The Magnet Effect of Price Limits on the Shanghai Stock Exchange and the Impact of the Shanghai - Hong Kong Connect

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I hereby certify that this has not been submitted for a higher degree to any other university or institution.

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Abstract

This paper tests for the existence of the magnet effect linked to price limits imposed in China's equity markets and how a market liberalization event affects trading in securities that are bound by price limits vis-à-vis those that are not. The magnet effect of price limits theorises that, instead of stabilising markets, price limits act as a magnet and their existence causes trading to accelerate towards the limits, increasing the likelihood of the limit being reached. This study provides evidence of the magnet effect in China and that the effect increases in magnitude following the opening of China's capital markets via the Shanghai-Hong Kong Connect (SHHKConnect). The increased magnitude of the magnet effect of price limits is due to the new inflow of capital from global markets via Hong Kong, as stronger results are found for those firms that experience the largest increase in capital inflow vis-à-vis those that do not.

Introduction

Across global equity markets, extreme stock price fluctuation has been shown to be higher in developing markets than in mature, developed markets (Bekaert and Harvey, 1995, Bekaert and Harvey, 1997, Caner and Önder, 2005, Harvey, 1995). While large price movements over short periods of time create opportunities for profit, these are generally considered an undesirable characteristic of a security market by market operators and regulators alike given the inherent uncertainty they bring. As a result, circuit breakers and other price stabilising mechanisms have been introduced around the world to curb such instances in equity markets by, for instance, providing greater consultation time between brokers and their clients (Kim and Yang 2004) and similarly in futures markets to mitigate risks around margin payments.[1]

Given the higher rates of stock price fluctuation in developing markets, it is therefore unsurprising that a greater number of price limits and other price stabilising mechanisms are found in developing equity markets rather than developed ones (Deb et al., 2010). Scholars generally attribute this to the fact that developing countries are commonly associated with greater levels of corruption and lower levels of efficiency when it comes to legal, regulatory and technology environments than advanced economies (Deb et al., 2010). One of the key elements in moving from a developing market to a mature developed market is financial liberalisation – namely opening capital markets to foreign investors. Engaging in this process of capital market liberalisation can have profound ramifications for a country's economic and capital market growth (Bekaert et al., 2005, Bekaert and Harvey, 2000, Ben Gamra, 2009). One type of capital market liberalisation occurs in the form of creating multilateral or bilateral investment, or other trade channels that enable foreign investors access to previously closed financial markets. Studies suggest that these kinds of liberalisation result in positive changes in the form of benefits to domestic firms' cost of capital, economic growth and private investment (Bekaert et al., 2005, Bekaert et al., 2006, Ben Gamra, 2009).

At the same time, a number of studies have found that financial liberalisation in developing markets has led to an increase in price and return volatility (Jaleel and

[1] The Black Monday Crash of 19th October 1987 and the subsequent recommendations Brady Commission Report of January 1998 brought the use and discussion of circuit breakers to the forefront of financial markets. The Crash saw the Dow Jones Industrial Average (DJIA) fall by 22.61% in one day, and is generally seen as having being driven by program traders as a reaction to computerised selling required by portfolio insurance hedge strategies. One of the findings of the Brady Commission Report that investigated the mid-October "market break" was that "circuit breaker mechanisms (such as price limits and coordinated trading halts) should be formulated and implemented to protect the market system" (Brady Commission Report, 1998).

Samarakoon, 2009, Füss, 2005, Wang, 2007, Bae et al., 2004), whilst others have found a decrease (Ndako, 2012, James and Karoglou, 2010). Furthermore, several authors have found that the introduction of price limits in markets has provided a positive impact (Kim et al., 2013, Lee and Kim, 1995, Ma et al., 1989); others report negative effects by focusing on instances of traders deviating from their optimal trading strategy to avoid being adversely affected or not being able to execute at the limit – the so called "magnet effect hypothesis" described by Subrahmanyam (1994). According to this hypothesis, price limits fail to minimise irrational behaviour and stabilise markets and instead may act as a magnet – the existence of which causes trading to accelerate towards the price limit and thus increases the likelihood of the price limit being reached.

This paper seeks to build on the mixed evidence surrounding the effects of market liberalisation and the impact of price limits on financial markets by re-visiting these issues in a Chinese. It will do so in two ways. First, by testing for magnet effects of price limits using intraday data. There are a limited number of papers that discuss the magnet effect of price limits in international stock exchanges in terms of intraday analysis (Hsieh et al., 2009, Du et al., 2009, Wong et al., 2009b), vis-à-vis daily analysis (Kim et al., 2013, Tooma, 2011). Of the current literature covering price limits, several authorities (Cho et al., 2003, Chou et al., 2013, Du et al., 2009, Hsieh et al., 2009, Tooma, 2011, Wong et al., 2009a, Wong et al., 2009b) report evidence in support of the magnet effect, whereas others (Abad and Pascual, 2007, Arak and Cook, 1997, Berkman and Steenbeek, 1998, Kim et al., 2013) report evidence to the contrary. Second, by examining the impact of the Shanghai-Hong Kong Stock Connect (SHHKConnect) on the magnet effect of price limits in China. The introduction of the SHHKConnect provides a natural experiment to examine the causal effect between market liberalisation and price limits.

Introduced on 17th November 2014 by the Securities and Futures Commission in Hong Kong and the China Securities Regulatory Commission (CSRC) in mainland China, SHHKConnect formalised the opening of the mainland Chinese securities market and opened up bilateral trade with the Stock Exchange of Hong Kong. SHHKConnect allows mainland Chinese investors to purchase designated securities listed on the Stock Exchange of Hong Kong (SEHK) for the first time in history. Similarly, the accompanying bilateral trade regulation allows Hong Kong based investors (domestic or international) to purchase designated securities listed on the Shanghai Stock Exchange.

While the intraday aspects of price limits are the focus of this study, other authors have examined issues relating to price limits. These include – but are not limited to – the trading interference (Lauterbach and Ben-Zion, 1993, Kim and Rhee, 1997, Ma et al., 1989), the volatility spillover effect (Fama, 1989, Lehmann, 1989, Kim and Yang, 2008, Chen et al., 2005a), and the delayed price discovery hypothesis. This body of literature is concerned with the market and trade impacts of price limits on an ex-post basis – namely the subsequent days after a limit hit and the ramifications for markets and participants. Another body of the price limit literature focuses on the optimal design of limits (Kim, 2001, Farag, 2013, Deb et al., 2013), as well as the use of price limits for objectives other than moderating investor behaviour, such as addressing corruption and market manipulation (Deb et al., 2010, Kim and Park, 2010). By contrast, this study focuses on the ex-ante impact of price limits in light of market liberalisation.

This paper applies a logistic regression framework to investigate whether, as per theory, the likelihood of a trading advancing towards a price limit increases as the limit draws near. After controlling for known microstructure frictions that contribute to price movements in security prices, this study identifies the existence of the magnet as a stock progresses through individual price steps. To isolate the identification of the magnet effect and market liberalisation, this research subdivides its sample into three groups. First, those which are dual-listed between the SSE and Securities Exchange Hong Kong (69 Dual-listed securities) and second, those that are simply available via Connect (474 Connect securities of the 543 eligible). Finally, a sample of the 100 largest securities on the Shenzhen Stock Exchange (SZSE) is also identified as a counterfactual to evaluate the impact the SHHKConnect on securities subject to price limits, but are not available to trade via the SHHKConnect.

Evidence of the magnet effect is observed for Connect securities trading on the SSE, with an increasing likelihood that prices advance towards a limit as the limit draws near. Both upper limit hits ("ceilings"), and lower limit hits ("floors") are tested, and significant results are found in both limit types – in line with other academic findings. More pronounced magnet effects were observed in Connect securities post-Connect whilst no change was observed on the non-Connect (Shenzhen) securities, indicating that the SHHKConnect led to a change in the magnet effect of price limits.

Robustness tests were carried out showing that the Connect securities that received the largest post-Connect Northbound trade volume exhibited the largest change in the magnet effect. An analysis of the SHHKConnect under a price limit regime appears to have impacted the trading decisions of Hong Kong based investors who seek higher investment returns in the mainland exchange days after a price limit hit, while no change in the delayed price discovery of price limits appears to have occurred on the SSE.

This paper is structured around the following sections: institutional details on the SSE and SZE; the relevant body of literature for this study; the study's hypothesis; data and descriptive statistics; the methodology; results and the conclusion of the paper.

Institutional Details

In this section, an account of the historical background and development of China's financial markets is provided. Institutional details regarding the market structure and operation of price limits on the SSE and SEHK are included, followed by details regarding the SHHKConnect.

China's Security Markets

Mainland China's two stock exchanges, the Shanghai Stock Exchange (SSE) and the Shenzhen Stock Exchange (SZSE), were both established in 1990. The two exchanges have experienced rapid growth in their market capitalisation for more than two-decades: at the beginning of 2003, the market capitalisation was CNY 2,829 billion (USD 455.5 billion) and CNY 1,424 billion (USD 229.3 billion) for the SSE and SZSE respectively. At the end of March 2015, their market capitalisation was CNY 29,221 billion (USD 4,705 billion) and CNY 18,480 billion (USD 2,975.8 billion). These two markets remain the primary exchanges in Mainland China, and they have been relatively closed to outsiders since their inception, compared to capital markets in other developed countries and regions.

The Chinese stock markets have experienced a slow but gradual liberalisation towards international investors. Before 1992, Chinese companies only issued A-shares, available to domestic Chinese investors. These A-shares are ordinary shares that are denominated and traded in Chinese Renminbi (RMB). International investors did not have access to the Chinese markets nor the A-shares, but the introduction of B-shares in February 1992 enabled foreign investors access to invest in the Chinese securities market. B-shares are a special class of share, quoted and traded in foreign currencies (typically traded in US dollars). February 2001 saw domestic Chinese investors granted access to trade B shares (through legal foreign currency accounts[2]) alongside foreign institutional investors for the first time.

As a result of China joining the World Trade Organization (WTO) in 2001, the Chinese government introduced the Qualified Foreign Institutional Investor (QFII) Scheme. The scheme which became operational in July 2003 facilitated certified foreign institutional

2 http://www.hkex.com.hk/eng/prod/secprod/eqty/documents/equities.pdf

investors having direct access to invest in China's stock markets. Notwithstanding the QFII licence, foreign institutional investors were only able to invest in China on a limited basis, and investments under the scheme were strictly regulated in terms of quota, products, accounts and funds conversion eligible to be traded. The eligible products under the scheme included A-shares and listed funds (simultaneously eliminating the need for new issues of B-class shares).

Along with A- and B-shares, H-shares are another class of shares that can be issued by Chinese companies. H-shares are issued by companies that are incorporated in mainland China but are listed and traded on the Stock Exchange of Hong Kong (SEHK). A major benefit of a mainland company listing on the SEHK is the easier access to capital given the Hong Kong government's more lenient regulation than the mainland government regarding external capital flows. Consequently, it is advantageous for mainland companies to list on the SEHK and gain greater access to capital.

Data obtained from the China Securities Regulatory Commission (CSRC) show that by March 2015, there were 208 H-shares companies listed, of which 69 were cross-listed on both SSE and SEHK. The A- and H-shares of a particular company share the same income stream but trade in different currencies and on different exchanges. Contrary to expectations, there exists a premium between these two shares classes, where the SSE listed A-shares trade at a premium to their SEHK pair.

Structure of the Shanghai Stock Exchange

At the end of 2015, there were 1,081 companies listed on the SSE with a total market capitalisation of CNY 29.52 trillion (USD 4.27 trillion). The average turnover of the SSE, on one of its 244 trading days in the year of 2015 was CNY 545.4 billion (USD 78.92 billion).

Security trading on the SSE is conducted with an electronic order driven mechanism with two trading sessions: a morning and an afternoon session. The first session starts with an opening call auction, from 9:15am to 9:25am, followed by continuous trading from 9:30am to 11:30am. The market is closed between 11:30am and 13:00pm when the second continuous trading session recommences in the afternoon between, 13:00pm to 15:00pm.

Limit orders and markets are entered and accepted during the continuous trading sessions. In these sessions, orders are sent through either the terminals at exchange members' firms or the terminals on the trading floor. The exchange maintains a fully lit order book, and dark trades are not permitted on the exchange[3].

After 22nd September 2004, the SSE displayed the top five levels bid and ask quotes present in the market[4]. Orders are matched automatically through a centralised exchange trading system and are executed according to price and time priority. Security settlement for A-shares is on the transaction (T) day and day trading is not permitted on the SSE, meaning that securities bought on day T can only be sold on day T+1. Short-selling and trades using margin were only permitted from March 2010. At the end of 2014, there were 91 member securities companies with margin trading and securities lending licences[5].

The board lot size at the SSE is 100 shares, while the maximum size for a single order is 1 million shares (10,000 board lots). For A-shares, if a single order requests 3,000 board lots (or RMB 2 million worth of securities); the order can be submitted as a block trade. Orders for block trades are accepted during the two continuous trading sessions throughout the day, while block trades are executed after the market has closed, from 15:00pm to 15:30pm. For the analytical purpose of this paper, only trading that takes place before 15:00pm is analysed, therefore block trade data are not included. The minimum price increment (tick) across all A-shares traded on the SSE is CNY 0.01, and all trades are subject to stamp duty, equivalent to 0.1% of trading value.

Structure of the Shenzhen Stock Exchange

The Shenzhen Stock Exchange (SZSE) is the smaller of the two mainland Chinse stock exchanges. At the end of 2016, there were 1,870 companies listed on the SZSE with a total Mainboard market capitalisation of CNY 7.27 trillion (USD 1.05 trillion). The average turnover of the SZSE, on one of its 244 trading days in the year of 2015 was CNY 382.9 billion (USD 55.31 billion)[6].

Similar to the SSE, security trading on the SZSE is conducted with an electronic order driven mechanism with two trading sessions: a morning and an afternoon session. The first session starts with an opening call auction, from 9:15am to 9:25am, followed by continuous trading from 9:30am to 11:30am. The market is closed between 11:30am and 13:00pm when the second continuous trading session recommences in the afternoon between, 13:00pm to

3 http://english.sse.com.cn/tradmembership/trading/overview/

4 This research only uses top level book depth, as supplied by the data provider, TRTH.

5 http://english.sse.com.cn/indices/publications/factbook/c/4172526.pdf

6 http://www.szse.cn/UpFiles/largepdf/20170321091732.pdf

14:57pm. From 14:57-15:00pm a closing call auction is conducted, at which point, continuous trade ceases for the day.

Limit orders and markets are entered accepted during the continuous trading sessions. The SZSE also allows for Immediate or Cancel and Fill or Kill orders to be entered during the continuous trading sessions. In these sessions, orders are sent through either the terminals at exchange members' firms or the terminals on the trading floor. The exchange maintains a fully lit order book, whilst dark trades are not permitted on the exchange.

Orders are matched automatically through a centralised exchange trading system and are executed according to price and time priority. Security settlement for A-shares is on the transaction (T) day and day trading is not permitted on the SZSE, meaning that securities bought on day T can only be sold on day T+1. Short-selling and trades using margin are only permitted from March 2010.

The board lot size at the SZSE is 100 shares, while the maximum size for a single order is 1 million shares (10,000 board lots). For A-shares, if a single order requests 3,000 board lots (or RMB 2 million worth of securities), the order can be submitted as a block trade. Orders for block trades are accepted from during the two continuous trading sessions throughout the day, while block trades are executed after the market has closed, from 15:05pm to 15:30pm. For the analytical purpose of this paper, only trading that takes place before 15:00pm is analysed, therefore block trade data are not included. The minimum price increment (tick) across all A-shares traded on the SZSE is CNY 0.01, and all trades are subject to stamp duty, equivalent to 0.1% of trading value.

Price Limit Determination in Mainland China's Financial Markets

The Chinese Securities Regulatory Commission mandates the imposition of daily price limits on both of the exchanges under its auspices, the SSE[7] and the SZSE[8], however the exchanges themselves handle the day-to-day monitoring and implementation of the price limits. Both mainland stock exchanges are subject to the same price limits, and for the purposes of simplicity, this research will discuss the limit determination in general, applying to both exchanges.

[7] http://english.sse.com.cn/tradmembership/rules/c/3977570.pdf

[8] http://www.szse.cn/main/en/rulseandregulations/sserules/200609259304.shtml

Introduced in 1996, the exchanges impose a daily price limit of 10% on securities[9] and mutual funds. The previous day's close price, the reference price, is the price from which the current day's maximum allowable movement is determined. The closing price of a security, for any given day, is the volume-weighted average price of all the trades up to, and including, the last trade of the day[10]. The price limit is calculated from the following:

$$PriceLimit_d = ClosingPrice_{d-1} \times (1 \pm 10\%)$$

where *d* is the day of the limit hit, *d-1* is the previous day. The result is rounded to the nearest tick. Orders that are within the limit of the day are accepted by the exchange and are executed or placed on the order book. Orders whose quotes are outside the limit are considered invalid, and are rejected by the exchange.

Price limits are not enforced on the first day of trading for the following:

- Initial Public Offerings or closed-end funds;
- Securities who issue further shares;
- Securities whose trading is resumed after suspension; or
- Special cases recognized by the exchange.

The Exchange may adjust the daily limit, subject to approval by the CSRC, although no alterations to the 10% limit were made during the period of study considered in this research.

Structure of the Hong Kong Stock Exchange

The Stock Exchange of Hong Kong (SEHK) is the only exchange in Hong Kong where securities are listed and traded. Operated by the Stock Exchange and Hong Kong Futures Exchange Limited, the SEHK is a wholly-owned subsidiary of Hong Kong Exchanges and Clearing Ltd (HKEx). At the end of 2016, there were 1,724 stocks listed on the Main Board of the SEHK, of which 236 stocks were mainland-China domiciled companies[11]. Additionally, there are 69 dual-listed stocks on both the SSE and the SEHK. These stocks have been the subject of several academic studies because they offer unique insight into the China's markets, which has historically been closed to overseas investors. The average daily turnover, on any one of the 245 trading days in 2016 on the SEHK was HK$ 66.45 billion (USD 8.53 billion[12]).

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9 The exchange also imposes a 5% limit of a subgroup of securities that are under Special Treatment. These Special Treatment stocks are ones which have had poor financial results in the two prior financial years, and are monitored for continued performance. They are restricted to a lower daily price limit as a result. Special Treatment securities are excluded from the analysis.

10 http://english.sse.com.cn/tradmembership/rules/c/3977570.pdf

11 http://www.hkex.com.hk/eng/stat/statrpt/factbook/factbook2016/Documents/FB_2016.pdf

12 1 HKD = 0.13 USD, May 2017

Similar to the SSE, the SEHK has two main trading sessions throughout the day. The pre-opening session begins the day from 9:00am to 9:30am, followed by the morning continuous trading session from 9:30am to 12:00pm. The afternoon session starts from 13:00pm to and runs to 16:00pm.

The SEHK is a pure order-driven market. After investors place orders with their broker, the orders are routed to the Third Generation of Automatic Order Matching and Execution System at the exchange. Orders are automatically matched and executed according to price and time priority. Five order types are available to traders on the SEHK: At-auction Orders, At-auction Limit Orders, Limit Orders, Enhanced Limit Orders and Special Limit Orders. The settlement for securities on the SEHK is T+2, and day trading and short selling are both permitted on the SEHK.

Trading costs are higher on the SEHK than the SSE or SZSE. Trading costs on the SEHK include a Transaction Levy (0.0027%), Trading Fee (0.005%), and Stamp Duty on Stock Transactions of (0.1%). Per transaction, buyers are also subject to the Transfer Deed Stamp of HK$5.00 and sellers are subject to the Transfer Fee of HK$2.50.

The size of a single board lot of a stock is determined by the issuer company and orders with an odd lot are not accepted by the trading system. Odd-lot orders are traded on a special lot market where prices are lower for stocks traded, compared to the same stocks traded on the board lot market.

Block trades are facilitated on the SEHK and are executed and reported during the regular trading sessions throughout the day. For the purpose of this paper, block trades are not included. There is no universal minimum price change across stocks on the SEHK; however Table 1 below details the minimum tick size at varying security prices.

Table 1 – Minimum Tick Size for Securities Trading on the SEHK

Lower Price of Security	Upper Price of Security	Tick Size
0.01	0.25	0.001
0.25	0.5	0.005
0.5	10	0.01
10	20	0.02
20	100	0.05
100	200	0.1
200	500	0.2
500	1000	0.5
1000	2000	1
2000	5000	2
5000	9995	5

All values in Hong Kong Dollars

There is no price limit rule on the SEHK, but in 2016 the SEHK introduced a Volatility Control Mechanism (VCM), which is applied to the constituents of the Hang Seng Index and the Hang Seng China Enterprises Index. The VCM is triggered if a stock price changes ± 10% away from the last traded price 5-min ago. The VCM enforces a 5-min cooling-off period, during which trades are only executed within the ±10% price band[13].

The Shanghai-Hong Kong Stock Connect (SHHKConnect)

The Shanghai – Hong Kong Connect (SHHKConnect) was launched on 17th November 2014, and created a bilateral investment channel, allowing mutual market access to trade designated stocks listed on either the SSE or the SEHK.

The SHHKConnect enables for the first time, both institutional and retail investors to trade on both SSE and SEHK and represents an important step in the development of China's economy, by increasing its access to the world and the world's access to China via financial liberalisation of its main equity markets.

Of the 1,041 stocks listed on the SSE (at the time of SHHKConnect), investors via Hong Kong brokers could invest in 543 of them, referred to as 'Northbound' trading. These SHHKConnect eligible firms represent approximately 90% of the total market capitalisation of the SSE. Mainland Chinese investors can invest in 263 SEHK-listed stocks, of the 1,789[14] securities listed on the SEHK. Otherwise known as 'Southbound trading', this represents approximately 80% of market capitalisation of the SEHK.

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13 This VCM was implemented after the study period for this research.

14 At the onset of the SHHKConnect and relevant for this period of study.

The eligible SEHK-listed stocks to be traded under the SHHKConnect include all the member securities of Hang Seng Composite LargeCap Index and Hang Seng Composite MidCap Index, as well as the H-shares that are not included in the indices mentioned above. The SSE-listed stocks eligible to be traded via the SHHKConnect include all the constituents stocks of the SSE 180 Index and the SSE 380 Index, as well as A-shares that have corresponding H-shares cross-listed on the SEHK (if they are not constituent members of the indices mentioned already).

Mainland Chinese investors with more than RMB 500,000 (USD 72,430) or more in their broker accounts are eligible to invest in the SEHK through the SHHKConnect. SHHKConnect has provided mainland Chinese investors with easier access to the Hong Kong stock market. Prior to SHHKConnect, to trade on the SEHK, mainland investors had to open a trading account with a Hong Kong based broker, but were restricted by various constraints regarding funds flow in and out of China.

Even though prior to SHHKConnect overseas institutional investors had the ability invest in the SSE by acquiring QFII licenses and QFII quotas, the bilateral investment channel provides greater freedom for international investors to access Chinese securities. SHHKConnect also provides an opportunity for international retail investors to access the Chinese capital market by enabling them to directly select and hold stocks listed on the SSE.

As per the rules of SHHKConnect, the SSE and the SEHK each established a subsidiary in the other territory to act as a non-member trading participant in the other market[15]. The role of each subsidiary is to facilitate cross-boundary order-routing for exchange participants (EPs) of their home market. The SEHK subsidiary located in Shanghai, receives orders to trade stocks listed in China from an EP registered with the SEHK. The subsidiary routes the orders to the trading system at the SSE for matching and execution. The same arrangement exists for Northbound trade. Both Northbound and Southbound trading activities are restricted to secondary market trading only, excluding investors from participating in IPOs across the markets.

Clearing and settlement under SHHKConnect is conducted by respective clearing houses in each market. For the SSE, the China Securities Depository and Clearing Corporation Limited (ChinaClear) conducts clearing operations, while on the SEHK, the Hong Kong Securities Clearing Company Limited (HKSCC) clears transactions. ChinaClear and HKSCC established a clearing link between themselves, enabling the clearing houses act as a participant of each other.

[15] http://www.hkex.com.hk/eng/market/sec_tradinfra/chinaconnect/Documents/Investor_Book_En.pdf

Under the SHHKConnect, securities are traded in the trade market's local currency but settled in RMB. For Southbound trades, Chinese investors trade SEHK listed stocks in Hong Kong dollars while these trades will be settled with ChinaClear in Chinese RMB. Northbound trades are settled by the HKSCC with its clearing participants and ChinaClear again in RMB [16]. Northbound trades are settled following settlement rules in the SSE, which is day T for stock settlement and day T+1 for money settlement and vice versa for Southbound trades.

During the periods examined in this study, dollar-based volume quotas were imposed in both trading directions. The dollar volume of transactions was restricted by maximum cross-boundary investment quotas: the Aggregate Quota and the Daily Quota. The quotas aimed to limit the amount of funds flowing in and out of Mainland China under Northbound and Southbound Trading, respectively. Buying activities through the SHHKConnect are suspended when either quota is reached, however sell orders are always allowed regardless of quota level. The SSE updates the daily quota balance for Southbound Trading every minute, while the SEHK updates the real-time daily quota balance for the Northbound Trading every 5 seconds.

For the majority of trades across SHHKConnect, the market to which the trade is directed dictates the rules of the transaction. However, there are some trading arrangements under SHHKConnect that are modified based on the original trading rules in the trade-directed market, such as the order types, order submission time, permitted trade type and permitted trading strategy (uncovered short selling is not allowed for the Southbound trading). The price limits for SSE listed companies are not affected by SHHKConnect.

Dual-listed A- and H-shares (SSE and SEHK listed respectively) are not mutually exchangeable and this fungibility did not change with SHHKConnect. An A-share, for example, cannot be bought on the SSE and sold on the SEHK as its equivalent H-share.

Literature Review

Price Limit Background

Price limits fall under stock market rules "circuit breakers", an umbrella term for trading restrictions that are triggered by significant price movements in (mostly[17]) predetermined time periods. According to Kim and Yang (2004), circuit breakers can be

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[16] The implication of this is therefore that all currency conversions are conducted outside of China.

[17] Most price limits are implemented on pre-determined rules, although some exchanges reserve the right to implement a price limit at their discretion such as the Spanish Stock Exchange (Kim et al., 2008).

categorised as price limits, firm-specific trading halts or market-wide circuit breakers. These rules are implemented with the intention of curbing excessive volatility, to calm investors until extreme price movements dissipate.

Unlike price limits, once a firm-specific trading halt is triggered by a price movement outside of a predetermined limit, trading of that security is halted by the exchange for a period of time. In some instances, exchanges can arbitrarily implement halts on securities with no limit being reached, such as the Spanish Stock Exchange (Kim et al., 2008). A firm-specific trading halt rule will generally denote the allowable price movement, quoted in percentage terms and using the previous day's close price as the reference, as well as the extent of the time the halt will remain in place. The rule will also generally detail how many halts can occur in a single trading day or session. An example of a firm-specific trading halt rule would state that a maximum of two halts within a trading session can occur and a halt for 5 minutes would be triggered by the security moving 10% from its previous session's closing reference price.

Market-wide trading halts are another example of a price stabilising mechanism that halt trading on the entire security market, triggered once a pre-determined index limit is reached during the trading session. A well-known example of a market-wide circuit breaker is the New York Stock Exchange's circuit breaker, documented in Kim and Yang (2004). This review will focus mainly on price limits, and more specifically, those implemented on stock markets as these are most applicable to the Chinese securities markets on which the study is conducted.

Price limits curtail a security's price to a maximum or minimum price in a day. This limit price is usually determined as a percentage move from the previous day's closing price. No cessation of trading occurs as trading at the limit price itself is permitted.

The earliest known price limits in the United States came in the form of price limits on cotton futures contracts in August 1917 as a result of excessive price volatility due to World War 1 (Kim and Yang, 2004). The Black Monday Crash of 19th October 1987 and the subsequent recommendations Brady Commission Report of January 1998 brought the use and discussion of circuit breakers to the fore. The Crash saw the Dow Jones Industrial Average (DJIA) fall by 22.61% points in one day, popularly explained as being driven by program traders as a reaction to computerised selling required by portfolio insurance hedge strategies. One of the findings of the Brady Commission Report that investigated the mid-October "market break" was that "circuit breaker mechanisms (such as price limits and coordinated trading halts) should be formulated and implemented to protect the market system" (Brady Commission Report, 1998).

The proposed benefits of price limits are to curb volatility, reduce margin requirements in futures markets and to provide consultation time between brokers and their clients (Kim and Yang 2004). Curbing volatility is a benefit to the market, as participants' inclusion in a market is better than their exclusion, given some participants are reticent to trade in volatile conditions. Limits are therefore in place to minimise periods of price volatility and panic, and should theoretically benefit the market if they encourage participants to continue trading. The benefit of reducing margin requirements is predominantly a benefit to futures markets as daily limits put forward by Brennan (1986).Brennan (1986) proposed the theory that price limits act as a partial substitute for margin requirements. If margin requirements are costly for some investors, price limits may reduce the margin amounts required for investors by limiting the daily allowable price movements, and therefore increase the amount of overall trading in a futures market.

Most of the literature and many of the empirical studies since the Brady Commission Report in 1998 have focused on the costs, or impediments, of price stabilising mechanisms on financial markets. The most commonly cited hypotheses relating to price stabilising mechanisms are: the volatility spillover hypothesis; the delayed price discovery hypothesis; the trading interference hypothesis; the magnet or gravitational effect; and the satellite market effect. An extended discussion of the theoretical and empirical results of these hypotheses follows.

Other papers, however, have stipulated that the primary role of price limits can be to counter market manipulation (Deb et al., 2010, Kim and Park, 2010). Instead of stock exchanges advertising that price limits are implemented to counter market manipulation (an announcement that would deter investors from participating in that exchange) the exchanges state that price limits are aimed at curbing excessive volatility. Deb et al. (2010) argued employing a game-theoretic model, that in a market prone to manipulation and characterised by high monitoring costs, price limits can increase monitoring efficiency, benefitting all market participants. Testing their theory with empirical evidence, Deb et al. (2010) used data from 43 countries and found that the probability of a price limit regime being in a stock exchange was greater in countries that incur higher monitoring costs due to poorer business disclosure, higher corruption level and lower efficiency in the legal, regulatory and technological environments. Kim and Park (2010) also researched whether price limits' main purpose was to curb excessive volatility or to deter market manipulation. This study produced a model showing that price limits may deter stock manipulation strategies and provided empirical evidence which was consistent with the hypothesis from 43 stock markets around the globe.

After providing a background to the history and implementation of price limits, the next sections detail some of the well-documented issues with price limits in the existing literature.

The Magnet / Gravitational Effect

The magnet effect of price limits implies that price limits draw trades closer to the limit than would otherwise be the case if the limit did not exist. Also known in the literature as the gravitational effect, the magnet effect was first described by Subrahmanyam (1994), who postulated that the magnet effect occurs because market participants, wanting to avoid being constrained from trading as the price limit nears, accelerate the timing of their trades, increasing the price movements and volatility. This often becomes a self-fulfilling prophecy, causing the limit hit event to occur. The magnet effect implies that the closer to a limit the price of a trade is, the more likely that the next price movement is towards that limit.

Tooma (2011) studied whether the magnet effect was present in interday returns for securities on the Egyptian Stock Exchange (ESE) with daily price limits. The 5% daily limit on the ESE actually caused the security to halt trading for the remainder of the day's session, effectively acting as a firm-specific trading halt, instead of a typical price limit. Tooma (2011), using daily data from 1994 to1997 when no price limits were imposed on the market, and 1997 to 2002 when a 5% daily limit was in place, tested the existence of the magnet effect. Tooma (2011) concluded, using a logit model, that the probability of hitting a limit was strongly related to the overnight return, consistent with the magnet effect.

There are a number of problems with the methodology and data use in the study on the ESE by Tooma (2011). Firstly, only five companies from the Egyptian Stock Exchange are used to test the magnet effect. These five companies are the only ones that experienced trades and limit hits in both time periods used. Tooma (2011) also used interday data to test a purely intraday effect of price limits. Close-to-close returns and opening prices of limit hit days, used in this study, are imprecise measures with which to determine the magnet effect.

Wong et al. (2009a) examined transactional data to test for the existence of the magnet effect of price limits on the Taiwan Stock Exchange (TSEC) extending the period January to December 2004. Wong et al. (2009a) provided evidence that supports the magnet effect hypothesis as well as noting that when limit hits are imminent, trading activities intensify with higher volume and volatility, in the 5-minute intervals prior to the limit hit. The most significant implication of the Wong et al. (2009a) study was that the type of investor has an impact on the likelihood of the magnet effect. Wong et al. (2009a) showed that individual investors are more likely to cause the magnet effect, whereas institutional investors were not. The study conjectured that institutional trading activities signal information to other participants in the stock markets, resulting in the disappearance of magnet effect in most cases (Wong et al., 2009a).

Goldstein and Kavajecz (2004) studied market-wide circuit breakers on the NYSE and reported the existence of the magnet effect. Using data for the turbulent days from the 24th to the 29th of October 1997 (Asian Financial Crisis), the study analysed the trading restriction NYSE Rule 80B, requiring that trading to be halted whenever the Dow Jones Industrial Average moved more than 350 points in a 30-minute period. Goldstein and Kavajecz (2004) found that traders altered the timing of their actions to their advantage around the implementation of the market-wide circuit breaker, specifically activity consistent with the magnet effect.

Subrahmanyam (1994) also modelled a two market scenario in which traders sent their trades from a dominant market to a satellite market if a price limit was approaching. This, it was argued, had the effect of transferring price variability from the dominant market to the satellite market, and potentially negating or nullifying the magnet effect in the process. Berkman and Steenbeek (1998) studied the influence of daily price limits on the price formation process of trading in Nikkei futures. The study analysed minute-by-minute transaction data from August to September 1992 for Nikkei 225 futures contracts traded on the Osaka Stock Exchange (OSE) with strict price limits imposed, and compared that to the trading of the same contract on the Singapore International Monetary Exchange (SIMEX), a market with more lenient price limits. Berkman and Steenbeek (1998) investigated the magnet effect and the satellite market hypothesis, proposed by Subrahmanyam (1994), and concluded that the empirical results did not confirm the existence of the magnet effect. The study, however, did provide evidence consistent with the satellite market effect which saw a relative decrease in trading volume and price volatility on the OSE (the primary market) compared to SIMEX (the satellite market) when the price moved closer to the price limit (Berkman and Steenbeek, 1998).

Du et al. (2009) studied the Korean Stock Exchange to analyse the existence of the magnet effect. The study analysed tick data for two 3-month periods, from September 1998 to December 1998 under a 12% daily price limit regime, and December 1998 to March 1999 under a 15% daily price limit regime. Utilising a time-distanced quadratic function, Du et al.

(2009) found the existence of the magnet effect in Korean stocks, and noted that the results were consistent across small, medium and large market capitalised securities.

Hsieh et al. (2009) investigated the magnet effect of price limits using transaction data from the Taiwan Stock Exchange (TSE). With data from 2000 for 439 firms, Hsieh et al. (2009) tested the magnet effect on varying price limits between 7% for the upper limit, and between 7-3.5% for the lower limit using intraday data in a logistic regression. Hsieh et al. (2009) confirmed the existence of the magnet effect and note that the magnet effect price limits cause an increase in short-run price volatility, and not a reduction, as is intended.

For the purposes of this research, the methodology used by Hsieh et al. (2009) was adopted. Hsieh et al. (2009) were not able to fully measure the impact of order imbalance due to the TSE operating a batch auction system for trading, resulting in no information about order demand before a limit. This paper improves up the process of Hsieh et al. (2009) by fully capturing the effect of order imbalance through the use of bid and ask sizes.

Some studies tested for but could not find existence of the magnet effect of price limits. Huang et al. (2001) found that the overreaction hypothesis was largely responsible for limit hits but that the magnet effect was not observed in their study of the Taiwan Stock Exchange. Similarly, Arak and Cook (1997) found that limits did not exert a magnet effect on price behaviour and may have a small stabilising effect on prices in their study on US Treasury Bonds.

Bildik and Gülay (2006) conducted no specific tested on the existence of the magnet effect, but instead argued that price increases and volatility in sessions before a limit, constituted a magnet effect. The study showed that price limits spread volatility out by at least one session and partially two sessions following the limit hit, in comparison to stocks that do not hit limits. Bildik and Gülay (2006) in fact examine the volatility spillover hypothesis associated with price limits.

Wong et al. (2009b) studied the Shanghai and Shenzhen stock exchanges in 2002 and reported evidence for the existence of the magnet effect. Using intraday transaction data from January to December 2002, Wong et al. (2009b) measured the price volatility and volume increases of securities that approach their respective daily 10% price limits. The paper showed that when stock hits are imminent, stock prices approach limit bounds faster, with increased volatility and with higher trade frequency.

Following the quadratic methodology used to detect the magnet effect from Du et al. (2009), Wong et al. (2009b) found an asymmetrical effect of price limits between ceiling a floor hits, and argued that the reason that floor limits are different to ceilings was due to the trading mechanism and market structure unique to Chinese exchanges. The absence of market makers and the inability to short sell meant that investors had limited ability to hedge their downside risk. This meant that the nature of rising and falling prices was inherently different, and as such, an asymmetry of the magnet effect of price limits was explainable.

When investigating Chinese securities, Kim et al. (2013) did not find supporting evidence for the magnet effect in Chinese securities, however with only daily data at their disposal, Kim et al. (2013) acknowledged that intraday data would be more suitable to conduct a reliable test of the magnet effect. Given the daily data available, Kim et al. (2013) instead adopted a methodology employed by Kim and Sweeney (2001).

Kim et al. (2013) conducted an ex-post test of the magnet effect by comparing the proportion of instances where prices reached a high (low) near their limits between periods with price limits and a period without. Kim et al. (2013) concluded that there should be a lower number of instances of near limit highs (lows) in a period where price limits existed, given that the magnet effect would pull the security to the limit, if the magnet effect existed.

Ex-post analysis excludes the possibility of the magnet effect occurring for securities that don't reach their limit, as the theory suggests that prices increase as they near the limit. Without intraday data, the fact that this happened cannot be confirmed or denied. Also, this methodology ignored the fact that securities that reached their limit could have been influenced by the magnet effect. This method attempted to disprove the magnet effect by contradiction, that is, by arguing that the magnet effect did not exist because the proportion of securities that reached a high (but not a ceiling) in a price limit scenario was not what was theoretically predicted. As stated, this ignored the securities that did reach their limit, as this was untestable without intraday data.

Chou et al. (2013) also found support for the magnet effect when studying the effects of price limits on the Taiwan Stock Exchange. Chou et al. (2013) concluded that the magnet effect existed by analysing trading volume before and during a period when a price limit was hit. For fear of illiquidity at a price limit, the study argued "noise traders would engage in active trading that pulls the price to the limit. Thus, if there is really a magnet effect, one would expect the turnover to be high before and during a limit hit." (Chou et al., 2013). The testable hypothesis presented in this paper suggested that there should exist an inverse relationship between the duration of a limit hit and the pre-hit volume of trade. However, Chou et al. (2013) outlined a flaw with the study's methodology when claiming that they "cannot exclude the possibilities that other effects that may also drive the negative relation" between limit hit duration and pre-limit trade volume, as they focus on volume of trade rather than the price movements in the period before a limit is hit.

The Volatility Spillover Hypothesis

Price limits effectively interrupt the price discovery process of stock or futures markets by placing "physical" limitations to the possible trading price of a security or contract. As a result of this interrupted process, the security or contract may be subject to greater uncertainty which may increase the underlying price volatility. This was the argument put forth by Fama (1989), and in effect states, that rather than reducing volatility, price limits may cause volatility to transfer or spillover to subsequent trading periods instead of occurring in a one-period jump or increase (Chen et al., 2005b, Lehmann, 1989). This is argued to be a drawback of implementing price limits as volatility continues for longer than it would have, had no price limit been in place.

Looking to the literature that empirically tests this hypothesis, Berkman and Lee (2002) studied the changing of price limits over time in the emerging market of Korea and showed that price limits can have benefits for decreasing volatility and that narrow limits are beneficial for smaller stocks. Berkman and Lee (2002) investigated daily prices and volume of stock trading in Korea from 1994 to 1996 under two different daily price limit regimes. The first time period (April 1994 to March 1995) had price limits of fixed Korean Won amounts per security. The second period (April 1995 to April 1996) saw a constant percentage limit applied to all securities of 6% daily fluctuation from the previous day's closing price. Berkman and Lee (2002) tested the impact of the change in the relative price limit on the same security, and the difference between the two price limit regimes. Berkman and Lee (2002) showed that stocks that experienced the largest widening of their price limits also experienced a relative increase in volatility, although these securities also saw the largest relative decrease in trading volume. This study concluded that price limits can have benefits to volatility despite the diminished liquidity.

Berkman and Lee (2002) found adverse effects of widening price limits on smaller Korean securities and also suggested that this was why emerging markets may have tighter limits in place than established markets, having implications in emerging markets where price limits exist and whose economies are undergoing a market liberalisation event.

Kim and Yang (2008) investigated the effects of price limits on volatility and information asymmetry in the Taiwan Stock Exchange (TSE). This paper analysed transaction and limit order data in 2000 for securities listed on the TSE under varying price limit regimes. In the year of 2000, the floor of the price limit was lowered from 7% down to 3.5% of the previous day's close, whereas the upper limit stayed fixed at 7%. This study concluded that for securities that achieved consecutive limit hits, defined as a limit hit followed by a trade at the limit price, price volatility dropped off significantly. This, Kim and Yang (2008) suggested, confirmed that investor overreaction existed and that price limits can reduce price volatility. This research did not find evidence of the information asymmetry hypothesis however, which suggested that bid-ask spreads would be lower after a limit was hit, rather than before.

Lee and Kim (1995) also analysed the effects of price limits on price volatility on the Korean Stock Exchange. Using daily returns and closing prices for Korean stocks between 1980 and 1989, this study tested the impact of price limits in reducing volatility by comparing return volatilities between high price limit portfolios (6.67% effective daily price limit) with low price limit portfolios (2.67% effective daily price limit). Lee and Kim (1995) showed that price limits serve to reduce stock price volatility, contradicting the volatility spillover hypothesis.

Ma et al. (1989) looked at the effectiveness of price limits on future commodities contracts and their impact on volatility and price resolution. Ma et al. (1989) analysed daily end of day price and volume data for a variety of agricultural commodity futures contracts from 1977 to 1988. Ma et al. (1989) concluded that price limits appeared to be accompanied by substantial reductions in volatility and therefore did not confirm the existence of the volatility spillover hypothesis.

To understand the effects of price limits on price volatility in the Taiwanese stock market, Chen (1993) studied daily and monthly data for securities on the Taiwan Stock Exchange (TSE) from January 1985 to June 1990. During that period, the Taiwanese stock exchange experienced market rule changes, moving daily price limits from 5% down to 3%, back to 5% and then finally remaining elevated at 7%, allowing Chen (1993) to study different price regimes and their effects on volatility. The results from Chen (1993) however, did not show that price limits have an impact on reducing equity price volatility, and to the contrary, in fact that limits slightly exacerbated volatility.

Bildik and Gülay (2006) examined the effects of price limits on the Turkish stock exchange by testing the volatility spill-over, delayed price discovery, and trading interference hypotheses. Using daily stock prices and returns from 234 stocks traded continuously on the Istanbul Stock Exchange (ISE) between January 1998 to December 2002, the study investigated the impact on trading of 10% daily price limits from the volume weighted average price of each security from the previous trading session. The study compared price volatility, average return and trading volume across 3 categories of securities. The categories included: stocks that hit their limit and remain limit-locked until the end of the session (limit locked), stocks that hit their limit but did not stay locked (non-limit locked), and a final group of securities that did not hit a price limit. This study was unique due to the fact that the ISE has two trading sessions per day with the price limit being recalculated at the beginning of each trading session. The tests conducted by Bildik and Gülay (2006) of the volatility spillover hypothesis indicate that increases in volatility began before a limit was hit. The study also showed that price limits spread volatility out further into other trading session following the limit hit than for stocks that did not hit limits.

Phylaktis et al. (1999) examined the effect that price limits have on stock volatility in the Athens Stock Exchange. Using daily price and volume data from January 1990 to January 1996, Phylaktis et al. (1999) tested the impact on stock volatility when an 8% daily price limit was introduced in August 1992. The study tested the information hypothesis, that limits slow down information and have no effect on volatility, and the over-reaction hypothesis, which states that limits allow investors time to reassess in times of turmoil and therefore reduce volatility. Phylaktis et al. (1999) found evidence in support of the information hypothesis, showing that the imposition of daily price limits did not have the desired effect of reducing stock market volatility in the Athens Stock exchange.

Bildik and Elekdag (2004) examined the effects of price limits on volatility in stock returns in the Istanbul Stock Exchange (ISE). This study focused on the overreaction and information hypotheses between 1990 to 2001 using daily stock prices and volume. Similar to Phylaktis et al. (1999), Bildik and Elekdag (2004) tested the information and over-reaction hypotheses by analysing a structural break in the price limit regime in Turkey. For the first time period in this study (1990-1994), the ISE had one single trading session with a 10% daily price limit. For the second period (1994-2001), two trading session were introduced, each with a 10% price limit calculated from the previous session's closing price, implying a daily limit of 21%. Bildik and Elekdag (2004) provided evidence that stock return volatility had decreased despite the increase in daily price limits from 1994 onwards, disproving the information hypothesis and contradicting the findings of Phylaktis et al. (1999).

Bildik and Elekdag (2004) also found that the introduction of a two hour trading break in the daily trading session on the Istanbul Stock Exchange, reduced volatility by acting as a circuit breaker. This session break allows for the dissemination of market information and could therefore prevent overreactions to news events, consistent with overreaction hypothesis.

Kim et al. (2008) studied the relative performance of trading halts and price limits on the Spanish Stock Exchange. The study evaluated trading activity, liquidity, volatility and information efficiency of Spanish securities with intraday trade and quote data from January 1998 to April 2001. Price limits for securities were set at a daily limit of 15% from the previous day's closing price. Trading halts could be enforced by the Spanish securities regulator (CNMV) on any security for any duration of time until CNMV believed that new information related to the security has been released or that the circumstances provoking the suspension no longer existed. Kim et al. (2008) found that stock price volatility stayed at the same level after trading halts were triggered but increased after price limit hits were hit.

Polwitoon (2004) studied the effects of varying price limit regimes on stock return volatility from the Stock Exchange of Thailand (SET). For 20 days following the October 1987 crash, the SET narrowed price limit from 10 % of the previous trading day's closing price to 5 %, thus allowing the investigation of the effects of changed price limits on stock returns. Polwitoon (2004) did not find any "cool off" period for traders during the narrow price limits and instead found evidence of overreaction, suggesting that price limits were ineffective at mitigating volatility.

Henke and Voronkova (2005) investigated the impact of price limits on volatility and autocorrelation in the call auction segment of the Warsaw Stock Exchange (WSE). Using daily stock return and trading volume data from January 1996 to November 2000, the study hypothesised that because call auctions provide time-out periods between market clearings, price limits will not reduce volatility. Henke and Voronkova (2005) tested the effects of a 10% price limit within a call auction on stock volatility and found that the limits merely delayed price adjustments and caused volatility spillovers.

Kim and Rhee (1997) analysed price limit performance on the Tokyo Stock Exchange using daily data from 1989 to 1992 for price limits that varied between 5% and 30% depending on the price of the security. Kim and Rhee (1997) tested the impacts on three stock groups: securities which hit their limits, securities that reach 90% of their limit, and the third group for securities that reach 80% of their limit. By using these three groups, the study attempted to separate what happened to stocks that hit limits to the those which experienced large price movements, but did not trigger limit hits. The paper tested the volatility spillover, delayed price discovery and the trading interference hypotheses. Kim and Rhee (1997) found that for stocks that hit their limits, volatility did not return to normal levels as quickly as the stocks that did not reach their limits, providing supporting evidence for the volatility spillover hypothesis.

In their study, Chen et al. (2005b) found that the effect of price limits in Chinese securities markets was different for ceiling and floor limit hits as well as an observable difference between bullish and bearish market conditions. Using daily stock price and return data from 1996 to 2003 for stocks listed on the Shanghai and Shenzhen Stock Exchanges, Chen et al. (2005b) tested the volatility spillover hypothesis, the delayed price discovery hypothesis and the trading interference hypothesis under a 10% daily price limit regime.

Chen et al. (2005b) found evidence that price limits effectively reduced stock volatility for downward price movements during period when the stock market was advancing, but did not find this for upward price movements, indicating asymmetrical outcomes for up and down limit hits. During periods of stock market declines, price limits did appear to be effective at reducing volatility for upward price movements but not for downward movements.

Kim et al. (2013) investigated price limits for Chinese securities from 1992 to 2000 and showed benefits of price limits in facilitating price discovery, moderating transitory volatility and mitigating abnormal trading activity. The study investigated the period of 1992 to 1996 in which no price limits were in place and compares this to the period of 1997 to 2000 where a 10% daily price limit was implemented. The study observed the impact of narrower limits on poorly performing securities (Special Treatment stocks in China, 5% daily limit) returns. Kim et al. (2013) found counter evidence to the volatility spillover hypothesis and showed that price limits can moderate volatility in Chinese securities, and showed that a tighter price limit on stocks of poorly performing firms appeared to help moderate volatility.

Lu (2016) studied the performance of price limits on cross-listed Chinese securities on the Shanghai, Shenzhen and Hong Kong Stock exchanges. Lu (2016) tested the performance of a 10% daily price limits on securities listed on Shanghai and Shenzhen in comparison to their cross-listed securities on Hong Kong where no price limits were imposed. Using daily stock price and returns data from 1997 to 2012, Lu (2016) examined the effects of limits on volatility spillover hypothesis, the price discovery hypothesis and the trading interference hypothesis. Lu (2016) found that for stocks with high trading activity, volatility spillover for cross-listed Chinese securities became statistically insignificant.

Veld-Merkoulova (2003) studied agricultural commodities futures markets to investigate the effect of price limits on price discovery and volatility. With daily price and return data for 7 commodities from 1972 to 1998 with varying price limits, the paper concluded that price limits did not appear to significantly reduce market volatility.

Farag (2013) studied varying price limit regimes in emerging markets and found that switching from narrow to wider daily price limits increased volatility and disrupted the trading mechanism. The paper analysed data from Egypt from 1998 to 2011 with a change in price limits from 5% to 10% (with a halt and then 20% daily maximum price movement), Thailand from 1995 to 2011 with a change from 10% to 30% and the Korea from 1989 to 2011 with a change in daily price limits from 4.6% to 15%. The findings suggested that in emerging markets, switching to wider limits increased volatility, a noteworthy consideration when implementing daily price limits.

The Delayed Price Discovery Hypothesis

The delayed price discovery hypothesis states that price limits delay prices reaching their intrinsic value and are therefore a disruptive market rule, rather than a benefit to the market. Observed in studies by Fama (1989) and Lehmann (1989), the hypothesis is commonly tested by observing price movements in the following trading periods after a limit hit event. If positive returns are observed in the trading session after an upper (ceiling) limit hit, this provides evidence of the delaying aspect of price limits, as the security continued to move in the same direction once not limited. The converse is also true for lower (floor) limit hits being followed by negative reruns in the subsequent trading session. However, should price reversals occur, indicating that prices retraced their movement in the subsequent trading session after a limit, this would indicate that the limit stopped the participants from overreacting, and provided a "cooling off" period instead. The "cooling off" or "overreaction reaction" hypothesis is the converse of the delayed price discovery hypothesis.

The early study by Chen (1993) of the Taiwan Stock Exchange found that limits hindered the price discovery process, having a delaying effect. By showing that serial correlations of stock returns were inversely related to the range of the price limits themselves, Chen (1993) showed a delaying effect of the limit. Chen (1993) concluded that this study did not support the contention of the Brady Committee where the implication was that price limits were the necessary tool to contain volatility.

Bildik and Gülay (2006), in examining the subsequent price movements following the limit-hits, compared the return series around limit-hit and limit-lock sessions, identifying the return behaviour of stocks whose prices reached their limits. Bildik and Gülay (2006) showed that price continuations for stocks that hit their limits occurred significantly more often than those for the stocks that did not reach their daily limit, supporting findings that price limits caused a delay in price discovery.

Polwitoon (2004) found that when daily price limits were tightened on the Stock Exchange of Thailand from 10% to 5%, the number of price continuations increased substantially, and declined when the wider limits were reimposed. Price reversals, the study also found, increased substantially during the narrower 5% daily price limit regime.

Henke and Voronkova (2005) tested the effects of a 10% price limit within a call auction on stock volatility and found that the limits merely delayed price adjustments and caused volatility spillovers. Kim and Rhee (1997) testing Japanese between 1989 and 1992, found that for stocks that hit their limits, price continuations occurred more frequently than for stocks that did not reach limits, providing evidence for the delayed price discovery hypothesis.

Huang et al. (2001) studied price limits and their impact on price continuations and reversals from the Taiwan Stock Exchange. With 7 years of data from 1990 to 1996 with 7% daily price limits, Huang et al. (2001) tested the overreaction hypothesis and found that price reversals were observed in the trading period following the price limit hit, which was consistent with the overreaction hypothesis.

Kim et al. (2008) concluded from their research on the Spanish Stock Exchange that information was efficiently reflected in stock prices when trading resumed after trading halts were triggered. The study also concluded, in spite of this, market overreaction may have occurred for ceiling price limit hits on the Spanish Stock Exchange.

Farag (2015) assessed the influence of price limits on the overreaction hypothesis on the Egyptian Stock Exchange. Emerging markets are considered to be less efficient than mature markets as information does not get disseminated to all investors at the same time, and as a result when new information arrives in the market, investors tend to overreact or underreact (Farag, 2015). Using daily stock prices and market capitalisation data from 1999 to 2010, Farag (2015) assessed the impact of price limits changing from 5% daily price limits (1999-2002) to a price limit and halt combination in 2002. From 2002 onwards, stocks would halt for 30 minutes if they moved more than 10% from their previous day's close, then resume trading. If the security moved away from its previous day's close by 20%, the security would cease trading until the end of the session. Farag (2015) found that stocks experienced price reversals, consistent with the overreaction hypothesis, contradicting the delayed price discovery hypothesis.

Veld-Merkoulova (2003) also found evidence that supported the hypothesis that price limits delay price discovery instead of facilitating it in commodities futures markets. Veld-

Merkoulova (2003) noted however that limits tended to be hit in periods of high market volatility, and therefore the results could be skewed by volatility clustering, common for financial time series studies.

Another finding from their study of Chinese securities, Chen et al. (2005b) found that price limits delayed efficient price discovery for upward price movements towards a ceiling limit. For downward price movements towards floor limit hits, Chen et al. (2005b) instead found that price limits effectively reduced panic in the stock market, instead of delaying price discovery the, limits served to minimise overreaction. An implication of this study is that the effectiveness of price limits is associated with investor sentiment and whether the market is advancing or declining.

Studying the Chinese securities markets from 1992 to 2000, Kim et al. (2013) found that in fact price limits could facilitate equilibrium price discovery, in contrast to many findings about the delayed price discovery nature of price limits. However, Li et al. (2014) did not find delayed price discovery in China's stock market, whether in upper limit hit or lower limit hits, which the study suggested provided some evidence supporting effectiveness of price limits.

In researching the delayed price discovery in Chinese securities, Lu (2016) found that for stocks with high trading activity, the delay of efficient price discovery became statistically insignificant in cross-listed Chinese securities.

The Trading Interference Hypothesis

The trading interference hypothesis states that price limits interfere with the trading process, measured in trading volume levels on the day of the limit hit, compared with subsequent days after the hit. First proposed by Lauterbach and Ben-Zion (1993), the study proposed that both price limits and trading halts were "obviously cost-interfering with market liquidity". If trading volume is higher on subsequent days after a stock hits a price limit than on the day of the limit hit itself, then trading is considered to have been impeded by the price limit and the trading interference hypothesis holds.

In their study of the Istanbul Stock Exchange, Bildik and Gülay (2006) examined the trading interference hypothesis by analysing the trading volume of the three groups of stocks (limit hit, limit lock and no limit) for 10 sessions either side of the limit-hit session. The study provided evidence that supports the trading interference hypothesis by showing a clearer and stronger spillover in trading volume of stocks that hit their limits.

Bildik and Gülay (2006) produced results that supported the volatility spill-over hypothesis, and also provided evidence that limits interfered with the positive relationship between volatility and volume, indicating that limits have a detrimental effect on liquidity. This has interesting implications and could yield further studies as the volume available at limits unknown. Should research find that liquidity dries up at the limit, it could be argued that limits are more akin to trading halts than first thought.

Kim and Rhee (1997) analysed price limit performance on the Tokyo Stock Exchange, testing for the existence of the trading interference hypothesis. Kim and Rhee (1997) concluded that for stocks that hit their limits, trading activity increased on the day after the limit day, while trading activity drastically declined for the subgroup of stocks that did not hit their limit but still experienced large price changes, confirming support for the existence of the trading interference hypothesis. Similarly Kim et al. (2008) found that trading activity increased after trading halts and price limits, and that liquidity increased after trading halts but decreased after price limit hits on the Spanish Stock Exchange.

Ma et al. (1989) found that while volatility was substantially reduced as a result of price limits in the agricultural commodities futures markets, volume was maintained in the post limit period, suggesting that liquidity was not impaired, providing counter evidence to the trading interference hypothesis. Ma et al. (1989) found that the time immediately prior to price limits in commodity futures markets, prices tended to move in the direction of the limit, while following the limit, prices tended to stabilise or reverse directions, implying that price limits may have provided a "cooling off" period for the markets.

For Chinese securities over the period of 1996 to 2003 listed on Shanghai and Shenzhen Stock Exchanges, Chen et al. (2005b) did not find evidence consistent with the trading interference hypothesis proposed by Lauterbach and Ben-Zion (1993). Total trading volume for both ceiling and floor limit hits did not increase for time periods after the limit hit, and in fact, decreased significantly, contradicting the trading interference hypothesis.

In contrast, Kim et al. (2013) showed that price limits mitigated abnormal trading activity, findings which contradicted the trading interference hypothesis and Lu (2016) found that for stocks with high trading activity, the trading inference hypothesis for cross-listed Chinese securities became statistically insignificant.

Li et al. (2014) found mixed results on trading volume and therefore inconclusive on the trading interference hypothesis. Trading volume remained higher after ceiling limit hits while it stayed depressed after floor hits suggesting that price limits only mitigated abnormal trading activity for lower limit hits.

Optimal limits

The optimal design of the price limits is also frequently discussed in price limit literature. Some of the topics of discussion are listed below showing what previous research has found to be pertinent when designing and implementing a price limit regime on an exchange.

Deb et al. (2013) investigated how flexible price limits could be introduced by analysing stocks on the Tokyo Stock Exchange. Deb et al. (2013) have proposed that where price limits are to be introduced, but have drawbacks such as volatility spillover on consecutive limit hit days, then flexible limits determined by known factors such as firm size and trade volume should be introduced. Deb et al. (2013) contributed to the optimal price limit debate by furthering the argument that price limits should be more firm specific and not a blanket application to the entire market.

Kim and Limpaphayom (2000) investigated the characteristics of stocks that hit their limits on the Taiwan and Thailand stock exchanges. Examining daily and monthly stock return data from 1990 to 1993, the paper investigated the characteristics of stocks that hit 7% daily limits in Taiwan and 10% daily limits in Thailand. Kim and Limpaphayom (2000) identified that volatile stocks (measured by beta and residual risk), actively traded and with a small market capitalisation, were most likely to hit their price limits. Kim and Limpaphayom (2000)'s contribution to the literature suggested that these characteristics should help shape price limit legislation to minimise constraining market trading.

George and Hwang (1995) studied price limits on the Tokyo stock Exchange from 1984 to 1989 under 10% daily price limits, finding that the price limit rules differentially affected active and inactive stocks and prevented prices from moving to new levels when changes in security values were associated with large order imbalances.

Kim (2001) studied the existence of price limits and the effects on stock market volatility on the Taiwan Stock Exchange (TSE). From 1962, the TSE had 11 different daily price limit regimes, but due to data availability, Kim (2001) covered the 6 price limit regime changes that occurred between 1975 and 1996. For this period, the price limits varied between 2.5% to 7% for different lengths of time. Kim (2001) found that stock market volatility was usually not lower when price limits were made narrower.

Chen et al. (2005a) studied the effects of price limits on illiquid stocks traded on Chinese stock markets, finding that illiquid securities hit limits more often than liquid ones. Chen et al. (2005a) used data from Shanghai and Shenzhen Stock exchanges between July 1999 and December 2002 for A-shares (liquid) and B-shares (illiquid) of the same company that were both subject to 10% daily price limits. Chen et al. (2005a) observed that illiquid securities, due to their wide bid-ask spreads, hit limits more often than liquid securities with tighter spreads, and proposed that either wider limits should be set for illiquid stocks or that the previous day's reference price be the closing mid-point instead of just the closing price, as illiquid stocks had wider spreads.

Hypothesis Development

This section outlines the testable hypotheses that this paper addresses.

The Magnet Effect of Price Limits

A central aim of this research paper is to demonstrate the existence, or at a minimum, provide evidence that supports or rejects the existence of the magnet effect. According to the initial hypothesis, price limits "[circuit breakers] may actually increase price variability and the probability of the price crossing the circuit breaker bounds if the price is very close to the breaker limit and if agents place a high value on their desire to trade. These effects can occur because strategic traders may sub-optimally advance their trades to assure themselves of their ability to trade. The circuit breaker thus may yield results that are exactly the opposite of what regulation intended it to accomplish" (Subrahmanyam, 1994). Trades that are close to a limit will have a higher likelihood of advancing towards that limit given traders' concerns about their anticipated inability to trade, despite this decision potentially being economically suboptimal.

This paper follows the reasoning put forth by Hsieh et al. (2009) that "if the magnet effect holds, we should observe a higher probability that the price moves toward and eventually hits the limits when that price approaches the limit. That is, the closer the price gets to its upper (lower) limit, the greater is the probability that the price will move up (down) to reach the limit." (Hsieh et al., 2009).

From this theoretical standpoint, the following hypothesis is formulated:

> *H1. Distance to a price limit is* ***significant*** *in determining the likelihood of a trade advancing towards a limit*

The Impact of SHHKConnect on the Magnet Effect on Chinese Securities

From the point of view of the mainland exchange, the SHHKConnect allows foreign investors, via brokers in Hong Kong, to purchase a select group of securities. Therefore, SHHKConnect introduces new investor sentiment and trading behaviour into an established market. This allows funds to enter the mainland stock market, although given the bilateral nature of the regulation, mainland investors also have the ability to route their capital out of their own domestic stock exchanges to markets trading similar securities and that are not subject to price limits.

This study creates two groups of securities to analyse the impact of the SHHKConnect on the magnet effect. The first group is used to test the magnet effect on securities listed on SSE that are exposed to the market liberalisation event. The second group of securities is used to determine whether or not the magnet effect of price limits changed in the period of study for securities that were not impacted by the SHHKConnect. For this particular group, securities listed on the SZSE are used that are also subject to a daily movement by a 10% price limit, but not involved in SHHKConnect.

Based on this reasoning, the following hypothesis is constructed:

H2. The introduction of the SHHKConnect ***changes*** *the magnet effect of price limits for Connect securities;*

Data and Descriptive Statistics

Data

Thomson Reuters Tick History

Data for the SSE, SZEH and SEHK used in this study are obtained from the Securities Industry Research Centre of Asia-Pacific (SIRCA) distributed by the Thomson Reuters Tick History (TRTH) database. These data include trade and quote data which include: the bid and ask quote and depth (for one level); trade volume and trade price. The quote size and price information is distributed every 3 seconds, whereas the trade price information is available timestamped to the millisecond. This study also uses TRTH End of Day and Corporate Actions data to calculate the end of day reference price for the subsequent day's limit calculation[18].

Sample period

This study analyses data extending a two-year period to evaluate the impact of the SHHKConnect on the magnet effect of price limits. The SHHKConnect was officially launched on the 17th November 2014. This study uses one full year prior to the Connect launch date (period 1: 1st November 2013 – 16th November 2014) and one full year following the launch of Connect (period 2: 17th November 2014 – 30th November 2015). Throughout this paper, the year prior to the implementation of SHHKConnect is referred to as Pre-Connect, and the time period after Connect is referred to as Post-Connect.

Data for all trading days in each market are examined[19]. For SSE and SZSE, there are 510 trading days during the sample period. In the final sample, there are 264,441 stock-day observations for stock that are traded on the SSE, and 42,167 for stock-day observations for stock that are traded on the SZSE.

Security Classification

Groups of securities from the SSE and the SZSE are used to test the hypotheses in this research paper. Given not all securities on those markets are relevant for assessing the hypotheses in this research, an outline of the securities sampled in each market follows below.

The Shanghai Stock Exchange Securities

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[18] To calculate the closing reference price, Corporate Action data are applied to determine if the Adjusted Close Price needs to be further amended by stock splits or dividends. To do this, any dividend payments made on a day are removed from the Adjusted Close Price. From then stock split or consolidation ratios are applied to the dividend-adjusted close price. This forms the close price that is used as the reference price for the following day's limit.

[19] The two regions, the Mainland China and Hong Kong, have different holiday schedules due to their unique history.

Of the 1,041 securities tradeable on the SSE, this research establishes 2 groups for the purpose of this study:

Shanghai group 1: 69 dual-listed, Connect eligible stocks. This security group includes the 69 Shanghai dual-listed stocks that are listed on both the SSE and SEHK. All cross-listed stocks are eligible for trading through SHHKConnect but have had a pre-existing arrangement for dual-listing since before SHHKConnect event.

Shanghai Group 2: 474 non dual-listed, Connect eligible Shanghai listed stocks. This security group includes stocks that are eligible to be traded through SHHKConnect that are not included in the 69 dual-listed securities contained in Shanghai group 1. For such Northbound trading, that is, Hong Kong-based investors trading stocks listed in SSE, there are 543 SSE-listed stocks that are eligible to be traded through SHHKConnect.

The Shenzhen Stock Exchange Securities

Of the 1,700 securities tradeable on the SZSE, this study uses the following subset:

Shenzhen group 1: 100 Shenzhen, non-Connect eligible stocks. These 100 securities were selected by market capitalisation and daily trading volume to fall within the range of the 474 Connect securities included within Shanghai group 2. The purpose of this group is to act as a control for securities where price limits exist but those which aren't affected by the SHHKConnect.

Descriptive Statistics

The following tables provide information on the number of daily price limits that occurred for each group in the study period and the market capitalisation of the groups.

Table 2 – Market Capitalisation Summary Statistics

All market capitalisation values are calculated as the closing price on 16th November 2014 multiplied by the total Shares Outstanding attained from Thomson Reuters Tick History Data Service. The market capitalisation values are in Chinese Renminbi (RMB) and at the time of publication, 1 RMB is equivalent to $US0.14.

	Dual-listed	**474 Connect**	**100 Shenzhen**
Number of securities	69	474	100
Market of Trade	Shanghai	Shanghai	Shenzhen
Market Capitalisation (RMB)			
Quartile 1	23,848,425	6,399,289	14,901,211
Mean	114,387,307	17,803,721	26,981,005
Median	37,747,257	9,976,906	20,575,594
Quartile 3	73,668,718	18,234,319	27,866,649

Table 2 shows the market capitalisation of the securities in the three groups from the SSE and SZSE[20]. The largest 100 securities from Shenzhen have a mean market capitalisation of 26.98 million RMB ($US 3.91 million), which closely matches the 474 Connect securities, with a mean market capitalisation value of 17.80 million RMB ($US 2.58 million)[21]. This is in contrast to the dual-listed securities, whose mean market capitalisation is four times larger than the average Shenzhen security, and with its largest security value being more than 10 times larger than the largest Shenzhen company (1.23 billion RMB and 122 million RMB).

Table 3 provides the summary statistics on the number and duration of price limit hits across the three groups considered during the study period. *Total Limit Hit Days*, measures the number of days that a security triggers a price limit, and *Hits Per Day* measures how many times the limit was hit during that day. *Locked Limit Days,* measures days where the security closes the day at its limit price, and a Non-Locked Limit Day identifies instances of a retracement of the security price from the limit before the close of trade.

Table 3 shows a large increase in the number of limit hit occurrences, for both ceiling and floor hits, after the SHHKConnect, across all security groups. The smallest change pre- and post-Connect for Limit Hit Days is a three-fold increase for the 474 Connect ceiling hits, while the smallest change for the average Limit Hit Days Hits Per Day is a two-fold increase for ceiling hits for the 100 Shenzhen securities.

While the total number of hits increases, the average duration of limit hits decrease for the majority of securities. Connect securities see an average decrease in the duration for both ceilings (-40%) and floors (-14%) after Connect, whereas the mean duration of hit decreases for Shenzhen for ceilings (27%), but increases for floors (200%).

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20 Market capitalization values are at the date of Connect, 17th November 2014. The closing price from the 16th of November day for each security is multiplied by the number of shares outstanding for that company. All values are in Chinese RMB.

21 The largest 100 securities outside the 543 Connect securities on SSE had an average market capitalisation of 7.12 million RMB ($US 0.92 million). As such, the Shenzhen securities were selected to so as to closely resemble the Connect securities.

Table 3 – Price Limit Summary Statistics

Total Limit Hit Days accounts for all days that feature a price limit. Locked Limit Days count for the days where the closing price of the day is equal to the limit price, Non-Lock Days are days in which a limit is hit, but a price retracement occurs before the closing trade of the day. Ceilings are upper limit hits, where the maximum price of the day was 10% higher than the previous day's close. Floors are lower limit hits, where the minimum price of the day was 10% lower than the previous day's close. The Hits per Day metrics display results for limit hit days only.

	Ceilings		Floors	
Price Limit Summary Statistics	Pre-Connect	Post-Connect	Pre-Connect	Post-Connect
Panel A: Dual-Listed				
Total Limit Hit Days	177	988	23	911
Locked Limit Days	94	663	5	508
Non-Locked Limit Days	83	325	18	403
Duration				
Mean	50.24	24.22	23.96	17.48
Median	0.01	0.00	0.48	0.25
Hits per day				
Minimum	1	1	1	4
Mean	197	1,188	81	2,543
Median	47	389	22	807
Maximum	2,281	20,312	518	21,356
Panel B: 474 Connect				
Total Limit Hit Days	1438	6676	272	7770
Locked Limit Days	799	4421	108	4778
Non-Locked Limit Days	639	2255	164	2992
Duration				
Mean	93.94	68.62	46.04	45.44
Median	0.00	0.00	2.52	1.70
Hits per day				
Minimum	1	1	1	1
Mean	383	2,337	163	5,067
Median	267	1,190	77	166
Maximum	3,049	45,555	1,836	54,141
Panel C: 100 Shenzhen				
Total Limit Hit Days	252	1301	33	1378
Locked Limit Days	158	867	11	854
Non-Locked Limit Days	94	434	22	524
Duration				
Mean	531.26	388.93	59.99	177.44
Median	5.91	5.96	3.16	5.81
Hits per day				
Minimum	1	1	1	1
Mean	25	86	36	379
Median	9	43	13	40
Maximum	216	2,359	194	3,946

Methodology

The research design applied in this study adapts the methodology set out in Hsieh et al. (2009). Specifically, logistic regression analysis is applied to examine whether the magnet effect is observable on the Shanghai, Shenzhen and Hong Kong markets. Further fixed effects analysis is conducted to determine the impact of the SHHKConnect on the effectiveness of price limits on the Shanghai market.

The logistic regression

Subrahmanyam (1994) posits that as a security price advances closer to its price limit, the likelihood of the price further advancing towards the limit increases—the magnet effect. Such a test lends itself naturally to logit regression analysis[22]. Hsieh et al. (2009) sets out a logistic framework to measure the conditional probability of a trade ticking up or ticking down in the presence of price limits. The generic form of the logistic regression[23] is:

$$\ln\left(\frac{p}{1-p}\right) = \alpha + \beta X + \varepsilon = X_k' B \quad (1)$$

In Equation 1, p is the probability, for example, of a security advancing towards the daily price limit, and X is a vector of explanatory variables. Given the estimates of the coefficient of the explanatory variables, *beta*, and the values of *X,* the standard measurement of the odds of a security advancing towards a daily price limit during a trading day is determined by:

$$\frac{p_0}{1-p_0} = e^{\alpha+\beta X_0} \quad (2)$$

Following Hsieh et al. (2009) this logistic framework is modified to determine the impact of distance from the price limit, measured in ticks, and the probability of a price change in the direction of the price limit after controlling for a number of microstructure frictions that affects a price movements (Hausman et al. (1992), Easley et al. (1996) and Karpoff (1987)). Specifically, the following logistic regression equation is estimated:

[22] The logistic regression model accounts for two issues relating to the standard linear probability model, namely, 1) the assumption that the relationship between the dependent and explanatory variables being nonlinear, and, 2) that as the explanatory variables increase, so does the dependent variable, but never outside the 0-1 bound of probability. The logistic cumulative distribution function, underpinning the logistic regression, resolves these two issues.

[23] A logistic regression estimates the probability of a binary variable, in response to a set of explanatory variables. The coefficients of the logistic regression output are log odds. While the interpretation of the logistic regression output is easier to understand in the form of odds and probabilities, regressing against these values directly violates standard linear probability model assumptions. Once log-odds are exponentiated, the conditional odds of the independent variable on the overall dependent variable are established. The odds are interpreted as the ratio of the probability of a trade advancing towards a daily price limit occurring, p, and the probability of that the price does not advance towards the limit as *1-p*.

$$
\begin{aligned}
X_k'B = \ & \beta_0 + \beta_1 TickDistance_{k-1} + \beta_2 TickGroup_{k-1}^{m} \times TickDistance_{k-1} + \beta_3 \Delta T_k \\
& + \beta_4 Volume_{k-1} + \beta_5 Volume_{k-2} + \beta_6 Volume_{k-3} + \beta_7 Spread_{k-1} \\
& + \beta_8 Bid_{k-1} + \beta_9 Ask_{k-1} + \beta_{10} BuyerSeller_{k-1} + \beta_{11} BuyerSeller_{k-2} \\
& + \beta_{12} BuyerSeller_{k-3} + \beta_{13} OrderImbalance_{k-1} \\
& + \beta_{14} OrderImbalance_{k-2} + \beta_{15} OrderImbalance_{k-3} + \beta_{16} Market_{k-1} \\
& + \beta_{17} Market_{k-2} + \beta_{18} Market_{k-3}
\end{aligned}
$$

where $X_k'B$ is the conditional probability of a price of the k^{th} transaction being greater (less) than that of the $k\text{-}1^{th}$ transaction. β_0 captures the deviation in the dependant variable that is not explained by the independent variables.

The distance from the current trade price to the daily price limit is the key variable of interest in this research. To measure the impact of distance from a limit, two variables for tick distance are included: one measuring the distance, and the other measuring the distance at a particular subgroup of tick level. This distinction is important, because not only is the absolute distance of interest, the relative distance between ticks is also important for the purposes of comparing changes at various distances from the limit. $\beta_1 TickDistance_{k-1}$ measures the impact of distance on the likelihood of a trade advancing towards a limit. For the purposes of this study, ticks 2-15 from the daily price limit are included, as this distance is sufficient to begin to see the magnet effect of the price limit[24].

The second distance from price limit variable, $\beta_2 TickGroup_{k-1}^{m} \times TickDistance_{k-1}$ is a combination of two factors. Firstly, a dummy variable to indicate the particular tick group that is the focus of that regression, $TickGroup_{k-1}^{m}$, and the value of the distance itself, $TickDistance_{k-1}$. The combination of these terms enables measurement of the additional impact of this subgroup of ticks on the likelihood of a trade moving towards the daily price limit.

$\beta_3 \Delta T_k$ measures the duration of time between the k^{th} trade and $k\text{-}1^{th}$ trade. Easley et al. (1996) show that longer durations between trades have the effect of decreasing the price impact of trades. Conversely, if the prices are stable in the transaction period, the coefficient of the duration variable should be zero.

Karpoff (1987) shows that the number of securities traded is positively correlated to the magnitude of the price change of a security. To control for the impact of traded volume on price movements, three lagged log-transformed volume variables are included, β_4, β_5 and β_6.

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[24] The analysis can be conducted for any number of ticks away from price limits however as starting point this paper uses 2-15 as Hsieh et al. (2009) find the existence of the magnet effect to begin 9 ticks and 4 ticks out from the ceiling and floor limits respectively.

The value of the prevailing security's bid-ask spread before a trade is also captured to determine its impact on the movement of a security price. The variable $\beta_7 Spread_{k-1}$ is the value of the bid-ask spread just prior to the trade in question, or if no bid-ask spread exists, then $\beta_7 Spread_{k-1}$ is set to 0[25].

Also included in the regression are two variables, $\beta_8 Bid_{k-1}$ and $\beta_9 Ask_{k-1}$, as indicator variables for whether a bid quote and ask quote are available immediately prior to a transaction. $\beta_8 Bid_{k-1}$ and $\beta_9 Ask_{k-1}$ are equal to 1 if there exists a bid price or ask price prior to transaction *k*, otherwise if no bid price or ask price are available, the value is set to 0. This is to account for securities whose trading is illiquid.

Liquidity and order imbalance are important factors in asset price determination (O'Hara, 2003, Amihud and Mendelson, 1986). The quantity of buy orders relative to sell orders is an indication of pent up demand for a security, and is therefore relevant to the price movement of a security. Hsieh et al. (2009) are unable to measure order imbalance accurately given the institutional details of the Taiwan market[26]. In this paper, with access to order book data, a better estimate of order imbalance is employed, consistent with the extant literature. The variable $OrderImbalance_{k-n}$ is calculated as:

$$OrderImbalance_{k-n} = \frac{BidSize_{k-n}}{AskSize_{k-n}}$$

where *k* is the current transaction and *n* is the number of the lags required (*n*=1, 2,3).

Three lagged variables $BuyerSeller_{k-n}$ are included to identify whether a trade is buyer or seller initiated. $BuyerSeller_{k-n}$ takes the value of 1 (-1) if the *k-n*th transaction price is greater (less) than the average of the bid price and ask price at time, T_{k-n}. If a trade occurs at the midpoint, and therefore an undetermined initiation, the value of $BuyerSeller_{k-n}$ is set to 0.

To capture the impact of a security price movement given the broader stock market movements, three variables, $Market_{t-n}$ are included that track the returns of the respective stock market indices. For the regression undertaken on the Shanghai-listed securities, the variables $Market_{t-n}$ capture the one-minute continuously compounded returns of the

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25 For a given security prior to any trade, if a bid price is 1.05 and the ask price is 1.10, then the value of the bid-ask spread $\beta_7 Spread_{k-1}$, will be equal to 0.05 (=1.10-1.05). However, in this example, if either the bid (1.05) or the ask (1.10) are not available resulting from no buyer or seller interest, then the bid-ask spread is incalculable, and then $\beta_7 Spread_{k-1}$ is set to 0.

26 The Taiwanese market Hsieh et al. (2009) studied has batch auctions instead of continuous trading as in the Chinese securities markets. As a result, the only information that Hsieh et al. (2009) received from the market is the auction clearing price and the total clearing volume of the auction (excluding information such as the number of trades and the average transaction size). Hsieh et al. (2009) calculated a proxy for order imbalance by combining a buyer or seller determined trade indicator variable with a per trade volume measure, giving a per-unit volume impact of the buyer or seller initiation effect. The trade data available to this research paper utilises continuous trade data that is based on tick size of 0.01 RMB.

Shanghai Composite Index (SSE Composite), where *n* is the number of the lag required (*n*=1, 2,3). For the regression undertaken on the Shenzhen-listed securities, the variables $Market_{k-n}$ capture the one-minute continuously compounded returns of the Shenzhen Composite Index (SZSE Composite), where *n* is the number of the lag required (*n*=1, 2,3).

The explanatory variable that enables this research to evaluate the hypothesis of the existence of the magnet effect is the distance a trade price is from the daily price limit, the distance-to-limit. The distance-to-limit variable is measured in ticks, or the smallest price increment that a trade price can advance by in any given trade. To determine if the variable that measures distance-to-limit impacts the likelihood of a trade advancing towards a price limit, it is therefore necessary to determine the *change* in the odds of a movement towards a limit *between* distance-to-limit values. In other words, this research is interested in understanding what the *relative* change in the odds is between moving from *m* ticks out from a daily price limit, to *m-1* ticks out from the limit.

From there it follows, that if this value of the *change in the odds between ticks* is economically and statistically significant, there is support for the magnet effect of price limits. It also follows from the theory, that if the magnet effect holds, not only is the likelihood of trade advance more likely than it was at the previous tick, that the *larger change in the odds should occur at the values closer to the limit*. The increase in likelihood of a price advancing towards a daily price limit should *increase* as the proximity to the limit *increases*.

To determine if there is a change in the odds of an advance between ticks, it is first necessary to calculate the odds of security advancing from a new position, *m-1*, which is one tick closer to the price limit[27]. The odds of a security ticking up or down towards a limit from the new position, *m-1* (one tick closer) are as follows:

$$\frac{p_1}{1-p_1} = e^{\alpha+\beta X_0-(\beta_1+\beta_2)} \tag{3}$$

The odds of a security ticking up or down from a particular distance (*m-1*) towards a price limit are given in Equation 3– where β_1 and β_2 are explanatory variables that are related to the distance from price limit.

Given that the change in the odds of a price advancing from distance *m* is expressed in Equation 2, and the change in the odds of a price advancing from a distance *m-1* in Equation 3, the *percentage change in odds* can now be calculated for all tick subgroups. If the magnet effect is to hold, then not only should the change be greater than zero for an advancement

[27] The value of the distance-to-limit coefficient of the equation is negative, the equation is *reducing* or *removing* a unit of *m* (in this case distance), rather than adding a unit which is the more common practice in regression coefficient interpretation.

towards a price limit, the value of the *percentage change in odds* should increase as the distance to the price limit decreases. The following equation defines the percentage change in odds:

$$\frac{\left(\frac{p_1}{1-p_1}\right)-\left(\frac{p_0}{1-p_0}\right)}{\left(\frac{p_0}{1-p_0}\right)} = e^{-(\beta_1+\beta_2)} - 1 \qquad (4)$$

The percentage change in odds of the distance-to-limit variable, comprised of β_1 and β_2, between the tick distances m_0 and m_1,is given in Equation 4.

If the magnet effect is evident, the percentage change in odds of the distance variables ought to be economically larger for ticks closer to the limit than for those further away. This regression is run for each security for ticks 2-15 and the values of β_1 and $\beta_2$are recorded and tabulated. As per Hsieh et al. (2009), the values of β_1 and β_2 are only included in further analysis at each tick level if the coefficient is statistically significant at the 5% level, otherwise the value of the coefficient is determined to be insignificantly different from zero, and is therefore set to the value of zero.

Values of β_1 and β_2, once assessed for statistical significance, are the then added together to create the mean and median values for the entire security group in question. Once converted using Equation 4, the existence of the magnet effect of price limits is assessed.

The mean values of the percentage change in odds at each tick value are interpreted as the value of the magnet effect at the point. The median values are used in the interpretation of the starting point of the magnet effect with respect to tick distance from limit. Following Hsieh et al. (2009), the magnet effect is considered to begin at tick level where the median value of the percentage change in odds is greater than 0.

Fixed Effects Linear Regression

Turning to whether the magnitude or statistical significance of the magnet effect changes following the introduction of the SHHKConnect, a firm-fixed effects linear regression is conducted. By employing a fixed effects model, this study controls for time independent effects for each firm that are possibly correlated with the magnet effect of price limits.

To determine the changes in the magnet effect between the Pre and Post-Connect time periods, and accounting for variations in firms within the subgroup of securities, a firm-fixed effects regression is employed, estimated by the following equation:

$$nbeta_k = a_0 + \beta_0 Connect + FEFirm_k + \varepsilon \qquad (5)$$

where nbeta_k is the cumulative value of the log odds at each tick level, a_0 is a constant, $\beta_0\mathrm{Connect}$ is a dummy variable indicating the time period of the study, either Pre-Connect (0), or Post-Connect (1), and FEFirm_k controls for the firm-specific fixed effects for each firm k.

This paper compares the cumulative value of the mean log odds of the logistic regression output at each tick level, rather than at each tick level individually across the pre and post SHHKConnect study time periods. Per security, the magnet effect at each tick level, measured by the log odds, may have changed in magnitude or significance. Also, the first point at which the magnet effect becomes evident, when the median value of percentage change of odds is greater than zero, may have also changed due to SHHKConnect. Accounting for both these potential changes in the magnet effect, this study aggregates the value of the cumulative magnet effect, given by:

$$nbeta_k = \sum_{m=1}^{15}(\beta_1 + \beta_2)_{m,k} \quad (6)$$

where $nbeta_k$ denotes the total cumulate value of log odds of the coefficient of the distance to limit variables values of β_1 and β_2 at that particular tick group, *m*, for a given security, *k*.

From the results of Equation 5, the hypotheses pertaining to the impact that the SHHKConnect had on the magnet effect and the effectiveness of price limits on the SSE can be evaluated.

Results

Table 4.1 reports summary statistics of the likelihood of ceiling limit hits occurring using daily data during the sample periods. Specifically, Table 4.1 reports the frequency of ceiling limit being triggered or hit, conditional on the distance, measured in ticks/price steps from the maximum permissible price of the day. Results in Table 4.1 Panel A, indicate that, on average in the pre-Connect period, dual-listed securities that trade 1 tick away from their ceiling limit advance further 94% of the time and trigger a ceiling limit hit. Similarly, for securities that are 2 ticks out from the maximum ceiling price, on average 88% of the time continue to increase in price and trigger the price limit, whereas those security days 30 ticks out from the limit price, on average, only 31% trigger a limit hit. As such, figures in Table 4.1 can be considered ‘limit hit conversion rates’. Results in Table 4.1 Panel A show that pre-Connect, dual-listed securities experience a monotonic increase in the frequency of their limit hits as they move closer to the limit, prima facie evidence of the magnet effect in dual-listed securities prior to the introduction of the SHHKConnect.

Table 4.1 Panel B presents limit-hit conversion rates in the post-Connect period, and reports a 96% frequency of reaching the limit when prices are 1-tick out from the limit price of the day, which is 2 percentage points higher than the average for the pre-Connect securities. This pattern of conversion rates being higher in the post-Connect period for dual listed securities is identified out to 30 ticks from the limit hit price.

Panels C and D in Table 4.1 report limit hit conversion rates pre and post-Connect for the sample of Connect securities, respectively. These results reflect those reported for dual-listed securities—frequencies monotonically increase as the distance to the limit decreases, and post-Connect rates on average are higher, indicative of the magnet effect. Panels E and F report results for the 100 Shenzhen securities that are not involved in SHHKConnect. Again, conversion rates monotonically increase as the distance to the limit decreases are observed, which indicate preliminary evidence of the magnet effect in Shenzhen. Also, the first 2 ticks closest to the limit exhibit higher conversion rates pre-Connect, diverging from the results of the Connect securities.

Table 4.2 presents the results of ex-post floor limit hit conversion rate analysis for dual-listed (Panels A and B), Connect securities (Panels C and D) and Shenzhen securities (Panels E and F). Results for floor limit days mirror those on ceiling limit days. The limit conversion rates monotonically decrease out from the limit and the post-Connect rates are higher on average than the pre-Connect rates for the Connect stocks, and the first 2 ticks of the Shenzhen exhibit higher conversion rates pre-Connect.

Table 4.1 - Percentage of Ceiling Limit Hits

This table reports the total number of ceiling limit hit moves for the 69 dual-listed, 474 Connect and 100 Shenzhen securities as a proportion of the total number of days when the maximum (minimum) price reached on any given day is between 1-30 ticks out from the limit. The mean is a weighted average mean for each security and the difference (expressed as an absolute percentage) is the difference of the mean between adjacent ticks near the price limit. Panel A shows the pre-Connect dual-listed values, Panel B shows the post-Connect dual-listed values, Panel C shows the pre-Connect 474 Connect values, Panel D shows the post-Connect 474 Connect values, Panel E shows the pre-Connect 100 Shenzhen values and Panel F shows the post-Connect 100 Shenzhen values.

	Number of ticks to ceiling price limit																													
Ceiling Hits	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
A - Dual-listed Pre-Connect																														
Median (%)	100	100	100	100	83	76	67	67	60	59	50	49	42	34	33	32	27	22	19	18	15	13	11	10	8	7	5	5	5	5
Mean (%)	94	88	83	79	74	66	63	60	57	55	51	46	43	41	39	37	35	33	31	30	28	26	24	23	21	20	20	19	18	17
Difference (%)		6	5	4	5	8	4	3	3	2	4	5	2	2	2	3	2	2	1	1	2	2	2	1	2	1	1	1	1	1
B - Dual-listed Post-Connect																														
Median (%)	100	94	89	85	81	79	76	75	73	70	68	68	64	63	63	61	60	57	56	54	52	50	50	49	47	46	45	43	43	42
Mean (%)	96	92	88	85	81	79	76	74	72	69	66	65	63	62	60	58	57	55	54	53	52	50	49	48	47	46	45	44	43	42
Difference (%)		4	4	3	4	2	3	2	3	3	3	2	2	2	2	1	1	2	2	1	1	1	1	1	1	1	1	1	1	1
C - Connect 474 Pre-Connect																														
Median (%)	100	100	100	100	90	83	78	75	71	67	67	60	58	55	50	50	50	50	50	44	43	40	40	38	33	33	33	30	29	29
Mean (%)	97	91	87	84	80	76	73	71	68	65	63	60	58	55	54	51	50	48	46	45	44	42	41	40	39	37	36	35	33	32
Difference (%)		5	4	3	4	4	3	2	3	3	2	3	2	2	2	2	2	2	2	1	1	1	1	1	1	2	1	1	1	1
D - Connect 474 Post-Connect																														
Median (%)	100	97	93	90	88	86	84	82	80	79	77	75	73	72	71	70	67	67	65	64	63	62	60	58	57	56	55	54	53	52
Mean (%)	97	95	92	89	87	85	83	81	79	77	75	74	72	71	70	68	67	65	64	63	61	60	59	58	57	56	55	54	53	52
Difference (%)		2	3	3	2	2	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
E - 100 Shenzhen Pre-Connect																														
Median (%)	100	100	100	100	100	93	80	78	72	67	60	57	50	50	50	50	50	50	43	43	40	37	33	33	29	29	25	25	23	21
Mean (%)	98	95	87	84	81	78	75	72	70	66	62	59	58	57	55	53	50	49	46	45	44	42	41	39	38	37	35	33	32	31
Difference (%)		3	8	3	3	3	3	3	2	4	4	3	1	1	2	2	3	1	3	1	2	1	1	2	1	1	2	2	1	1
F - 100 Shenzhen Post-Connect																														
Median (%)	100	95	94	91	89	86	85	83	81	80	77	76	75	72	71	70	67	67	64	63	62	60	60	57	57	54	54	53	53	52
Mean (%)	96	94	92	90	87	86	84	81	79	78	76	75	73	71	70	68	67	65	64	63	62	61	59	58	57	56	55	54	52	52
Difference (%)		2	2	2	3	2	2	2	2	1	2	2	2	2	1	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1

Table 4.2 - Percentage of Floor Limit Hits

This table reports the total number of floor limit hit moves for the 69 dual-listed, 474 Connect and 100 Shenzhen securities as a proportion of the total number of days when the minimum price reached on any given day is between 1-30 ticks out from the limit. The mean is a weighted average mean for each security and the difference (expressed as an absolute percentage) is the difference of the mean between adjacent ticks near the price limit. Panel A shows the pre-Connect dual-listed values, Panel B shows the post-Connect dual-listed values, Panel C shows the pre-Connect 474 Connect values, Panel D shows the post-Connect 474 Connect values, Panel E shows the pre-Connect 100 Shenzhen values and Panel F shows the post-Connect 100 Shenzhen values.

	Number of ticks to floor price limit																													
Floor Hits	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
A - Dual-listed Pre-Connect																														
Median (%)	100	100	100	100	100	100	75	50	50	33	21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mean (%)	94	86	82	79	71	65	63	53	49	43	41	33	31	30	28	24	22	21	18	17	14	13	13	13	11	10	9	8	8	7
Difference (%)		8	4	3	8	6	2	10	4	6	2	8	1	1	2	3	3	1	3	1	3	1	0	0	2	1	1	1	1	0
B - Dual-listed Post-Connect																														
Median (%)	100	100	92	89	86	84	82	80	77	75	72	71	70	69	69	68	65	65	65	63	62	61	59	57	56	56	56	54	52	52
Mean (%)	97	95	91	89	86	84	82	80	78	76	74	73	71	70	69	67	66	64	62	61	59	57	56	54	53	52	51	49	48	47
Difference (%)		2	4	3	3	2	3	2	2	1	2	1	2	1	1	1	1	2	2	2	2	2	1	2	1	1	1	1	1	1
C - Connect 474 Pre-Connect																														
Median (%)	100	100	100	100	100	100	100	75	60	50	50	50	50	33	33	33	25	24	12	3	0	0	0	0	0	0	0	0	0	0
Mean (%)	97	94	87	82	76	73	68	63	57	54	51	49	46	43	40	38	36	34	32	29	27	26	25	25	24	22	21	20	20	18
Difference (%)		4	7	5	6	3	4	5	7	3	3	3	3	3	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1
D - Connect 474 Post-Connect																														
Median (%)	100	96	94	92	91	89	87	86	85	83	82	81	80	78	77	76	75	75	74	73	71	71	69	68	67	67	67	65	64	63
Mean (%)	97	95	93	91	89	88	86	85	83	82	81	79	78	77	76	75	74	73	72	71	70	69	68	67	66	65	64	63	62	61
Difference (%)		3	2	2	2	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
E – 100 Shenzhen Pre-Connect																														
Median (%)	100	100	100	100	100	93	80	78	72	67	60	57	50	50	50	50	50	50	43	43	40	37	33	33	29	29	25	25	23	21
Mean (%)	98	95	87	84	81	78	75	72	70	66	62	59	58	57	55	53	50	49	46	45	44	42	41	39	38	37	35	33	32	31
Difference (%)		3	8	3	3	3	3	3	2	4	4	3	1	1	2	2	3	1	3	1	2	1	1	2	1	1	2	2	1	1
F - 100 Shenzhen Post-Connect																														
Median (%)	100	95	94	90	88	86	84	83	81	80	79	78	77	75	75	74	71	71	69	67	67	67	65	65	63	63	61	61	60	60
Mean (%)	97	94	91	88	86	85	83	82	81	79	77	76	75	73	73	71	70	69	68	66	65	64	63	62	61	60	60	59	58	57
Difference (%)		3	3	3	2	1	2	1	1	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Logistic Regression Output

Tables 5.1 and 5.2 present the mean and median coefficient estimates of Equation 1 that test for the existence of the magnet effect in China's securities markets after controlling for known market microstructure measures. Reported coefficients are the log odds of a price advance (towards a limit) at each price level, measured in ticks, away from the trigger price. The variable of interest, 'distance from a limit', is captured by coefficients $\beta_1 + \beta_2$ as a single term. A negative coefficient results from a reduction in the distance variable each tick change towards the limit, and implies that the odds of hitting the limit increase exponentially as the price gets closer to the limit.

Ceiling Limit Regressions

Panel A of Table 5.1 reports results for dual-listed Shanghai securities, pre- and post-Connect. Consistent with Hsieh et al. (2009) the magnet effect is identified when the median value of the distance coefficient is equal to zero. In the pre-Connect period, the median value of the distance coefficient is 0.00 at 3 ticks away from the limit price, whereas in the post-Connect period, the median value is 0.00 at 12 ticks from the limit price, suggesting that the magnet effect manifests earlier (further out from the limit) following the introduction of the SHHKConnect.

According to the magnet effect hypothesis, a security should be more likely to move towards a limit the closer it gets to the limit. The mean (median) value of the distance coefficient 2 ticks out in the pre-Connect period is -0.49 (-0.30), while for the post-Connect period, the mean (median) value of the distance coefficient is 0.60 (-0.50) at 2 ticks out. The largest negative distance coefficients in Panel A are closer to the limit, implying that the relationship between distance and the likelihood of advancing towards the limit is stronger the closer the price is to the limit, as expected. This study interprets the higher likelihood of a movement towards a limit occurring closer to the limit, and decreasing as the distance increases, as evidence for the existence of the magnet effect—consistent with hypothesis 1. This study also interprets the change in the magnitude of the mean and median values of the coefficients between the time periods to be indicative of a change in the magnet effect induced by the introduction of the SHHKConnect.

Panel B of Table 5.1 reports results for ceiling hits in 474 Connect Shanghai securities. Results are analogous to those identified for dual-listed securities. The distance coefficients are negative in both pre- and post-Connect time periods, and are largest at ticks closest to the limit, decreasing as tick level increases. Further, for Connect securities, the magnet effect commences earlier and is more pronounced post-Connect vis-a-vis pre-Connect.

Panel C reports the results for the 100 Shenzhen securities. Unlike, ex-post results identified in Table 4.1 and Table 4.2, Table 5.1 shows, ex-ante, the magnet effect does not manifest in Shenzhen securities. Distance coefficients, means and median values, are non-zero or economically insignificant values.

The evidence found in this study for the existence of the ex-ante magnet effect in ceiling limit hits for securities on the SSE, is consistent with the findings from Wong et al. (2009b). However, these findings contradict those of Kim et al. (2013) who do not find evidence for the magnet effect of ceiling price limits in their study of Chinse securities.

Floor Limit Regressions

Table 5.2 reports corresponding estimates for price limit floors. Results for the 69 dual-listed, 474 Connect and 100 Shenzhen securities are set out in Panels A, B and C respectively. Corresponding results are identified, for Connect securities: the distance coefficients are strongest closest to the limit, implying a magnet effect and the magnet effect begins later and is larger in magnitude (-0.22 pre and -0.53 post-Connect at 2 ticks for the dual-listed, and - 0.37 pre and - 0.57 post-Connect for the 474 Connect securities). The only difference is the median of the distance coefficients which suggest the magnet effect does not exist in the pre-Connect regime, despite the mean values indicating a strong economic effect[28]. A more pronounced magnet effect of ceiling limit hits than of floors is observed in Wong et al. (2009b), who also document the asymmetry of the magnet effect on the SSE.

The results of the floor regression for the 100 Shenzhen securities are analogous to the ceilings for this group of securities, showing no evidence for the magnet effect, nor indicating a change in the magnitude between pre- and post-Connect periods.

[28] Only 23 floor limit hits are recorded for the pre-Connect 69 dual-listed securities meaning results are reliant on a small data sample.

Table 5.1 – Logistic regression output for the distance variables for ceiling limit hits

The estimated regression is as follows: $X_k'B = \beta_0 + \beta_1 TickDistance_{k-1} + \beta_2 TickGroup_{k-1}^{m} \times TickDistance_{k-1} + \beta_3 \Delta T_k + \beta_4 Volume_{k-1} + \beta_5 Volume_{k-2} + \beta_6 Volume_{k-3} + \beta_7 Spread_{k-1} + \beta_8 Bid_{k-1} + \beta_9 Ask_{k-1} + \beta_{10} BuyerSeller_{k-1} + \beta_{11} BuyerSeller_{k-2} + \beta_{12} BuyerSeller_{k-3} + \beta_{13} OrderImbalance_{k-1} + \beta_{14} OrderImbalance_{k-2} + \beta_{15} OrderImbalance_{k-3} + \beta_{16} Market_{k-1} + \beta_{17} Market_{k-2} + \beta_{18} Market_{k-3}$

This table provides the log odds of the logistic regression output for β_1 (tick distance), β_2 (tick group) and their sum $\beta_1 + \beta_2$, (distance coefficient), for each tick 2-15 from the ceiling limit. A regression is run for each tick distance and for each security in the subgroup and the cross-sectional means and medians are presented. The estimate of β_1 or β_2 for each individual firm is set equal to 0 if the p-value of the estimate is greater than 5%, indicating that the estimate is not significantly different from zero. Panel A shows the results for the Dual-listed; Panel B the 474 Connect; and Panel C the 100 Shenzhen securities.

Ceilings	Pre-Connect						Post-Connect					
	β1		β2		Distance-to-limit (β1 + β2)		β1		β2		Distance-to-limit (β1 + β2)	
Ticks	Mean	Median	Mean	Median	Mean	Median	Mean	Median	Mean	Median	Mean	Median
Panel A 69 Dual-listed												
2	0.01	0.00	-0.50	-0.30	-0.49	-0.30	0.00	0.00	-0.60	-0.51	-0.60	-0.50
3	0.01	0.01	-0.19	0.00	-0.18	0.00	0.00	0.00	-0.28	-0.21	-0.27	-0.21
4	0.01	0.01	-0.06	0.00	-0.05	0.00	0.00	0.00	-0.17	-0.13	-0.17	-0.12
5	0.01	0.01	-0.05	0.00	-0.04	0.00	0.00	0.00	-0.11	-0.08	-0.10	-0.08
6	0.01	0.01	-0.02	0.00	0.00	0.01	0.00	0.00	-0.08	-0.05	-0.08	-0.05
7	0.01	0.01	-0.01	0.00	0.01	0.01	0.00	0.00	-0.06	-0.04	-0.06	-0.04
8	0.01	0.01	0.01	0.00	0.02	0.01	0.00	0.00	-0.04	-0.02	-0.04	-0.02
9	0.01	0.01	0.01	0.00	0.02	0.01	0.00	0.00	-0.03	-0.01	-0.02	-0.01
10	0.01	0.01	0.00	0.00	0.01	0.02	0.00	0.00	-0.02	-0.02	-0.02	-0.01
11	0.01	0.01	0.01	0.00	0.02	0.02	0.00	0.00	-0.02	-0.01	-0.01	-0.01
12	0.01	0.01	0.00	0.00	0.01	0.01	0.00	0.00	-0.01	-0.01	-0.01	0.00
13	0.01	0.01	0.00	0.00	0.01	0.02	0.00	0.00	-0.01	0.00	0.00	0.00
14	0.01	0.01	0.00	0.01	0.02	0.02	0.01	0.00	-0.01	0.00	0.00	0.00
15	0.01	0.01	0.01	0.01	0.03	0.02	0.01	0.00	-0.01	0.00	0.00	0.00
Panel B 474 Connect												
2	0.00	0.00	-0.45	-0.31	-0.45	-0.31	0.00	0.00	-0.48	-0.44	-0.48	-0.44
3	0.00	0.00	-0.19	0.00	-0.19	0.00	0.00	0.00	-0.23	-0.20	-0.23	-0.20
4	0.00	0.00	-0.11	0.00	-0.11	0.00	0.00	0.00	-0.14	-0.11	-0.14	-0.11
5	0.00	0.00	-0.06	0.00	-0.06	0.00	0.00	0.00	-0.09	-0.07	-0.09	-0.07
6	0.00	0.00	-0.03	0.00	-0.03	0.00	0.00	0.00	-0.06	-0.05	-0.06	-0.05
7	0.00	0.00	-0.01	0.00	-0.01	0.00	0.00	0.00	-0.04	-0.03	-0.04	-0.03
8	0.00	0.00	-0.01	0.00	-0.01	0.00	0.00	0.00	-0.03	-0.02	-0.03	-0.02
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.02	-0.02	-0.02	-0.02
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.02	-0.01	-0.02	-0.01
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.02	-0.01	-0.01	-0.01
12	0.00	0.00	0.01	0.00	0.01	0.00	0.00	0.00	-0.01	0.00	-0.01	0.00
13	0.00	0.00	0.01	0.00	0.01	0.00	0.00	0.00	-0.01	0.00	-0.01	0.00
14	0.00	0.00	0.01	0.00	0.01	0.00	0.00	0.00	-0.01	0.00	-0.01	0.00
15	0.00	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Panel C 100 Shenzhen												
2	0.00	0.00	0.06	0.00	0.05	0.00	0.00	0.00	-0.01	0.00	-0.01	0.00
3	0.00	0.00	0.07	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.06	0.00	0.05	0.00	0.00	0.00	0.03	0.00	0.03	0.00
5	0.00	0.00	0.04	0.00	0.04	0.00	0.00	0.00	0.02	0.00	0.02	0.00
6	0.00	0.00	0.03	0.00	0.03	0.00	0.00	0.00	0.01	0.00	0.01	0.00
7	0.00	0.00	0.03	0.00	0.03	0.00	0.00	0.00	0.01	0.00	0.01	0.00
8	0.00	0.00	0.02	0.00	0.02	0.00	0.00	0.00	0.01	0.00	0.01	0.00
9	0.00	0.00	0.02	0.00	0.02	0.00	0.00	0.00	0.01	0.00	0.01	0.00
10	0.00	0.00	0.02	0.00	0.02	0.00	0.00	0.00	0.01	0.00	0.01	0.00
11	0.00	0.00	0.02	0.00	0.02	0.00	0.00	0.00	0.01	0.00	0.01	0.00
12	0.00	0.00	0.02	0.00	0.02	0.00	0.00	0.00	0.01	0.00	0.01	0.00
13	0.00	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.01	0.00
14	0.00	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.01	0.00
15	0.00	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.01	0.00

Table 5.2 – Logistic regression output for the distance variables for floor limit hits

The estimated regression is as follows: $X_k'B = \beta_0 + \beta_1 TickDistance_{k-1} + \beta_2 TickGroup_{k-1}^{m} \times TickDistance_{k-1} + \beta_3 \Delta T_k + \beta_4 Volume_{k-1} + \beta_5 Volume_{k-2} + \beta_6 Volume_{k-3} + \beta_7 Spread_{k-1} + \beta_8 Bid_{k-1} + \beta_9 Ask_{k-1} + \beta_{10} BuyerSeller_{k-1} + \beta_{11} BuyerSeller_{k-2} + \beta_{12} BuyerSeller_{k-3} + \beta_{13} OrderImbalance_{k-1} + \beta_{14} OrderImbalance_{k-2} + \beta_{15} OrderImbalance_{k-3} + \beta_{16} Market_{k-1} + \beta_{17} Market_{k-2} + \beta_{18} Market_{k-3}$

This table provides the log odds of the logistic regression output for β_1 (tick distance), β_2 (tick group) and their sum $\beta_1 + \beta_2$, (distance coefficient), for each tick 2-15 from the floor limit. A regression is run for each tick distance and for each security in the subgroup and the cross-sectional means and medians are presented. The estimate of β_1 or β_2 for each individual firm is set equal to 0 if the p-value of the estimate is greater than 5%, indicating that the estimate is not significantly different from zero. Panel A shows the results for the Dual-listed; Panel B the 474 Connect; and Panel C the 100 Shenzhen securities.

	Pre-Connect						**Post-Connect**					
Floors	β1		β2		Distance-to-limit (β1 + β2)		β1		β2		Distance-to-limit (β1 + β2)	
Ticks	Mean	Median	Mean	Median	Mean	Median	Mean	Median	Mean	Median	Mean	Median
Panel A 69 Dual-listed												
2	0.01	0.01	-0.23	0.00	-0.22	0.01	0.00	0.00	-0.54	-0.48	-0.53	-0.48
3	0.01	0.00	0.03	0.00	0.05	0.00	0.00	0.00	-0.27	-0.23	-0.26	-0.23
4	0.01	0.01	0.12	0.00	0.13	0.01	0.00	0.00	-0.17	-0.14	-0.17	-0.13
5	0.01	0.01	0.09	0.00	0.11	0.01	0.00	0.00	-0.11	-0.10	-0.11	-0.10
6	0.01	0.01	0.13	0.00	0.15	0.01	0.00	0.00	-0.08	-0.07	-0.07	-0.07
7	0.02	0.01	0.15	0.00	0.16	0.01	0.00	0.00	-0.05	-0.05	-0.05	-0.05
8	0.02	0.01	0.13	0.00	0.15	0.01	0.00	0.00	-0.04	-0.03	-0.03	-0.03
9	0.02	0.01	0.13	0.00	0.14	0.01	0.00	0.00	-0.03	-0.02	-0.02	-0.02
10	0.02	0.01	0.05	0.00	0.06	0.01	0.00	0.00	-0.02	-0.02	-0.02	-0.02
11	0.01	0.01	0.04	0.00	0.06	0.01	0.00	0.00	-0.02	-0.01	-0.01	-0.01
12	0.01	0.01	0.04	0.00	0.05	0.01	0.00	0.00	-0.01	-0.01	-0.01	-0.01
13	0.02	0.01	0.05	0.00	0.06	0.01	0.00	0.00	-0.01	-0.01	-0.01	-0.01
14	0.01	0.01	0.05	0.00	0.07	0.01	0.00	0.00	-0.01	0.00	-0.01	0.00
15	0.01	0.01	0.03	0.00	0.05	0.01	0.00	0.00	-0.01	0.00	0.00	0.00
Panel B 474 Connect												
2	0.00	0.00	-0.37	0.00	-0.37	0.00	0.00	0.00	-0.51	-0.51	-0.51	-0.51
3	0.00	0.00	-0.14	0.00	-0.14	0.00	0.00	0.00	-0.25	-0.25	-0.25	-0.25
4	0.00	0.00	-0.07	0.00	-0.06	0.00	0.00	0.00	-0.15	-0.15	-0.15	-0.15
5	0.01	0.00	-0.05	0.00	-0.04	0.00	0.00	0.00	-0.10	-0.10	-0.10	-0.10
6	0.00	0.00	-0.03	0.00	-0.03	0.00	0.00	0.00	-0.07	-0.07	-0.07	-0.07
7	0.00	0.00	-0.02	0.00	-0.02	0.00	0.00	0.00	-0.05	-0.05	-0.05	-0.05
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.04	-0.04	-0.04	-0.04
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.03	-0.03	-0.03	-0.03
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.03	-0.02	-0.03	-0.02
11	0.00	0.00	0.01	0.00	0.01	0.00	0.00	0.00	-0.02	-0.02	-0.02	-0.02
12	0.00	0.00	0.01	0.00	0.01	0.00	0.00	0.00	-0.02	-0.01	-0.02	-0.01
13	0.00	0.00	0.01	0.00	0.01	0.00	0.00	0.00	-0.01	-0.01	-0.01	-0.01
14	0.00	0.00	0.01	0.00	0.01	0.00	0.00	0.00	-0.01	-0.01	-0.01	-0.01
15	0.00	0.00	0.01	0.00	0.01	0.00	0.00	0.00	-0.01	0.00	-0.01	0.00
Panel C 100 Shenzhen												
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.06	0.00	-0.06	0.00
3	0.00	0.00	0.04	0.00	0.04	0.00	0.00	0.00	-0.01	0.00	-0.01	0.00
4	0.00	0.00	0.09	0.00	0.09	0.00	0.00	0.00	-0.02	0.00	-0.01	0.00
5	0.00	0.00	0.06	0.00	0.06	0.00	0.00	0.00	-0.01	0.00	-0.01	0.00
6	0.00	0.00	0.12	0.00	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	0.02	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.03	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	0.00	0.00	0.02	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.01	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	0.00	0.00	0.02	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.02	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	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	-0.01	0.00	-0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00

The Percentage Change in Odds

Figure 1 depicts the conversion from log odds to percentage change in odds for the three groups of securities in question as prices move from 15 to 2 ticks out from price limit triggers. The percentage change is change in the odds between two ticks, as the security price moves tick closer to the limit[29]. Panel A depicts the results for ceiling limit hits, while Panel B shows the floor results.

For the 69 dual-listed and the 474 Connect securities, the Connect securities, the figure shows the increase in likelihood of advancing towards a limit hit as the distance to the limit decreases. The tick closest to the limit exhibits the largest percentage change in odds. The rate of change declines as the distance increases, reaching zero at a point indicating the magnet effect ceases to exist at that point. Similar results exist for ceilings and floors.

The 100 Shenzhen securities do not appear to exhibit any magnet effect properties, nor is there an indication that the pre- and post-Connect values differ with any economic significance.

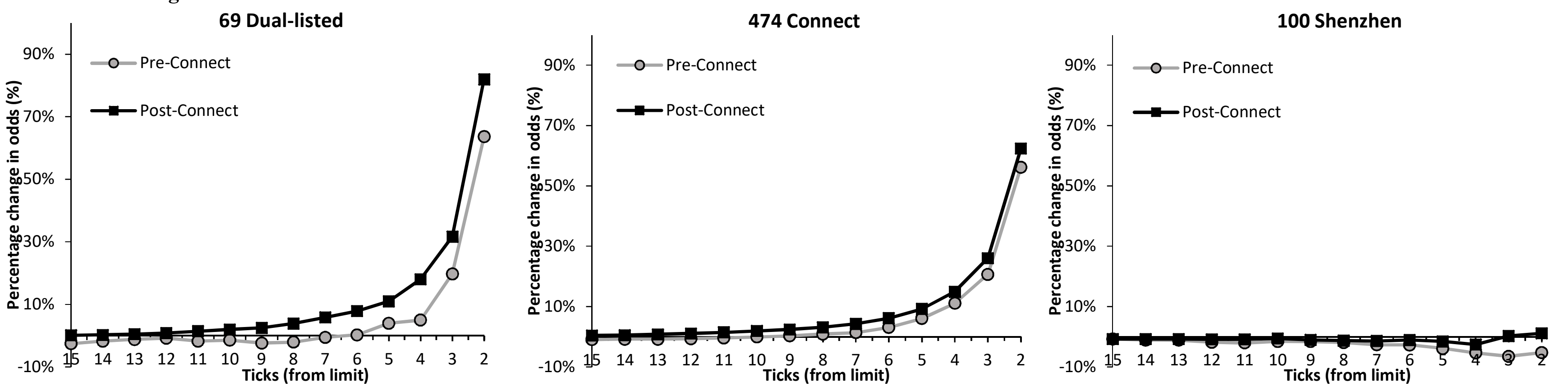
The absolute difference between the pre and post-Connect magnitude of the magnet effect for the Connect securities is also visible from Figure 1. In all instances, the post-Connect percentage change in odds at 2 ticks out is larger than the pre-Connect rates. The dual-listed securities exhibit changes for ceilings (63.60% pre and 81.95% post) and floors (24.49% pre and 70.64% post). Similarly, the 474 Connect securities display changes for ceilings (56.17% pre and 62.36% post) and floors (44.42% pre and 67.04% post). The consistent difference between pre and post-Connect values for ceilings and floors for Connect securities suggests the SHHKConnect had an impact on the magnet effect of price limits on the SSE.

[29] The percentage change in odds is calculated as $e^{-(\beta_1+\beta_2)} - 1$ (Equation (4)), where $(\beta_1 + \beta_2)$ is the distance coefficient.

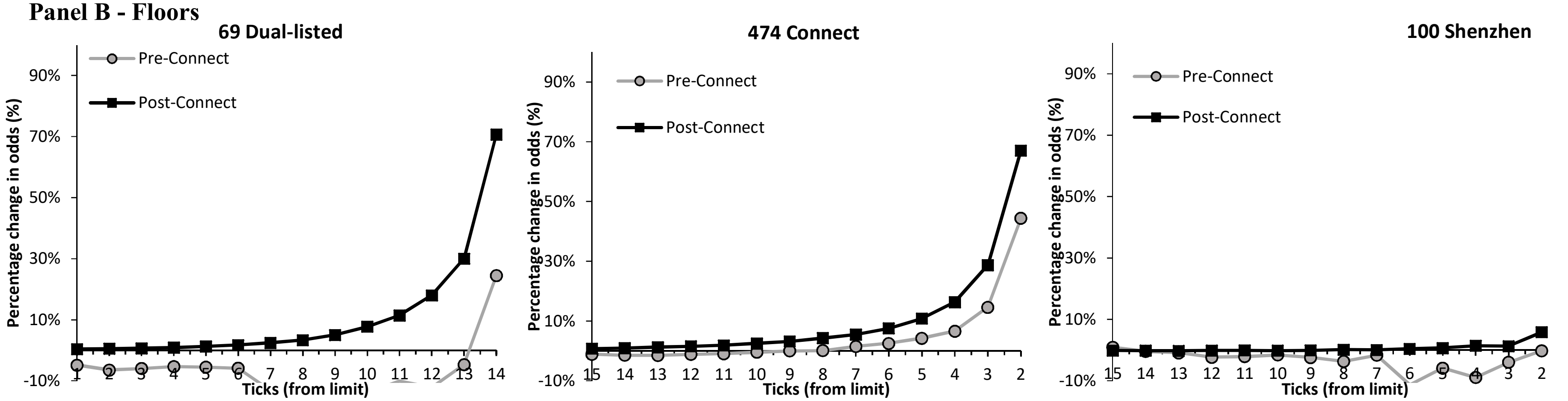
Figure 1 – Percentage change in odds between ticks

These figures show the percentage change in the odds for limit hits for the 69 Dual-listed, 474 Connect and 100 Shenzhen securities. The percentage change in odds is the change in the odds between adjacent ticks from the limit, derived from the mean of $\beta_1 + \beta_2$, calculated from Equation (4) as $e^{-(\beta_1+\beta_2)} - 1$. The figures show change for each tick distance from the limit on a pre- and post-Connect basis.

Panel A - Ceilings



Panel B - Floors



Firm-fixed Linear Regression

Having presented evidence of the magnet effect on the SSE, next this study assesses whether the magnet effect is statistically and significantly different between pre- and post-Connect periods to measure the impact of the SHHKConnect on the magnet effect—hypothesis 2. Table 6 reports mean coefficient estimates of firm-fixed effects regression for both ceiling and floor limit hits for the three groups of securities. Estimates of the variable of interest, $\beta_0 Connect$ are predominantly negative, suggesting the cumulative log-odds have decreased—the magnet has intensified after the introduction of the SHHKConnect.

Panel A shows the cumulative values of the magnet effect in the post-Connect period are larger for all tick levels, 2 through 15, than in the pre-Connect period for price ceilings and floors, in dual-listed securities. The negative and monotonic increase (as ticks increase) in the value of the estimates indicate the magnet effect is stronger in the post-Connect period. Panel B displays the results for the 474 Connect securities. Similar evidence is reported with aforementioned results in dual-listed securities

Finally, Panel C of Table 6 shows the results of the firm-fixed regression results for the control group of securities, the 100 Shenzhen securities that were not eligible for trading via the SHHKConnect. The table shows no in change in the value of the ceiling limit regression on a pre- and post-Connect basis as the t-values associated with the Connect variable are consistent and statistically not significant for the value of the ticks from 2-15. The statistically significant estimates from ticks 2 through 6 of the floor firm-fixed effects; however, the economic interpretation of the evidence for the magnet effect for pre- and post-Connect time periods is indistinguishable as shown in Figure 1. From these findings, this study concludes that the SHHKConnect did result in a change in magnitude of the magnet effect of price limits for Connect securities on the SSE.

Table 6 – Firm-Fixed Effects Regression Results

This table displays the output of the firm-fixed effects regression. The estimate for the coefficient $\beta_0 Connect$ from the equation $nbeta_k = a_0 + \beta_0 Connect + FEFirm_k + \varepsilon$ (5) is displayed as well as the t-value and statistical significance of this estimate. This table shows the results for ceiling and floor limit hit analysis. Panel A reports the 69 Dual-listed securities; Panel B reports the 474 Connect securities; Panel C reports the 100 Shenzhen securities.

Firm-fixed Effects	**Ceiling**		**Floor**	
Tick	**Estimate**	**t-Value**	**Estimate**	**t-Value**
Panel A - Dual-listed				
2	-0.70	-2.45**	-2.27	-2.18**
3	-0.61	-2.88***	-2.02	-2.34**
4	-0.53	-3.42***	-1.72	-2.37**
5	-0.42	-3.45***	-1.43	-2.38**
6	-0.36	-3.73***	-1.21	-2.37**
7	-0.30	-3.72***	-0.99	-2.35**
8	-0.24	-3.62***	-0.79	-2.33**
9	-0.19	-3.58***	-0.60	-2.31**
10	-0.15	-3.63***	-0.43	-2.37**
11	-0.12	-3.74***	-0.35	-2.37**
12	-0.09	-3.64***	-0.28	-2.42**
13	-0.07	-3.98***	-0.21	-2.50**
14	-0.05	-4.37***	-0.13	-2.55**
15	-0.03	-4.33***	-0.06	-2.48**
Panel B - 474 Connect				
2	-0.47	-3.90***	-0.83	-4.41***
3	-0.38	-4.58***	-0.70	-4.82***
4	-0.31	-4.85***	-0.57	-4.72***
5	-0.26	-5.26***	-0.46	-4.63***
6	-0.23	-5.95***	-0.39	-4.78***
7	-0.20	-6.46***	-0.33	-4.99***
8	-0.17	-6.79***	-0.28	-5.27***
9	-0.16	-7.61***	-0.23	-5.42***
10	-0.13	-7.91***	-0.19	-5.52***
11	-0.11	-8.10***	-0.15	-5.46***
12	-0.09	-8.16***	-0.11	-5.35***
13	-0.07	-7.11***	-0.09	-5.60***
14	-0.05	-6.72***	-0.06	-5.46***
15	-0.02	-6.54***	-0.02	-4.92***
Panel C - 100 Shenzhen				
2	-0.24	-1.56	-0.51	-2.80**
3	-0.17	-1.38	-0.45	-2.57**
4	-0.10	-1.03	-0.40	-2.28**
5	-0.08	-0.96	-0.30	-2.34**
6	-0.06	-0.91	-0.23	-2.47**
7	-0.05	-0.89	-0.11	-1.37
8	-0.04	-0.84	-0.09	-1.36
9	-0.04	-0.91	-0.06	-0.98
10	-0.03	-0.98	-0.04	-0.84
11	-0.03	-0.90	-0.03	-1.01
12	-0.01	-0.69	-0.01	-0.49
13	-0.01	-0.38	0.01	0.750
14	0.00	-0.23	0.01	1.430
15	0.00	-0.01	0.01	1.510

Note:***, **, * represent statistical significance at the 1%, 5% and 10% level respectively.

Robustness Tests and Additional Analysis

Post-Connect Northbound Trade Volume Increasing the Magnet Effect

This study asserts that the increase in the magnet effect on the Connect securities post SHHKConnect results from the increase in trading volume of these securities from foreign investors. The magnet effect existed in these markets for these securities, and the increase in trade from the SHHKConnect increased the magnet effect, resulting in the effect starting earlier and increasing in magnitude.

To assess this hypothesis, this study identifies a sub-sample that received the most post-Connect (December 2014 until November 2015) Northbound trade volume[30]. Data published by the SEHK[31] records the Top 10 companies that receive the most trade volume in Northbound trade on a monthly basis. Aggregating this list for the post-Connect months, a group of 25 securities is selected, comprising companies that most frequently appeared in the Top 10 monthly list published by the SEHK.

Figure 2 displays the results of the conversion from log odds to percentage change in odds for the Top 25 securities. Panel A depicts the results for ceiling limit hits, while Panel B shows the floor results, for 2-15 ticks out from the limit.[32]

Panel A Figure 2 displays the change in the ceiling limit logistic regression output for the Top 25 Connect Shanghai securities. Reported results are analogous to those presented for the Connect securities, however the Top 25 securities show a greater acceleration in the magnet effect post-Connect. The percentage change in log odds post-Connect shows a 133% increase in the magnitude of the magnet effect at 2 ticks out, compared to the pre-Connect values, increasing from 42.93% to 100.38% – the largest economic impact of the magnet effect recorded in this study.

Panel B Figure 2 reports the results for floors and shows a significantly larger percentage change in the log odds in the pre-Connect time period than the post-Connect one, although the small sample size (one security with pre-Connect limit hits) casts doubt on this result.

Table 7 shows the results of the firm-fixed effects regression for the Top 25 Shanghai Connect securities by volume. Results for ceiling limits hits reported in Panel A, show that the post-Connect values are significantly different to the pre-Connect ones, implying that the

[30] For the purposes of this test, only Northbound trade volumes into mainland China are relevant

[31] https://www.hkex.com.hk/eng/csm/chinaconndstat_monthly.htm

[32] Logistic coefficient estimates for Equation (1) for this sub-group, 'Top 25 securities by volume', are presented in Appendix 1.

magnet effect increased in magnitude as a result of the SHHKConnect. Panel B reports results for floor limit hits, and shows that no statistically significant difference between the pre and post-Connect values exists. On the whole, this first robustness test finds the acceleration in the magnet effect of price limits is due to the introduction of the SHHKConnect.

Figure 2 – Percentage change in odds for the Top 25 Shanghai securities by volume

This figure shows the weighted average percentage change in the odds for limit hits for the Top 25 Shanghai securities by volume. The percentage change in odds is the change in the odds ratio between adjacent ticks from the limit, derived from the mean of $\beta_1 + \beta_2$, calculated from Equation (4) as $e^{-(\beta_1+\beta_2)} - 1$. The figure shows the percentage change in odds for each tick distance from the limit on a pre and post-Connect basis.

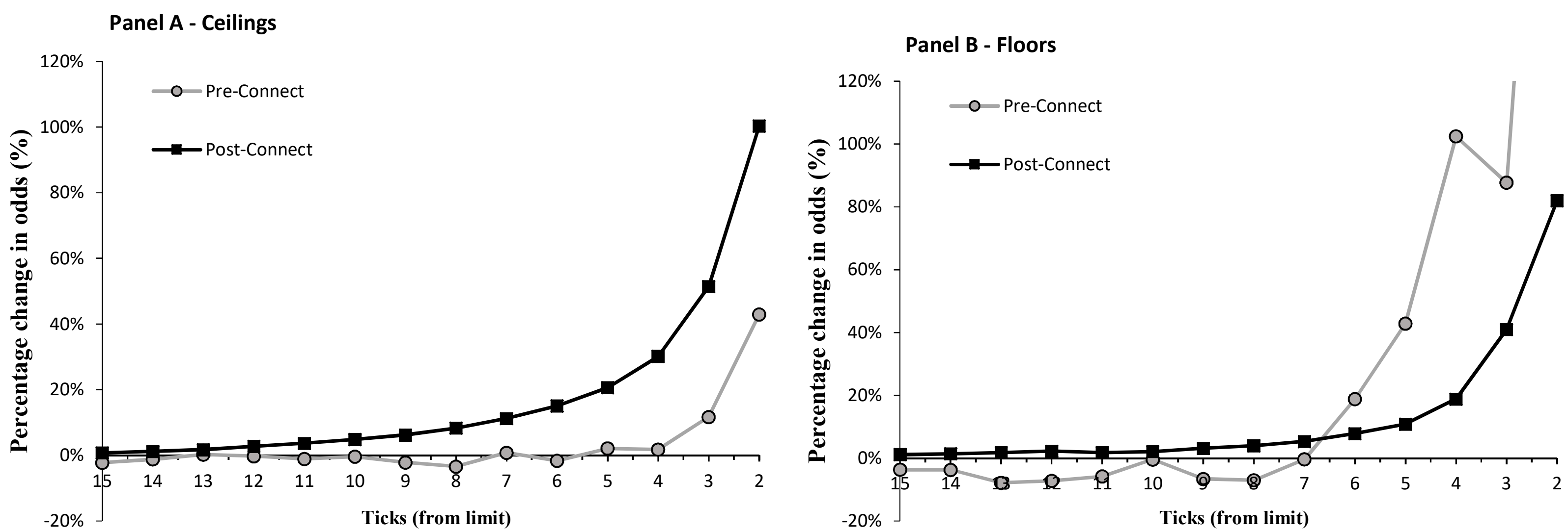


Table 7 – Firm-fixed effects regression for the Top 25 Shanghai Connect securities by volume

This table displays the output of the firm-fixed effects regression. The estimate for the coefficient $\beta_0 Connect$ from the equation $nbeta_k = a_0 + \beta_0 Connect + FEFirm_k + \varepsilon$ (5) is displayed as well as the t-value and statistical significance of this estimate. This table shows the results for ceiling and floor limit hit analysis. This table shows the results for ceiling and floor limit hit analysis for the Top 25 Connect Shanghai securities, on a pre and post Connect basis.

Top 25 Connect Shanghai Securities	**Ceiling**		**Floor**	
Tick	**Estimate**	**t-Value**	**Estimate**	**t-Value**
2	-1.70	-2.44**	1.31	0.570
3	-1.37	-2.45**	0.50	0.300
4	-1.06	-2.37**	0.22	0.190
5	-0.82	-2.27**	-0.31	-0.38
6	-0.65	-2.25**	-0.57	-0.90
7	-0.49	-2.17**	-0.66	-1.33
8	-0.39	-2.17**	-0.61	-1.46
9	-0.28	-1.98*	-0.50	-1.40
10	-0.20	-1.78*	-0.40	-1.33
11	-0.15	-1.68	-0.37	-1.48
12	-0.10	-1.56	-0.30	-1.37
13	-0.07	-1.63	-0.20	-1.26
14	-0.05	-1.92*	-0.10	-0.95
15	-0.03	-2.18**	-0.05	-0.92

Note:***, **, * represent statistical significance at the 1%, 5% and 10% level respectively.

The Impact of SHHKConnect and Price Limits: Dual-listed Securities

In addition to the finding that the magnet effect increased as a result of the increased Northbound trading volume, this study attempts to ascertain other implications of price limits in the presence of a market liberalisation event. The existence of the dual-listed securities on the SSE and SEHK provides a natural experiment in which to test the effects of price limits. While the SSE dual-listed A-shares securities are limited to a daily maximum price movement, the paired SEHK dual-listed H-shares are not.

The SEHK Securities

Of the 2,004 securities listed on the SEHK, 263 became eligible for Southbound trading once SHHKConnect became active. Data obtained from the China Securities Regulatory Commission (CSRC) show that by March 2015, there were 208 H-shares listed, of which, 69 companies were cross-listed in both SSE and SEHK. The A- and H-shares of a particular company share the same income stream but trade in different currencies and on different exchanges.

Data for these SEHK securities included 33,662 stock-day observations from 513 trading days for one full year prior to SHHKConnect (period 1: 1st November 2013 – 16th November 2014) and one full year after the launch of Connect (period 2: 17th November 2014 – 30th November 2015).

Table 8 reports the price returns for days after limit hits for the SSE and SEHK dual-listed securities, as well as the proportions of continuations and reversals associated with the price returns. These are common measures used in the literature to ascertain the impact of price limits on securities in terms of delayed price discovery. If delayed price discovery is observed then it would be expected that instances of continuations following ceiling limit hit days, and reversals following floor limit hit days, would increase (Kim and Rhee, 1997).

The close-to-open return, also known as the overnight return, is the percentage return from the close on the day of the limit *d*, until the opening price on the day after the limit, *d+1*[33]. Continuations are recorded when the overnight return is in the same direction as the limit hit movement (positive price movement for ceilings, negative price movement for floors). Reversals are recorded when the overnight return is a retracement of the limit hit (positive price movement for floors, negative price movement for ceilings).[34] *Locked Limit Days* count for the days where the closing price of the day is equal to the limit price, whereas

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[33] This return is calculated as $\text{Return}_{(\text{close-to-ope }) d+1} = \frac{\text{OpenPrice}_{d+1}}{\text{ClosePrice}_{d}} - 1$.

[34] The continuation and reversal returns are based on the overnight return calculation.

Non-Lock Days are days in which a limit is hit, but a price retracement occurs before the closing trade of the day.

Panel A also shows that the SSE-listed duals to not experience a statistically significant change in the proportion of continuations or reversal, pre- and post-Connect. While the SHHKConnect has been shown to increase the magnet effect of price limits on the SSE-list secs, SHHKConnect has not changed the delayed price discovery impact of price limits.

Panel A in Table 8 displays the aforementioned returns and proportion of movements for the ceiling limits for the SEHK and SSE duals for locked limit days. The proportion of continuations decreases between pre- and post-Connect, showing a statistically significant change of -12.07% for SEHK. Reversals between these periods offset the continuations with similar statistical significance, indicating that the price pressure in the morning after limit hits had decreased for the SEHK dual-listed securities.

The magnitude of the continuations for each of the markets may explain how the SHHKConnect could have changed the trading behaviour of Hong Kong investors. Panel A shows that pre-Connect continuation returns for each of the markets, and the superior price return potential for the SSE-listed duals becomes apparent. The pre-Connect SEHK return is 1.30% compared to the 3.69% return available for the SSE-dual. The expected return differential is sustained post-Connect, with a 2.46% premium return available for Hong Kong-based investors should they choose the SSE dual over the SEHK dual. Not only does the Hong Kong investor pay lower transaction costs[35], the continuations return suggests a larger magnitude price return is available on the mainland exchange.

Panel B observes the price movements on the days after the hits for floors and suggests a similar to ceilings although is not significant (based on a small subset of pre-Connect floor limit hits). Instances for floors are reported in Panel B, and exhibit the same proportion of price continuations and reversals as the ceilings. These results are not shown to be statistically significant however, though this is likely to only 5 pre-Connect floor limit instances resulting in locked limit days.

Panels C and D Table 8 present the results for the non-lock-limited days for continuations and reversals. The pre-Connect continuations and reversal returns for SEHK duals (1.40% for ceilings and -0.96% for floors) are similar to, and in some instances lower

[35] Compared to the SSE, investors in SEHK are subject to greater trading costs. In addition to brokerage fees, trading costs at SEHK include a Transaction Levy (0.0027%), Trading Fee (0.005%), and Stamp Duty on Stock Transactions of (0.1%). Per transaction, buyers are also subject to the Transfer Deed Stamp of HK$5.00, and sellers are subject to the Transfer Fee of HK$2.50.

than the returns of the SSE duals (1.13% for ceilings and -2.00% for floors) suggesting little profit incentive from one market in particular. The post-Connect continuation returns indicate no large difference in the ceilings returns (1.41% on the SEHK and 1.34% on SSE), whereas the floor returns indicate a marginally higher return (smaller loss) on the SEHK (-2.07% and -3.43% on the SSE).

From these results, this study concludes that the impact of the SHHKConnect for lock-limit days did not change the delayed price discovery impacts of price limits on the SSE where the price limits are imposed. However, for the market without the price limit of SEHK, the continuations returns of lock-limited day returns in Shanghai provided a profitable trading strategy for Hong Kong based investors, which changed the nature of the continuations on the SEHK on days following a SSE locked-limit day.

Table 8 – Continuations and Reversals of Overnight Returns

This table shows the proportion of continuations and reversals of price movements, of a security determined by the overnight return. The close-to-open return, also known as the overnight return, is the percentage return from the close on the day of the limit *d,* until the opening price on the day after the limit, *d+1.* It is calculated as $Return_{(close-to-open)d+1} = \frac{OpenPrice_{d+1}}{ClosePrice_{d}} - 1$. Continuations occur when the overnight return is in the same direction as the limit hit movement (positive price movement for ceilings, negative price movement for floors). Reversals occur when the overnight return is a retracement of the limit hit (positive price movement for floors, negative price movement for ceilings). The proportions in Shanghai represent the average proportional movement of the SSE Dual-listed securities on the day after a limit hit. The SEHK duals securities proportion of continuations and reversals are monitored on the days after their SSE pair reaches its price limit. Locked limit days occur when the closing trade price of the day is the limit price, whereas non-locked days feature a price limit hit, but then a retracement during the remainder of the day before the closing price of the day.

	SEHK duals			SSE duals		
	Pre-Connect	Post-Connect	Difference	Pre-Connect	Post-Connect	Difference
Locked Limit days						
Panel A – Ceilings						
Proportion of Continuations	61.29%	49.22%	-12.07%**	73.40%	72.27%	-1.13%
Proportion of Reversals	25.81%	41.41%	15.60%***	22.34%	23.64%	1.30%
Continuations Return	1.30%	1.41%	0.11%	3.69%	3.87%	0.18%
Reversals Return	-0.47%	-0.37%	-0.10%	-1.12%	-2.21%	-1.09%
Limit hit days	94	663		94	663	
Panel B - Floors						
Proportion of Continuations	60.00%	37.78%	-22.22%	100.00%	62.92%	-37.08%*
Proportion of Reversals	20.00%	50.72%	30.72%	-	25.84%	-
Continuations Return	-2.34%	-2.01%	-0.33%	-3.85%	-5.55%	-
Reversals Return	3.49%	1.58%	1.91%	-	3.48%%	-
Limit hit days	5	508		5	508	
Non-locked Limit days						
Panel C - Ceilings						
Proportion of Continuations	32.53%	34.70%	2.17%	10.84%	20.62%	9.77%***
Proportion of Reversals	51.81%	54.26%	2.45%	83.13%	76.00%	-7.13%
Continuations Return	1.40%	1.41%	0.01%	1.13%	1.34%	0.21%
Reversals Return	-0.82%	-0.37%	0.45%	-1.64%	-2.38%	-0.74%
Limit hit days	83	325		83	325	
Panel D - Floors						
Proportion of Continuations	16.67%	33.59%	16.92%	66.67%	37.41%	-29.26%**
Proportion of Reversals	72.22%	55.64%	-16.58%	33.33%	56.11%	22.78%*
Continuations Return	-0.96%	-2.07%	-1.11%	-2.00%	-3.43%	-1.43%
Reversals Return	0.37%	1.00%	0.63%	2.57%	0.68%	1.89%
Limit hit days	18	403		18	403	

Note:***, **, * represent statistical significance at the 1%, 5% and 10% respectively.

Conclusion

The SHHKConnect enables for the first time, both institutional and retail investors to trade on both SSE and SEHK and represents an important step in the development of China's economy, by increasing its access to the world and the world's access to China via financial liberalisation of its main equity markets.

This paper seeks to build on the mixed evidence surrounding the effects of market liberalisation and the impact of price limits on financial markets by re-visiting these issues in a Chinese context and providing new evidence for Chinese stock markets. Based on the current literature, this paper adds to the current debate by proposing two hypotheses: (1) by testing for evidence for the intraday magnet effect of price limit in Chinese securities markets, and (2); aiming to understand impact of the Shanghai-Hong Kong Stock Connect (SHHKConnect) on price limits in the Shanghai Stock Exchange.

Employing a logistic regression to investigate whether, as per the theory, the likelihood of a trading advancing towards a limit increases as the limit draws near, this study find evidence for the magnet effect for Connect securities trading on the SSE, with an increasing likelihood prices advancing towards a limit as the limit draws near. Both ceilings limit hits, and floors limit hits are tested, and significant results are found in both limit types – in line with (Du et al., 2009, Hsieh et al., 2009, Wong et al., 2009b) and confirming hypothesis (1).

This study then conducted a firm-fixed regression analysis to test the changes in the magnet effect of price limits around the introduction of SHHKConnect. More pronounced magnet effects were observed in Connect securities post-Connect whilst no change was observed on the non-Connect (Shenzhen) securities, indicating that the SHHKConnect led to a change in the magnet effect of price limits – answering hypothesis (2).

Robustness tests were carried out showing that the Connect securities that received the largest post-Connect Northbound trade volume exhibited the largest change in the magnet effect. An analysis of the SHHKConnect under a price limit regime appears to have impacted the trading decisions of Hong Kong based investors who seek higher investment returns in the mainland exchange days after a price limit hit, while no change in the delayed price discovery of price limits appears to have occurred on the SSE.

A possible avenue for further research involves observing the magnet effect in china with detailed order book flow that distinguishes between retail and institutional investors. Data on the much discussed, but unconfirmed retail investor dominated Chinese securities markets would build on the work of Wong et al. (2009b) who used trade size as an investor proxy to show that a high proportion of institutional investors in a market minimises the magnet effect of price limits. Detailed order flow data would alleviate the need for proxies, and assist in the understanding of the magnet effect.

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Table 9 – Logistic regression output for distance variables for Top 25 Shanghai Connect securities by volume

This table provides the log odds of the logistic regression output (from the expression $X_k'B$) for the variables β_1 , β_2 and their sum $\beta_1 + \beta_2$ for each tick 2-15 from the ceiling limit. A regression is run for each tick distance and for each security in the subgroup and the cross-sectional means and medians are presented. The estimate of β_1 or β_2 for each individual firm is set equal to 0 if the p-value of the estimate is greater than 5%, indicating that the estimate is not significantly different from zero. Panel A shows the results for ceiling limit hits; Panel B shows the results for floor limit hits.

	Pre-Connect						**Post-Connect**					
	β1		β2		Distance-to-limit (β1 + β2)		β1		β2		Distance-to-limit (β1 + β2)	
Ticks	Mean	Median	Mean	Median	Mean	Median	Mean	Median	Mean	Median	Mean	Median
Panel A Ceilings												
2	0.01	0.00	-0.37	-0.37	-0.36	-0.37	0.00	0.00	-0.70	-0.51	-0.70	-0.51
3	0.01	0.00	-0.12	0.00	-0.11	0.00	0.00	0.00	-0.42	-0.27	-0.42	-0.27
4	0.01	0.00	-0.03	0.00	-0.02	0.00	0.00	0.00	-0.27	-0.16	-0.26	-0.16
5	0.01	0.00	-0.03	0.00	-0.02	0.00	0.00	0.00	-0.19	-0.10	-0.19	-0.10
6	0.02	0.00	-0.01	0.05	0.02	0.05	0.00	0.00	-0.14	-0.07	-0.14	-0.07
7	0.01	0.00	-0.02	0.00	-0.01	0.00	0.00	0.00	-0.11	-0.08	-0.11	-0.08
8	0.02	0.00	0.01	0.01	0.03	0.01	0.00	0.00	-0.08	-0.06	-0.08	-0.06
9	0.01	0.00	0.01	0.01	0.02	0.01	0.00	0.00	-0.06	-0.03	-0.06	-0.03
10	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.05	-0.03	-0.05	-0.03
11	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00	-0.04	-0.02	-0.04	-0.02
12	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.03	-0.01	-0.03	-0.01
13	0.00	0.00	-0.01	0.00	0.00	0.00	0.00	0.00	-0.02	-0.01	-0.02	-0.01
14	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00	-0.02	-0.01	-0.01	-0.01
15	0.01	0.00	0.01	0.00	0.02	0.01	0.00	0.00	-0.01	-0.01	-0.01	-0.01
Panel B Floors												
2	0.00	0.00	-1.41	-1.41	-1.40	-1.40	0.00	0.00	-0.60	-0.43	-0.60	-0.43
3	0.00	0.00	-0.63	-0.63	-0.63	-0.63	0.00	0.00	-0.35	-0.21	-0.34	-0.21
4	0.00	0.00	-0.71	-0.71	-0.71	-0.71	0.00	0.00	-0.18	-0.13	-0.17	-0.13
5	0.00	0.00	-0.36	-0.36	-0.36	-0.36	0.00	0.00	-0.11	-0.08	-0.10	-0.08
6	0.00	0.00	-0.18	-0.18	-0.17	-0.17	0.00	0.00	-0.08	-0.05	-0.08	-0.05
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.05	-0.03	-0.05	-0.03
8	0.00	0.00	0.07	0.07	0.07	0.07	0.00	0.00	-0.04	-0.02	-0.04	-0.02
9	0.00	0.00	0.06	0.06	0.07	0.07	0.00	0.00	-0.03	-0.02	-0.03	-0.02
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.02	-0.01	-0.02	-0.01
11	0.00	0.00	0.06	0.06	0.06	0.06	0.00	0.00	-0.02	-0.01	-0.02	-0.01
12	0.00	0.00	0.07	0.07	0.08	0.08	0.00	0.00	-0.02	-0.01	-0.02	-0.01
13	0.01	0.01	0.08	0.08	0.08	0.08	0.00	0.00	-0.02	-0.01	-0.02	-0.01
14	0.00	0.00	0.03	0.03	0.04	0.04	0.00	0.00	-0.02	0.00	-0.01	0.00
15	0.00	0.00	0.03	0.03	0.04	0.04	0.00	0.00	-0.01	0.00	-0.01	0.00