R-squared
[4,5]	-0.00***	-0.18***	-0.21***	0.08	0.70***	-0.55***	-0.05	-0.21***	-0.75***	0.56***	[]	-0.32***	0.16	0.21***	0.18***	[]	[]	[]	0.37
[4,5]	0.00	0.01	-0.31	0.37**	-0.44**	-0.81***	0.33	-0.58***	0.78***	-0.40***	[]	-0.35**	-0.15	-0.09	0.10	[]	[]	[]	0.39
[0,1]	0.00	-0.71***	[]	[]	[]	[]	[]	[]	[]	[]	[]	[]	[]	0.06	-0.04	[]	[]	[]	0.33
[0,1]	0.00	-0.74***	[]	[]	[]	[]	[]	[]	[]	[]	[]	[]	[]	-0.14	0.13**	0.00***	0.86***	0.08***	0.35
[5,5]	0.00	-0.12	-0.68***	0.43***	0.20	0.08	-0.62***	0.54***	-0.90***	0.04	0.14	0.00	-0.03	-0.14	0.09	[]	[]	[]	0.37
[0,1]	0.00	-0.77***	[]	[]	[]	[]	[]	[]	[]	[]	[]	0.13	-0.04	-0.03	0.26**	[]	[]	[]	0.37
[0,1]	0.00	-0.80***	[]	[]	[]	[]	[]	[]	[]	[]	[]	-0.22	[]	-0.28	[]	[]	[]	[]	0.40
[2,4]	0.00	-1.10***	-0.96***	0.41***	0.15***	-0.74***	-0.08**	[]	[]	[]	[]	-0.08	-0.46***	-0.23	-0.17	0.01	0.87***	0.08***	0.37
[0,1]	0.00	-0.81***	[]	[]	[]	[]	[]	[]	[]	[]	[]	0.07	[]	-0.38	-0.01	[]	[]	[]	0.39
[4,5]	0.00	-0.99***	-0.61**	-0.11	0.49***	0.34	-0.14	-0.43***	-0.61***	0.25	[]	-0.14	0.05	-0.20	0.25	[]	[]	[]	0.33
[0,1]	0.00	-0.77***	[]	[]	[]	[]	[]	[]	[]	[]	[]	0.14	-0.23	0.15	-0.42	[]	[]	[]	0.37
[3,4]	0.00	-0.07	0.30**	0.55***	-0.63***	-0.45**	-0.43**	0.52***	[]	[]	[]	[]	[]	0.00	[]	[]	[]	[]	0.34
[1,1]	0.00	0.18***	-0.87***	[]	[]	[]	[]	[]	[]	[]	[]	-0.24	-0.07	0.02	0.19	[]	[]	[]	0.32
[1,1]	0.00	0.19***	-0.84***	[]	[]	[]	[]	[]	[]	[]	[]	-0.13	-0.14**	0.03	0.01	[]	[]	[]	0.30
[3,4]	0.00	-0.57**	-0.13	0.54***	-0.09	-0.32	-0.68***	0.30	[]	[]	[]	0.00	-0.06	0.05	0.14	[]	[]	[]	0.29
[2,5]	0.00	-1.07***	-0.86***	0.53***	0.22***	-0.75***	-0.12	-0.06	[]	[]	[]	-0.01	-0.21***	0.00	[]	[]	[]	[]	0.30
[1,1]	0.00	0.16***	-0.84***	[]	[]	[]	[]	[]	[]	[]	[]	0.10	0.01	0.10	0.00	[]	[]	[]	0.32
[0,1]	0.00	-0.81***	[]	[]	[]	[]	[]	[]	[]	[]	[]	0.05	[]	-0.01	-0.13	[]	[]	[]	0.39
[0,1]	0.00	-0.78***	[]	[]	[]	[]	[]	[]	[]	[]	[]	[]	[]	0.24***	[]	[]	[]	[]	0.38
[2,4]	0.00	0.69***	-0.90***	-1.42***	1.34***	-0.64***	-0.08**	[]	[]	[]	[]	-0.08	[]	[]	[]	[]	[]	[]	0.35
[4,5]	0.00	-0.70***	0.16	0.66***	-0.05	0.02	-0.71***	-0.65***	0.51***	-0.05	[]	0.10**	0.14	0.04	0.30***	0.00	0.97***	0.03***	0.34
[0,2]	0.00	-0.71***	-0.10***	[]	[]	[]	[]	[]	[]	[]	[]	0.02	[]	-0.27	0.16	[]	[]	[]	0.33
[0,1]	0.00	-0.79***	[]	[]	[]	[]	[]	[]	[]	[]	[]	0.04	[]	[]	[]	[]	[]	[]	0.38
[0,1]	0.00	-0.76***	[]	[]	[]	[]	[]	[]	[]	[]	[]	0.22	0.02	0.13	-0.18	[]	[]	[]	0.36
[0,1]	0.00	-0.82***	[]	[]	[]	[]	[]	[]	[]	[]	[]	-0.01	[]	-0.61***	[]	[]	[]	[]	0.41
[0,1]	0.00	-0.77***	[]	[]	[]	[]	[]	[]	[]	[]	[]	-0.17	[]	0.11	0.33	0.00**	0.87***	0.10***	0.37
[0,1]	0.00	-0.78***	[]	[]	[]	[]	[]	[]	[]	[]	[]	[]	[]	-0.23**	0.13	[]	[]	[]	0.39
[4,4]	0.00	0.07	-0.12	-0.43	0.07	-0.87**	0.18	0.27	-0.46	[]	[]	0.14	0.03	0.82***	-0.22	[]	[]	[]	0.39
[1,1]	0.00	0.20***	-0.92***	[]	[]	[]	[]	[]	[]	[]	[]	0.17	0.30	0.10	-0.13	[]	[]	[]	0.35
[5,5]	0.00	-0.81***	0.09	0.62***	0.00	-0.04	0.15	-0.73***	-0.68***	0.43***	0.06	-0.12**	0.10	0.15***	-0.13**	[]	[]	[]	0.34
[0,1]	0.00	-0.75***	[]	[]	[]	[]	[]	[]	[]	[]	[]	-0.10	0.01	0.04***	0.05	[]	[]	[]	0.35
[3,5]	0.00	-1.55***	-1.50***	-0.65***	0.91***	0.34***	-0.54***	-0.59***	-0.08	[]	[]	[]	[]	0.34***	[]	[]	[]	[]	0.33

Appendix 4.3l Detailed Estimation Results

The first column [0,1] means that the estimation model is ARMA (0,1). The '[]' in the estimation results mean that the respective variables are not part of the model estimation.

SZSE B	ARMA											Price Limits Dummy				GARCH			
ΔOdImb	[p,q]											Up	Up9	Lo	Lo9	C	P	Q	R-squared
[1,4]	0.00	0.45***	-1.34***	0.35***	0.02	-0.03	[]	[]	[]	[]	[]	-0.22	0.30***	-0.05	0.07	[]	[]	[]	0.44
[3,4]	0.00	-0.86**	-0.64	0.11	-0.11	-0.20	-0.69***	0.08	[]	[]	[]	1.03	-0.16	-0.36	-0.57	1.07***	0.00	0.17***	0.48
[0,1]	0.00	-0.96***	[]	[]	[]	[]	[]	[]	[]	[]	[]	[]	[]	-0.08	-0.22	[]	[]	[]	0.48
[0,1]	0.00	-0.97***	[]	[]	[]	[]	[]	[]	[]	[]	[]	[]	[]	-0.09	-0.06	[]	[]	[]	0.48
[2,1]	0.00	0.03	0.16***	-1.00***	[]	[]	[]	[]	[]	[]	[]	0.06	0.28**	-0.11	-0.04	[]	[]	[]	0.49
[0,1]	0.00	-0.97***	[]	[]	[]	[]	[]	[]	[]	[]	[]	0.45**	0.48**	-0.03	-0.26	[]	[]	[]	0.48
[0,1]	0.00	-0.92***	[]	[]	[]	[]	[]	[]	[]	[]	[]	-0.09	[]	-0.16	[]	[]	[]	[]	0.46
[4,4]	-0.01	-0.68***	-0.73***	-0.83***	-0.01	-0.25***	0.17**	0.15	-0.84***	[]	[]	-0.48	1.67***	-0.51**	-1.48**	[]	[]	[]	0.49
[5,3]	0.01	-1.39***	-0.44***	0.44***	0.33***	0.14***	0.64***	-0.62***	-0.78***	[]	[]	-0.72	[]	0.14	-1.07	[]	[]	[]	0.37
[0,1]	0.00	-0.98***	[]	[]	[]	[]	[]	[]	[]	[]	[]	0.52	0.37**	0.08	-0.19	[]	[]	[]	0.48
[5,4]	0.00	-0.91***	-0.96***	0.03	0.05	0.02	-0.02	0.13***	-0.96***	-0.04	[]	0.46	-0.23	-0.04	-0.80***	[]	[]	[]	0.47
[1,4]	0.00	-0.88***	-0.10	-0.87***	0.04	0.02	[]	[]	[]	[]	[]	[]	[]	0.47	[]	[]	[]	[]	0.49
[0,1]	0.00	-0.93***	[]	[]	[]	[]	[]	[]	[]	[]	[]	-0.03	0.79**	-0.04	0.41	[]	[]	[]	0.46
[0,1]	-0.00***	-1.00***	[]	[]	[]	[]	[]	[]	[]	[]	[]	0.61***	0.33	-0.04	-0.20	[]	[]	[]	0.50
[4,5]	0.02	-0.92***	-0.85***	-0.70***	-0.07	0.14	0.00	-0.06	-0.64***	-0.19	[]	0.77**	-4.03***	-0.25	-0.82	[]	[]	[]	0.45
[3,5]	-0.01	-0.45***	-0.04	0.67***	-0.62***	-0.25***	-0.76***	0.84***	-0.13**	[]	[]	0.61	0.30	0.83**	[]	[]	[]	[]	0.57
[4,5]	0.00	-0.28	-0.29***	0.69***	0.35***	-0.63***	0.01	-1.00***	0.26	0.36***	[]	0.33**	-0.18	0.06	-0.08	[]	[]	[]	0.47
[1,3]	0.00	-0.62	-0.38	-0.59	0.05	[]	[]	[]	[]	[]	[]	-0.66	[]	0.02	-0.31	[]	[]	[]	0.50
[4,5]	-0.01	-1.33***	-0.65***	-1.00***	-0.75***	0.36***	-0.63***	0.45***	-0.22***	-0.79***	[]	[]	[]	0.29	[]	[]	[]	[]	0.51
[5,5]	0.00	-0.46	-0.70***	-0.65***	-0.33	0.09**	-0.46	0.30	-0.02	-0.34	-0.38	2.03	[]	[]	[]	[]	[]	[]	0.46
[3,5]	0.00	-0.74***	0.23**	0.58***	-0.19	-0.90***	-0.38**	0.46***	0.04	[]	[]	-0.06	-0.18	0.18	0.41	[]	[]	[]	0.47
[0,1]	0.00	-0.92***	[]	[]	[]	[]	[]	[]	[]	[]	[]	-0.09	[]	0.64	-0.40	[]	[]	[]	0.46
[0,1]	0.00	-0.95***	[]	[]	[]	[]	[]	[]	[]	[]	[]	-0.26	[]	[]	[]	[]	[]	[]	0.47
[5,5]	0.00	-0.80***	-1.38***	-0.73***	-0.83***	-0.15***	-0.18	0.68***	-0.61***	0.23***	-0.71***	0.47	-0.01	0.63	-0.84	[]	[]	[]	0.50
[0,1]	0.00	-0.98***	[]	[]	[]	[]	[]	[]	[]	[]	[]	0.19	[]	0.43	[]	[]	[]	[]	0.49
[3,5]	-0.01***	-0.81***	-0.37	0.43***	-0.16	-0.26***	-0.82***	0.41**	-0.15***	[]	[]	0.78**	[]	0.26	0.49	[]	[]	[]	0.51
[0,1]	0.00	-0.94***	[]	[]	[]	[]	[]	[]	[]	[]	[]	[]	[]	0.15	-0.53***	[]	[]	[]	0.47
[4,5]	0.00	0.41	-0.48	0.49	-0.26	-1.46***	0.99	-1.00	0.81	-0.32	[]	-0.06	0.25	-0.27	0.44	[]	[]	[]	0.52
[0,1]	0.00***	-1.00***	[]	[]	[]	[]	[]	[]	[]	[]	[]	-1.05***	-1.68***	-0.31***	-0.42**	[]	[]	[]	0.50
[4,5]	0.00	-0.57**	-0.73***	-0.26	0.27	-0.31	0.24	-0.45**	-0.57**	0.25	[]	0.75***	0.00	0.10	-0.09	[]	[]	[]	0.45
[3,4]	-0.01	-0.79***	-0.75***	0.20	-0.16	0.02	-0.91***	0.21	[]	[]	[]	1.16***	-0.44	0.53	0.10	[]	[]	[]	0.48
[1,2]	0.00	0.74***	-1.65***	0.65***	[]	[]	[]	[]	[]	[]	[]	[]	[]	0.08	[]	[]	[]	[]	0.45

Appendix 4.4 Empirical Results without considering ARCH effect

This table reports the number of shares that support the trading interference hypothesis in terms of three liquidity measures: the turnover ratio (*Tor*), log quote slope (*LogQslp*) and order imbalance (*OdImb*).

		5%			1%	
SSE A	*Tor*	*LogQslp*	*OdImb*	*Tor*	*LogQslp*	*OdImb*
Up	25	9	0	26	8	0
Lower	3	1	3	2	0	1
		5%			1%	
SSE B	*Tor*	*LogQslp*	*OdImb*	*Tor*	*LogQslp*	*OdImb*
Up	10	3	3	9	2	3
Lower	3	1	4	3	0	2
		5%			1%	
SZSE A	*Tor*	*LogQslp*	*OdImb*	*Tor*	*LogQslp*	*OdImb*
Up	25	6	0	21	5	0
Lower	0	2	2	0	2	0
		5%			1%	
SZSE B	*Tor*	*LogQslp*	*OdImb*	*Tor*	*LogQslp*	*OdImb*
Up	8	3	0	8	1	0
Lower	2	3	0	2	2	1

Chapter 5

Conclusion

5.1 Summary of Main Findings

There is an on-going debate on the effectiveness of price limits in the stock market. To test the performance of price limits, Kim and Rhee (1997) propose three hypotheses which are delayed price discovery hypothesis, volatility spillover hypothesis and trading interference hypothesis. The delayed price discovery hypothesis states that the price will continue to move in the same direction after price-limit-hits, which means that price continuation would impose a relative high trading cost on investors on the following trading day. The volatility spillover hypothesis asserts that the pent-up volatility on the day of a price-limit-hit is transferred to the next trading day, which implies that price limits create another volatile trading day. The trading interference hypothesis claims that stocks which hit price limits on day t will experience more trading on day $t+1$, which indicates that price limits prevent potential trading on the day of price-limit-hit.

Based on the study of daily data in Chapter 2, the delayed price discovery hypothesis is not rejected after price-limit-hits, especially after upper price-limit-hits. That is, a price continues to move in the same direction after price-limit-hits. In addition, the volatility spillover hypothesis is also not rejected. In other words, volatility is increased after price-limit-hits. These findings are consistent with the results of Chen, Rui and Wang (2005) in the Chinese stock market. In contrast with the study of daily data, the study of intraday data in Chapter 3 has shown that there is no evidence of price continuation after price-limit-hits, which means the delayed price discovery hypothesis is rejected. The rejection, however, does not mean the effectiveness of price limits. The initial reason behind the implementation of price limits is to stop market crashes in the downward movement and to prevent overreactions in the upward movement. There are no signs of price recovery after lower price-limit-hits or overreaction after upper price-limit-hits. The absence of price continuation could be due to the lack of time of information dissemination: there is no chance for price limits to send out a signal of extreme price movement which will cause herding behaviour. For daily data there is a long overnight period for investors to absorb information when a price hits the limits. Volatility spillover is also found in the study of the intraday dataset.

If price limits decrease liquidity, trading activity will be restricted on the day of a price-limit-hit. In other words, the trading interference hypothesis will not be rejected. The literature has shown that the hypothesis is not rejected when the trading activity is measured by the turnover ratio. In Chapter 4, the empirical results have confirmed that trading is interfered if it is measured by turnover ratio (5) shown in Table 4.1; however, the level of interference is decreased if the measures are log quote slope (17) and order imbalance (19) shown in Table 4.2. In conclusion, the average results show that price limits interferer with trading.

5.2 Answers to the Research Questions

As displayed in Figure 1.1, the research questions needed to be answered. First, price limits are not effective in preventing overreaction. When price reaches the upper the limits, the regime would not allow the price goes beyond the limits because the regime assumes the price movement is not rational and it will reverse in the following period. Price reversal, however, is not observed after price-limit-hits. For the upper price-limit-hits, the absence of price reversal suggests that investors do not overreact to the large and positive price movement. The original rational behind price limits is to prevent a stock market cash. When price attains the lower price limits, the system thinks it can stop the market decline. There is, however, no sign of price reversal after lower price-limit-hits. Secondly, price limits are not effective in alleviating volatility. The results have shown that volatility is not reduced after price-limit-his. Thirdly, price limits interfere with trading.

As an investor, there is profitable trading strategy which exploits price-limit-hits. It has been shown in Chapter 2 that the forecast tail probabilities provide some indications about price continuation. This, however, is not the case in Chapter 3. Therefore, a trading strategy can be constructed based on daily data. There is a long position in a stock on day *T* when the forecasted tail probability is large enough on day *T+1*. The long position is closed on day *T+1*. Without considering the transaction costs, the model generates large and positive returns. Even taking the costs into account, there is still positive profit overall. For example, with a total initial investment of 400 RMB, it will bring about 409.28 RMB. This result implies that the efficient market hypothesis is rejected. It is important to note that in contrast with transaction costs in the US and UK (0.48% and 0.57% round trip respectively, Pollin and Heintz; 2011), Costs in China are high, currently 1.4%.

For regulators, the existing price limit system is not worthwhile according to the findings, which show that there is no price reversal or reduction of volatility. Interestingly, a stricter price limit system that accompanies with trading halt is executed from 1st January 2016. The new price limit regime will temporally halt all the trading for 15 minutes if CSI 300 index which tracks the largest 300 stocks in the Chinese stock market falls by 5% and will halt all the trading for the whole day if CSI 300 drops by 7%. The new system was activated twice in its first week's implementation and then the system was stopped by the China Securities Regulatory Commission (CSRC) on 8th January 2016[32]. All of these call for some further improvements in the system, for example, increasing the existing 10% price limit rate. There is already a signal for the improvement, for example, SSE has decided to change the 5% of price limits on ST-shares to the 10% from 1st January 2013.

5.3 Limitations and Suggestions for Future Research

To make a direct and consistent comparison, the model specifications in the study of intraday data follow the study of daily data. As discussed in Chapter 3, the structure of the intraday data is different from that of daily data. A new model specifically based on the intraday data taking consideration of truncation could be proposed. However, the huge intraday dataset requires a large amount of time to handle. The size of dataset is about 8.55 GB. The model estimation in the equation (3.3), (3.4) and respective log-likelihood ratio tests take about 4 months to run on a computer with a very high specification.

[32] More details can be found from: http://www.bbc.co.uk/news/business-35253188

The focus of this study is on AB-shares. The truncated-GARCH-M is introduced in this study. First, as reported in Table 1.3, there are more than 2,900 stocks in the Chinese stock market. The truncated-GARCH-M model can directly be applied to those stocks to examine the effects of price limits. Secondly, the model can also be used in the other markets which also implement price limits. Thirdly, the truncated-GARCH-M model in this thesis is based on the assumption of doubly truncated normal distribution. It could be able to derive truncated-GARCH-M or even truncated-GARCH-EGARCH/GJR models based on the assumption of a doubly truncated Student-t distribution.

In addition, this thesis presents a short illustration of the trading strategy and the magnet effect. The trading rule suggests the usefulness of tail probability. It lays the foundation for different combinations of trading rules based on tail probability. Future studies can be conducted to explore the trading strategy and magnet effect for the overall market. In Chapter 4, some well-known liquidity measures are applied to test trading interference hypothesis. In further study, a composite liquidity measure can be explored.

As discussed in Chapter 1, circuit breaker mechanisms are categorised into three different types: price limits, firm-specific trading halts and market-wide trading halts. The market-wide trading halts have a very short life in Chinese stock market, which is from 1st January 2016 to 8th January 2016. This short period poses a limit for further study. Future research could conduct an event study to compare the performance between price limits and firm-specific trading halts.

References

Aitken, M., and Comerton-Forde, C. (2003). How should liquidity be measured? *Pacific-Basin Finance Journal, 11* (1), 45-59.

Allison, P. D. (2001). *Missing data.* Thousand Oaks, California: Sage.

Amihud, Y. (2002). Illiquidity and stock returns: cross-section and time-series effects. *Journal of Financial Markets, 5* (1), 31-56.

Bagehot, W. (1971). The only game in town. *Financial Analysts Journal, 27* (2), 12-14.

Bailey, W., Cai, J., Cheung, Y, L., and Wang, F. (2009). Stock returns, order imbalances, and commonality: evidence on individual, institutional, and proprietary investors in China. *Journal of Banking & Finance, 33* (1), 9-19.

Bali, T. G., Peng, L., Shen, Y., and Tang, Y. (2014). Liquidity shocks and stock market reactions. *Review of Financial Studies*, *27* (5), 1434-1485.

Bekaert, G., Harvey, C. R., and Lundblad, C. (2007). Liquidity and expected returns: lessons from emerging markets. *The Review of Financial Studies, 20* (5), 1783-1831.

Berkman, H., and Lee, J. B. T. (2002). The effectiveness of price limits in an emerging market: evidence from the Korean Stock Exchange. *Pacific-Basin Finance Journal*, *10* (5), 517-530.

Bikhchandani, S., Hirshleifer, D., and Welch, I. (1992). A theory of fads, fashion, custom, and cultural change as informational cascades. *Journal of Political Economy, 100* (5). 992-1026.

Bildik, R., and Gülay, G. (2006). Are price limits effective? evidence from the Istanbul Stock Exchange. *The Journal of Financial Research, 29* (3), 383-403.

Black, F. (1971). Toward a fully automated stock exchange. *Financial Analysts Journal, 27* (4), 28-35.

Blume, L., Easley, D., and O'Hara, M. (1994). Market statistics and technical analysis: the role of volume. *The Journal of Finance, 49* (1), 153-181.

Bollerslev, T. (1986). Generalised autoregressive conditional heteroscedasticity, *Journal of Econometrics*, *31* (3), 307-327.

Box, G. E. P., Jenkins, G. M., and Reinsel, G. C. (2008). *Times series analysis: forecasting and control*. (4th ed.) Hoboken, New Jersey: John Wiley & Sons.

Brady Commission Report. (1988). *Report of the Presidential Task Force on Market Mechanisms.* Retrieved February 23, 2013 from http://www.archive.org/stream/reportofpresiden01unit#page/n5/mode/2up

Brockman, P., and Chung, D. Y. (2002). Commonality in liquidity: evidence from an order-driven market structure. *The Journal of Financial Research, 25* (4), 521-539.

Brockman, P., Chung, D. Y., and Pérignon, C. (2009). Commonality in liquidity: a global perspective. *Journal of Financial and Quantitative Analysis, 44* (4), 851-882.

Brooks, C. (2008). *Introductory econometrics for finance*. (2nd ed.) Cambridge: Cambridge University Press.

Brown, S. J. and Warner, J. B. (1985). Using daily stock returns: the case of event studies. *Journal of Financial Economics*, *14* (1), 3–31.

Busse, J. A., and Green, T. C. (2002). Market efficiency in real time. *Journal of Financial Economics, 65* (3), 415-437

Campbell, J. Y., Grossman, S. J., and Wang, J. (1993). Trading volume and serial correlation in stock returns. *Quarterly Journal of Economics, 108* (4), 905-939.

Chan, S. H., Kim, K. A., and Rhee, S. G. (2005). Price limit performance: evidence from transactions data and the limit order book. *Journal of Empirical Finance, 12* (2), 269-290.

Chan, K., Menkveld, A. J., and Yang, Z. (2008). Information asymmetry and asset prices: evidence from the China foreign share discount. *The Journal of Finance, 63* (1), 159-196.

Chen, G. M., Kim, K. A., and Rui, O. M. (2005). A note on price limit performance: the case of illiquid stocks. *Pacific-Basin Finance Journal, 13* (1), 81-92.

Chen, G. M., Rui, O. M., and Wang, S. S. (2005). The effectiveness of price limits and stock characteristics: evidence from the Shanghai and Shenzhen Stock Exchanges. *Review of Quantitative Finance and Accounting, 25* (2), 159-182.

Chen, Y. M. (1993). Price limits and stock market volatility in Taiwan. *Pacific-Basin Finance Journal, 1* (2), 139-153.

Chiang, T.C., and Zheng, D. (2010). An empirical analysis of herd behavior in global markets. *Journal of Banking & Finance, 34* (8), 1911-1921

China Securities Regulatory Commission. (2012). *Annual Reports: CSRC Annual Report 2011*. Retrieved January 13, 2013 from http://www.csrc.gov.cn/pub/csrc_en/about/annual/201205/P020120515677609374835.pdf

Chiang, T.C., and Zheng, D. (2010). An empirical analysis of herd behavior in global markets. *Journal of Banking & Finance, 34* (8), 1911-1921

Cho, D. D., Russell, J., Tiao, G. C., and Tsay, R. (2003) The magnet effect of price limits: evidence from high-frequency data on Taiwan Stock Exchange. *Journal of Empirical Finance, 10* (1-2), 133-168.

Chordia, T., Roll, R., and Subrahmanyam, A. (2000). Commonality in liquidity. *Journal of Financial Economics, 56* (1), 3-28.

Chordia, T., Roll, R., and Subrahmanyam, A. (2001). Market liquidity and trading activity. *The Journal of Finance, ??* (2), 501-530.

Chordia, T., Roll, R., and Subrahmanyam, A. (2002). Order imbalance, liquidity and market returns. *Journal of Financial Economics, 65* (1), 111-130.

Chung, J. R. (1991). Price limit system and volatility of Korean Stock Market. *Pacific-Basin Capital Markets Research, 2*, 283-294.

Chung, J. and Gan, L. (2005). Estimating the effect of price limits on limit-hitting days. *Econometrics Journal, 8* (1), 79–96.

Cooper, S. K., Groth, J. C., and Avera, W. E. (1985). Liquidity, exchange listing, and common stock performance. *Journal of Economics & Business, 37* (1), 19-33.

Copeland, T. E., and Galai, D. (1983). Information effects on the bid-ask spread. *The Journal of Finance, 38* (5), 1457-1469.

Corwin, S. A., and Schultz, P. (2012). A simple way to estimate bid-ask spreads from daily high and low prices. *The Journal of Finance, 67* (2), 719-759.

Datar, V. T., Naik, N. Y., and Radcliffe, R. (1998). Liquidity and stock returns: an alternative test. *Journal of Financial Markets, 1* (2), 203-219.

De Bondt, W. F., and Thaler, R. (1985). Does the stock market overreact? *The Journal of Finance 40* (3), 793-805.

Deb, S. S., Kalev, P. S., and Marisetty, V. B. (2010). Are price limits really bad for equity markets? *Journal of Banking & Finance, 34* (10), 2462-2471.

DeFusco, R. A., McLeavey, D. W., Pinto, J. E., Runkle, D. E., and Anson, M. J. P. (2007). *Quantitative Investment Analysis.* (2nd ed.) Hoboken, New Jersey: John Wiley & Sons.

Demsetz, H. (1968). The cost of transacting. *Quarterly Journal of Economics, 82* (1), 33-53.

Engle, R. F. (1982). Autoregressive conditional heteroskedasticity with estimates of the variance of United Kingdom inflation, *Econometrica, 50* (4), 987-1007.

Engle, R. F. (2000). The econometrics of ultra-high-frequency data. *Econometrica, 68* (1), 1-22.

Fama, E. F., and French, K. R. (1993). Common risk factors in the returns on stocks and bonds. *Journal of Financial Economics, 33* (1), 3-56.

Engle, R. F. and Ng, V. K. (1993). Measuring and testing the impact of news on volatility, *Journal of Finance, 34* (6), 1749-1778.

Fama, E. F. (1965). The behaviour of stock-market prices. *The Journal of Business, 38* (1), 34-105.

Fama, E. F. (1989). Perspectives on October 1987 or What did we learn from the crash? In R. W. Kamphuis., Jr, R.C. Kormendi and J.W.H. Watson (eds.), *Black Monday and the Future of Financial markets.*(pp. 71-82). Chicago, IL: Irwin.

Fan, J. P. H., Wong, T. J., and Zhang, T. (2007). Politically connected CEOs, corporate governance, and post-IPO performance of China's newly partially privatized firms. *Journal of Financial Economics*, *84* (2), 330-357.

Farag, H. (2013). Price limit bands, asymmetric volatility and stock market anomalies: evidence from emerging markets. *Global Finance Journal*, *24* (1), 85-97.

Farag, H. and Cressy, R. (2012). Stock market regulation and news dissemination: evidence from an emerging market. *The European Journal of Finance*, *18* (3-4), 351-368.

French, K. R., and Roll, R. (1986). Stock return variance: the arrival of information and the reaction of traders. *Journal of Financial Economics, 17* (1), 5-26.

George, T. J. and Hwang, C. Y. (1995). Transitory price changes and price-limit rules-evidence from the Tokyo stock exchange. *Journal of Financial and Quantitative Analysis*, *30* (2), 313-327.

Goyenko, R. Y., Holden, C. W., and Trzcinkka, C. A. (2009). Do liquidity measures measure liquidity? *Journal of Financial Economics, 92* (2), 153-181.

Grossman, S. J. (1988). Program trading and market volatility: a report on interday relationships. *Financial Analysts Journal*, *44* (4), 18-28.

Harris, L. (2003). *Trading & exchanges: market microstructure for practitioners.* Oxford: Oxford University Press

Hansen, L. P. (1982). Large sample properties of generalized method of moments estimators, *Econometrica, 50* (4). 1029-1054.

Hasbrouck, J. (2009). Trading costs and returns for U.S. equities: estimating effective costs from daily data. *The Journal of Finance. 64* (3), 1445-1477.

Hasbrouck, J., and Seppi, D. J. (2001). Common factors in price, order flows, and liquidity. *Journal of Financial Economics, 59* (3), 383-411.

Henke, H., and Voronkova, S. (2005). Price limits on a call auction market: evidence from the Warsaw Stock Exchange. *International Review of Economics and Finance, 14* (4), 439-453.

Howe, J. S. and Schlarbaum, G. G. (1986). SEC trading suspensions: empirical evidence. *Journal of Financial and Quantitative Analysis 21* (3), 323–333.

Hsieh, P, H., Kim, Y. H., and Yang, J. J. (2009). The magnet effect of price limits: a logit approach*. Journal of Empirical Finance, 16 (5)*, 830-837.

Huang, Y. S. (1998). Stock price reaction to daily limit moves: evidence from the Taiwan Stock Exchange. *Journal of Business Finance & Accounting, 25* (3-4), 469-483.

Huang, Y. S., Fu, T. W., and Ke, M. C. (2001). Daily price limits and stock price behaviour: evidence from the Taiwan stock exchange. *International Review of Economics and Finance, 10* (3), 263-288.

Huang, R. D., and Stoll, H. R. (1996). Dealer versus auction markets: a paired comparison of execution costs on NASDAQ and the NYSE. *Journal of Financial Economics, 41* (3), 313-357.

Kamara, A., Lou, X., and Sadka, R. (2008). The divergence of liquidity commonality in the cross-section of stocks. *Journal of Financial Economics, 89* (3), 444-466.

Kempf, A., and Mayston, D. (2008). Liquidity commonality beyond best prices. *The Journal of Financial Research, 31* (1), 25-40.

Keynes, J. M. (1930). A treatise on money. vol.2, the applied theory of money London: Macmillan.

Kim, K. A. (2001). Price limits and stock market volatility. *Economics Letters, 71* (1), 131-136.

Kim, K. A., and Rhee, S. G. (1997). Price limit performance: evidence from the Tokyo Stock Exchange. *The Journal of Finance, 52* (2), 885-901.

Kim, K. A., Liu, H., and Yang, J. J. (2011). Reconsidering price limit effectiveness. Working paper.

Kim, K. A., Liu, H., and Yang, J. J. (2013). Reconsidering price limit effectiveness. *The Journal of Financial Research, 36* (4), 493-517.

Kim, Y. H., and Yang, J. J. (2004). What makes circuit breakers attractive to financial markets? A survey. *Financial Markets, Institutions & Instruments, 13* (3), 109-146.

Kim, Y. H., and Yang, J. J. (2008). The effect of price limits on intraday volatility and information asymmetry. *Pacific-Basin Finance Journal, 16* (5), 522-538.

Kim, Y. H., Yagüe, J., and Yang, J. J. (2008). Relative performance of trading halts and price limits: evidence from the Spanish Stock Exchange. *International Review of Economics and Finance, 17* (2), 197-215.

Kodres, L. E. (1993). Tests of unbiasedness in the foreign exchange futures markets: an examination of price limits and conditional heteroscedasticity. *Journal of Business, 66* (3), 463-490.

LeBaron, B. (1992). Some relations between volatility and serial correlations in stock market returns. *Journal of Business, 65* (2), 199-219.

Lang, M., and Maffett, M. (2011). Transparency and liquidity uncertainty in crisis periods. *Journal of Accounting and Economics, 52* (2-3), 101-125.

Lauterbach , B., and Ben-Zion, U. (1993). Stock market crashes and the performance of circuit breakers: empirical evidence. *The Journal of Finance, 48* (5), 1909-1925.

Lee, C. M. C., Ready, M. J. and Seguin, P. J. (1994). Volume, volatility, and New York stock exchange trading halts. *Journal of Finance, 49* (1), 183-214.

Lee, J. H., and Chou, R. K. (2004). The intraday stock return characteristics surrounding price limit hits. *Journal of Multinational Financial Management, 14* (4-5), 485-501.

Lee, J. H., Lin, S. Y., Lee, W. C., and Tsao, C. Y. (2006). Common factors in liquidity: evidence from Taiwan's OTC stock market. *International Review of Financial Analysis, 15* (4), 306-327.

Lee, S. B., and Chung, J. S. (1996). Price limits and stock market efficiency. *Journal of Business Finance & Accounting, 23* (4), 585-601.

Lee, S. B., and Kim, K. J. (1995). The effect of price limits on stock price volatility: empirical evidence in Korea. *Journal of Business Finance & Accounting, 22* (2), 257-267.

Lehmann, B. N. (1989). Commentary: volatility, price resolution, and the effectiveness of price limits. *Journal of Financial Services Research, 3* (2-3), 205-209.

Leland, H., and Rubinstein, M. (1988). Comments on the market crash: six months after. *Journal of Economic Perspectives, 2* (3), 45-50.

Lesmond, D. A., Ogden, J. P., and Trzcinka, C. A. (1999). A new estimate of transaction costs. *The Review of Financial Studies, 12* (5), 1113-1141.

Lesmond, D. A. (2005). Liquidity of emerging markets. *Journal of Financial Economics, 77* (2), 411-452.

Li, H., Zheng, D. and Chen, J. (2014). Effectiveness, cause and impact of price limit-evidence from China's cross-listed stocks. *Journal of International Financial Markets, Institutions & Money, 29* (March), 217-241.

Li, K., Wang, T., Cheung, Y. L., and Jiang, P. (2011). Privatization and risk sharing: evidence from the split share structure reform in China. *The Review of Financial Studies, 24* (7), 2499-2525.

Little, R. J. A., and Rubin, D. B. (2002). *Statistical analysis with missing data*. (2^{nd} ed.) Hoboken, New Jersey: John Wiley & Sons.

Long, J. S. (1997). *Regression models for categorical and limited dependent variables.* Thousand Oaks, California: Sage Publications.

Lu, C., Wang, K., Chen, H., and Chong, J. (2007). Integrating A- and B-share markets in China: the effects of regulatory policy changes on market efficiency. *Review of Pacific Basin Financial Markets and Policies, 10* (3), 309-328.

Ma, C. K., Rao, R.P., and Sears, R. S. (1989). Volatility, price resolution, and the effectiveness of price limits. *Journal of Financial Services Research, 3* (2-3), 165-199.

Massey, F. J. (1951). The Kolmogorov-Smirnov test for goodness of fit. *Journal of the American Statistical Association, 46* (253), 68-78.

Martin, P. (1975). Analysis of the impact of competitive rates on the liquidity of NYSE stocks. Economics Staff Paper, 75-3. Securities and Exchange Commission. Cited in: Lee, J. H., and Chou, R. K. (2004). The intraday stock return characteristics surrounding price limits hits. *Journal of Multinational Financial Management, 14* (4-5), 485-501.

Mei, J., Scheinkman, J. A., and Xiong, W. (2009). Speculative trading and stock prices: evidence from Chinese A-B share premia. *Annals of Economics and Finance, 10* (2), 225-255.

NASDAQ (2016). *Market Wide Circuit Breaker.* Retrieved February, 2016 from http://www.nasdaqtrader.com/trader.aspx?id=CircuitBreaker

NASDAQ (2016). *Trading Halts.* Retrieved February, 2016 from http://www.nasdaqtrader.com/Trader.aspx?id=TradeHaltCodes

Park, C. W. (2000). Examining futures price changes and volatility on the trading day after a limit-lock day. *Journal of Futures Markets, 20* (5), 445-466.

Pástor, L. and Stambaugh, R. F. (2003). Liquidity risk and expected stock returns. *Journal of Political Economy*, *111* (3), 642-685.

Phylaktis, K., Kavussanos, M., and Manalis, G. (1999). Price limits and stock market volatility in Athens Stock Exchange. *European Financial Management*, *5* (1), 69-84.

Pitman, E. J. G. (1939). A note on normal correlation. *Biometrika*, *31* (1-2), 9-12.

Pollin, R., and Heintz, J. (2011). *Transaction costs, trading elasticities and the revenue potential of financial transaction taxes for the United States*. Retrieved April, 2016 from http://www.peri.umass.edu/fileadmin/pdf/research_brief/PERI_FTT_Research_Brief.pdf

Roll, R. (1984). A simple implicit measure of the effective bid-ask spread in an efficient market. *The Journal of Finance*, *39* (4), 1127-1139.

Roll, R. (1988). The international crash of October 1987. *Financial Analysts Journal, 44* (5), 19-35.

Roll, R. (1989). Price volatility, international market links, and their implications for regulatory policies. *Journal of Financial Services Research, 3* (2-3), 211-246.

Ryoo, H. J., and Smith, G. (2002). Korean stock prices under price limits: variance ratio tests of random walks. *Applied Financial Economics*, *12* (8), 545-553.

Seasholes, M. S., and Wu, G. (2007). Predictable behaviour, profits, and attention. *Journal of Empirical Finance*, *14* (5), 590-610.

Sentana, E., and Wadhwani, S. (1992). Feedback traders and stock return autocorrelations: evidence from a century of daily data. *The Economic Journal*, *102* (411), 415-425.

Shanghai Stock Exchange. (2012). *News Releases: Notice of Revising Some Articles in "SSE Trading Rules"*. Retrieved January 13, 2013 from http://english.sse.com.cn/aboutsse/news/c/c_20130108_3679127.shtml

Shanghai Stock Exchange. (2006). *TRADING RULES OF SHANHAI STOCK EXCHANGE.* Retrieved January 13, 2013 from http://english.sse.com.cn/tradmembership/trading/rules/c/en_sserule20060515.pdf

Shen, C. H., and Wang, L. R. (1998). Daily serial correlation, trading volume and price limits: evidence from the Taiwan stock market. *Pacific-Basin Finance Journal, 6* (3-4), 254-273.

Subrahmanyam, A. (1994). Circuit breakers and market volatility: a theoretical perspective. *The Journal of Finance*, *49* (1), 237-254.

Tian, G.G., and Guo, M. (2007). Interday and intraday volatility: additional evidence from the Shanghai Stock Exchange. *Review of Quantitative Finance and Accounting, 28* (3), 287-306.

Titman, S., and Tiu, C. (2011). Do the best hedge funds hedge? *The Review of Financial Studies, 24* (1). 123-168.

Tobin, J. (1958). Estimation of relationships for limited dependent variables. *Econometrica*, *26* (1). 24-36.

Tong, W.H.S., and Yu, W.W. (2012). A corporate governance explanation of the A-B share discount in China. *Journal of International Money and Finance, 31* (2), 125-147.

Tsay, R. S. (2005). *Analysis of financial time series*. (2^{nd} ed.) Hoboken, New Jersey: John Wiley & Sons.

Von Hippel, P. T. (2004). Bias in SPSS 12.0 missing value analysis. *The American Statistician*, *58* (2), 160-164.

Wei, S. X. (2002). A censored-GARCH model of asset returns with price limits. *Journal of Empirical Finance*, *9* (2), 197-223.

Wong, D. K. T., and Li, K. W. (2010). Comparing the performance of relative stock return differential and real exchange rate in two financial crises. *Applied Financial Economics, 20* (1-2), 137-150.

Wong, W. K., Chang, M. C., and Tu, A. H. (2009). Are magnet effects caused by uninformed traders? Evidence from Taiwan Stock Exchange. *Pacific-Basin Finance Journal*, *17* (1), 28-40.

Wong, W. K., Liu, B. and Zeng, Y. (2009). Can price limits help when the price is falling? evidence from transactions data on the Shanghai stock exchange. *China Economic Review*, *20* (1), 91–102.

World Federation of Exchanges (2015). *Monthly Report.* Retrieved February, 2016 from http://www.world-exchanges.org/home/index.php/statistics/monthly-reports

Wyss, Rico von (2004). *Measuring and Predicting Liquidity in the Stock Market.* PhD Dissertation. University St. Gallen.

Yip, R. W. Y., and Young, D. (2012). Does mandatory IFRS adoption improve information comparability? *The Accounting Review, 87* (5), 1767-1789.