Price Limits and Stock Market Volatility in China

Wang, Dingyan and Chong, Terence Tai-Leung and Chan, Wing Hong

The Chinese University of Hong Kong, The Chinese University of Hong Kong and Nanjing University, Wilfrid Laurier University

26 January 2014

Price Limits and Stock Market Volatility in China

Terence Tai-Leung CHONG[1]
Department of Economics, The Chinese University of Hong Kong
and
Department of International Economics and Trade, Nanjing University

Dingyan WANG
Department of Economics, The Chinese University of Hong Kong

and
Wing Hong CHAN
School of Business & Economics, Wilfrid Laurier University

19/2/14

Abstract

This paper explores the effects of price limits on the stock market of China during global market turmoils. The characteristics of stocks that hit the price limits more frequently under market turmoil are investigated. It is found that the price limit system increases volatility significantly during the downward price movement. Moreover, price limit delays the efficient price discovery for upward and downward price movements. Finally, actively-traded stocks with a higher positive correlation with the entire market in the property industry hit the price limits more frequently.

Key words: A-share market; Price limit; Financial crises.

---

[1] We would like to thank Ingrid Lo and Julan Du for helpful comments. We also thank Min Chen, Margaret Loo, and Sophia Lok for able research assistance. Any remaining errors are ours.

Corresponding Author: Terence Tai-Leung Chong, Department of Economics, The Chinese University of Hong Kong, Shatin, N.T., Hong Kong. E-mail: chong2064@cuhk.edu.hk. Fax: (26035805) Phone: (852) 394318193. Homepage: http://www.cuhk.edu.hk/eco/staff/tlchong/tlchong3.htm.

1. Introduction

Price limits are literal boundaries set by authorities as a maximum range of upward and downward daily price movements aiming to provide a cooling-off period for investors during panic trading. Setting price limits is a policy aims to restrict extreme daily security price movements in the stock market. The introduction of price limits in the US was provoked by the market crash in October 1987, which led to discussions regarding the implementation of a market circuit breaker system. The New York Stock Exchange established the price limit mechanism to prevent the reoccurrence of market crashes. Today, such a mechanism has been widely adapted in Japan, Thailand, France, Korea, Malaysia and China. For instance, in Malaysia, the daily price limit of upward stocks is 69%, while that of the downward stocks is 51%. In China, price limits of both upward and downward stocks are 10%.

Although price limits have already been implemented in numerous countries, empirical research on the price limit remains scarce because of practical difficulties. Chiang at el. (1990) show that with price limits, the OLS estimation of systematic risk is biased. In addition, it is relatively difficult to obtain data on hitting limits with a reasonable sample size (Kim and Limpaphayom 2000). Existing studies provide mixed results on the impact of price limit. Some studies argue that price limits can moderate excessive volatility, mitigate panic behavior, or minimize price manipulation (Kim 2001, Kim and Park 2010, Kim and Rhee 1997, Kim and Yang 2004), while others criticize that price limits impede market efficiency, and cannot achieve their intended objectives of reducing the extreme market fluctuation. Fama (1989) argues that price limits have volatility spillover effects, delay price discovery and interfere with trading in the US market. Lee and Kim (1995) find that price limits reduce price volatility in the Korean stock market, while Berkman and Lee (2002) suggest that the effects of price limits would change with different levels of volatility and trading volumes.

Previous studies on price limits rarely attempted to investigate the Chinese stock market. The Chinese stock market has been playing an increasingly important role in the global financial market. The Shanghai Stock Exchange (SHSE) and the Shenzhen Stock Exchange (SZSE) have been growing rapidly over the past two decades. In 1990, the Chinese government first enacted the price limit policy for both upward and downward price movements to prevent potential social instability by negative influences of the financial market. The policy was once abolished in 1992 but resumed on December 16, 1996. The policy allows the price of a stock to only move by ±10% of the closing price from the previous trading day. An exception is for newly listed stocks in their first public trading day or first trading day after resumption, where ±20% price changes are allowed. Besides, bad performing firms will be assigned the special treatment (ST) status and imposes a tighter price limit of ±5% daily. In contrast to other countries where trading ceases after stocks hit the limits, SHZE and SZSE allow trading to continue but only at prices within the required range. If a stock hits its price limits for three consecutive days, it will be suspended for half a trading day until an explanation is provided.

Previous studies on the effect of price limits on the Chinese stock market focused on tranquil periods (Chen et al. 2005). The Chinese stock market has been increasingly affected by global financial crises as it open up its economy to the world. In this paper, we examine the effects of price limits in China during two global crises, namely, the Asian financial crisis (from July 1997 to December 1998) and the 2008 financial crisis (from August 2008 to

December 2009). In particular, we aim to test the hypotheses of volatility spillover, delayed price discovery, and trading interference during such periods. We will also investigate the attributes of stocks that easily hit their price limits during market turmoils.

The rest of this paper is organized as follows: Section 2 describes the data. Section 3 tests the effects of the price limit policy on the Chinese stock market during market turmoils. Section 4 investigates the attributes of stocks frequently hitting the price limits during market turmoils, and Section 5 concludes the findings of the study.

2. Data

We extract the daily A-share stock prices and trading volume data of both SZSE and SHZE from the CSMAR database. After eliminating those ST stocks and adjusting the effects of stock dividends, stock placing and ex-dividend, we obtain the final sample. Without directly detecting price hitting, we have to identify the occurrences of hitting prices by examining the daily open, low, high, and closing prices.

Table 1 reports the numbers of the Chinese A-share stocks hitting the price limits in three different periods. From 1997 to 2009, the number of price limit hits increases, indicating that the stock market has become progressively active. Furthermore, in all of the three periods, the upward price limits occupy a similar proportion of approximately 70%, which outshines the percentage of downward price limits. Therefore, regardless of tranquil or crisis periods, investors in China tend be exuberant when a firm has positive news, while they tend to be cautious and rational when the news is negative.

Table 1. *Summary Statistics of Price Limit Hits*

	Total	Upward	%	Downward	%	No. of Listed Companies
Asian Financial Crisis (1997–1998)	1405	1009	71.8%	396	28.2%	827
Tranquil Period (2004–2006)	5520	4065	73.6%	1455	26.4%	1459
2008 Financial Crisis (2008–2009)	8992	6508	72.3%	2484	27.7%	1725

This table shows the respective numbers of total price limit hits for all stocks within the three respective periods and the corresponding percentages of upper and lower price limits. *Upward* and *Downward* columns indicate the subsamples that hit price limits during the upward and downward movements, respectively.

To determine the attributes of stocks that tend to hit price limits during market turmoil, we examine the financial ratios of each individual stock, including the book-to-market value, total market capitalization, beta, the turnover ratio, residual risk, and the percentage of state-own shares. In addition, we introduce the state-owned factor and industry factor in our model. In accordance with the industry categories in SZSE and SHZE, the industries of A-share stocks can be divided into the following six groups: finance, utilities, properties, conglomerates, industrials and commerce. These factors are the candidate attributes of the stocks that easily hit the price limits.

In this paper, we select stocks with close price limit hits. In contrast to previous studies, we utilize the one-day price limit hits and consecutive limit hits.

Table 2. *Statistics of Consecutive Price Limit Hits*

	Total Hits	1 Day	2 Consecutive Days	3 Consecutive Days	4 Consecutive Days	5 Consecutive Days
Asian Financial Crisis (1997–1998)	1405	1242	68	7	0	0
		88.4%	9.7%	1.9%	0%	0%
Tranquil Period (2004–2006)	5520	4381	420	65	26	0
		79.4%	15.2%	3.5%	1.9%	0%
2008 Financial Crisis (2008–2009)	8992	7394	571	84	26	0
		82.2%	12.7%	2.8%	1.3%	0%

This table shows the respective numbers of total consecutive price limit hits for all stocks within the three respective periods.

Table 2 shows the numbers of one-time and consecutive price limit hits for three periods with the corresponding percentages of these price limits. The percentage of consecutive price limits hits is calculated as the number of price limit hits over the total number of hits. For example, in the Asian financial crisis, the percentage of two consecutive price limit hits is calculated as 68*2/1405=9.7%. Since the stock will be suspended for half a day if it hits the limit for three consecutive days, the case of a five consecutive-day hitting only happens if the stock also hits the limit in the next half day and the fifth day. From the absolute number and percentage, we can observe that the number of consecutive price limit hits is noticeable. As shown in Table 2, in both financial crises, the consecutive price limit hits take up over 10% of the total hits, which is nontrivial and cannot be deleted from the sample.

3. Empirical Analysis

There are three problems associated with price limits, namely volatility spillover (Fama 1989), delayed price discovery (Fama 1989) and trading interference (Lauterbach and Ben-Zion 1993). We test the following hypotheses in this paper:

Volatility Spillover Hypothesis**:** Price limits cause volatility to be spread out over a long period instead of occurring within a single day; thus, such limits do not actually reduce volatility.

Delayed Price Discovery Hypothesis: Positive (negative) overnight returns are observed on stocks that hit their upper (lower) limits.

Trading Inference Hypothesis: If price limits interfere with the trading process, we expect an increase in trading activity for stocks that hits the limit after the price limit hitting day, and a decrease or stabilization in trading activity for other stocks.

3.1 Test of the Volatility Spillover Hypothesis

The primary purpose of price limits is to reduce the volatility by controlling extreme price movements of stocks. However, previous studies have suggested that the underlying volatility of stocks increase when the price discovery process is interrupted by price limit hits. Fama (1989), Kuhn, Kurserk, and Locke (1991), and Lehmann (1989) study the volatility spillover hypothesis. Instead of having a sudden jump or drop in a single trading day, price limits may spread the volatility over a long period (Lehmann 1989). Price limits have been found to be ineffective in reducing volatility in the Tokyo, Taiwan and Thailand stock exchange markets (Kim, 2001; Kim and Rhee, 1997). Chen et al. (2005) also showed that price limits are ineffective in reducing volatility in the Chinese A-share markets in the period from 1997 to 2003.

We use $Stock_{hit}$ to denote the stocks that hit their price limits. $Stock_{0.9hit}$ represents the stocks that experience price change by at least 90% of their price limits but do not reach the limits. $Stock_{0.8hit}$ denotes those stocks with price change by at least 80% but do not reach 90% of their price limits. In China, price limits are set at ±10%. We construct a 21-day window to test volatility spillover. The volatility spillover hypothesis is supported if the stocks have higher volatility after the day they hit the price limits than other common stocks. We divide the 21-day window into three groups, namely, the first 10 days (Day -10), Day 0, and the last 10 days (Day +10). Day 0 is the day when the price limit is hit, Day -1 represents the day before the stocks hit the price limit, and Day +1 denotes the day after the hitting day, and so forth. We then compute the volatility for each day in the 21-day window for all the stock groups (i.e., $Stock_{hit}$, $Stock_{0.9hit}$ and $Stock_{0.8hit}$).

Following Fama (1989) and Chen et al. (2005), we define the volatility of return as

$$V_{t,j} = (r_{t,j})^2 \tag{1}$$

where $r_{t,j} = \ln(C_{t,j} / C_{t-1,j})$ is the daily return of stock j on Day t, $C_{t,j}$ is the close price of stock j on Day t. We compare volatility after the hitting day for the three stock groups respectively to generate implications about volatility spillover based on our previous assumption. If volatility spillover exists, shares in $Stock_{hit}$ are expected to have higher volatility than the other two groups (i.e., $Stock_{0.9hit}$ and $Stock_{0.8hit}$) after Day 0.

Tables 3, 4 and 5 report volatility of the three stock categories over the Asian financial crisis (1997 to 1998), the 2008 financial crisis (2008 to 2009), and the tranquil period (2004 to 2006), respectively. To eliminate the high pre-limit day volatility bias, we exclude the sample observations that a stock hits a price limit for the second or third consecutive day. The stock categories are based on the magnitude of their price movements on the event day of a 21-day window. Day 0 represents the day when *Hit* reach the price limits. *0.9Hit* denotes stocks that experience a price change of at least 9% from the previous day's close, but do not reach the price limit on Day 0. *0.8Hit* denotes stocks that experience a price change of between 8% and 9%. Daily squared returns times 100 are used as the volatility measure. The symbols ">>" and ">" indicate that the left-hand figure is greater than the right-hand figure at the 1% and 5% significance levels, respectively under the non-parametric Wilcoxon signed-rank tests.

The three groups experience the highest volatility on Day 0 when the largest price changes take place. After Day 0, the volatility is reduced substantially. Note that on Day 0, $Stock_{hit}$ has a higher volatility than $Stock_{0.9hit}$, which in turn has a higher volatility than $Stock_{0.8hit}$ with a significance level of $\alpha=0.05$. This result holds across all three sample periods. The volatility of $Stock_{hit}$ having an average value of 9.1 across three different samples is almost 40% higher than the other two comparison groups of stocks not hitting the limit for the upward price movement. For the downward price movement, the difference between the limit hitting stocks and the 80% hit group is even larger. The limit hitting stocks report an average volatility of 11.1 on Day 0 across the three samples, whereas the volatility of $Stock_{0.8hit}$ have average value of 7.8 that is 42% lower than the ones from limit hitting stocks.

Note from Table 3 that during the Asian financial crisis, the volatility of the stocks in all the three groups drop sharply after Day 0. Horizontally compared with the other two groups with upward price movements, except for Day 1, the volatility measures of $Stock_{hit}$ on the remaining 9 days are not significantly higher than those of $Stock_{0.9hit}$. As the control group without hitting price limits, $Stock_{0.9hit}$ has significantly higher volatility than $Stock_{0.8hit}$ in upward price movement. In the case of downward price movements, the volatility of $Stock_{hit}$ is significantly lower than those of $Stock_{0.9hit}$ and $Stock_{0.8hit}$ on Day 1 and Day 4. On Day 1, the volatility of $Stock_{hit}$ is 2.345 compared to 3.026 and 3.343 from $Stock_{0.9hit}$ and $Stock_{0.8hit}$, respectively. Therefore, during the Asian financial crisis, the price limit system reduced volatility significantly in horizontal comparison, especially in the downward movement case. The result is different from that of Chen et al. (2005).

Note from Table 4 that during the 2008 financial crisis, the volatility measures of $Stock_{hit}$ are significantly higher than those of $Stock_{0.9hit}$ and $Stock_{0.8hit}$ at the 1% level of significance. The increase in volatility after Day 0 is more obvious in the downward than in the upward price movement when we consider the number of days with significantly higher volatility after Day 0. $Stock_{hit}$ has higher volatility than $Stock_{0.9hit}$ for 7 out of the ten days including Day 1, 2, 3, 5, 6, and 9 after the stocks hitting the price limit during downward price movement. In contrast, the upward price movement reports a higher volatility on four separate days (Day 1, 2, 6, and 10) after the price limit hit. In addition, it is important to note that average volatility before the hit ranges from as low as 1.507 on Day -6 to 2.619 on Day -1 for upward price movement. The volatility remains high for the first two days after Day 0 having values hovering around 2.829 and 2.940 which are also larger than the normal daily volatility in any of the ten days preceding the hit. Therefore, the imposition of price limit significantly increases the volatility of the A-share market. This result is different from Chen et al. (2005), who show that the price limit mechanism is effective in reducing volatility in the Chinese A-share bearish markets for upward price movements.

Table 5 shows the result of the tranquil period from 2004 to 2006. Note that the volatility of $Stock_{hit}$ does not increase significantly, except for Day 1, for the downward price movement. For upward price movement, the volatility is significantly higher than that of $Stock_{0.9hit}$ on Day 1, 2 and 3. Therefore, during the tranquil period, the price limit reduces the volatility for downward price movements, but not for upward price movements. This is consistent with Chen et al. (2005) and agrees with the presumption that investors tend to overreact to good news and act cautiously to bad news when the market is growing stably.

__Table 3__.Volatility Spillover Hypothesis Test on the 1997 to 1998 Stock Sample

Stock Sample during the Asian Financial Crisis (1997 to 1998)											
Upward Price Movement						Downward Price Movement					
Day Window	Hit		0.9 Hit		0.8 Hit	Day Window	Hit		0.9 Hit		0.8 Hit
-10	1.195		1.084		1.077	-10	0.780	<	0.889		0.887
-9	1.117		1.083	>	0.957	-9	1.033		0.730	<<	0.949
-8	1.092		1.239	>>	1.017	-8	0.775		0.862		0.878
-7	1.347		1.181		1.157	-7	0.725	<<	0.928		0.933
-6	1.026		1.106		1.001	-6	1.101	<	1.081		1.104
-5	1.150		1.239		0.978	-5	1.451	>	1.233	>	1.021
-4	1.223		1.152		1.158	-4	1.307	>>	0.993	>	0.857
-3	1.548		1.499		1.327	-3	1.367	>>	1.024	>	0.880
-2	1.731	<	2.118		2.058	-2	0.894		0.749	<	0.846
-1	2.229		2.177	>>	1.710	-1	2.354	<<	2.686	>	2.451
0	9.125	>>	8.573	>>	6.595	0	11.142	>>	10.419	>>	7.846
1	2.206	>	1.879	>>	1.210	1	2.345	<<	3.026		3.343
2	1.588		1.500	>>	1.153	2	3.335	>	2.925	>>	1.910
3	1.479		1.388	>>	1.057	3	1.646		1.366	>>	0.975
4	1.359		1.300	>>	1.013	4	1.057	<	1.138		1.153
5	1.244		1.192	>	1.018	5	0.956		0.845	<	1.029
6	1.078		1.196	>	1.020	6	0.749		0.643		0.636
7	1.190		1.282		1.003	7	0.857	>>	0.690		0.677
8	1.228		1.105		1.026	8	0.883	>	0.867	>>	0.851
9	1.164		1.029	>	0.828	9	0.835		0.914		0.849
10	1.062		1.031		0.912	10	0.851	>	0.831		0.769
Total Observations	1009		1009		805	Total Observations	396		709		551

Note: The stock categories are based on the magnitude of their price movements on the event day of a 21-day window. Day 0 represents the day when *Hit* reach the price limits. *0.9Hit* denotes stocks that experience a price change of at least 9% from the previous day's close, but do not reach the price limit on Day 0. *0.8Hit* denotes stocks that experience a price change of between 8% and 9%. Daily squared returns times 100 are used as the volatility measure. >> and > indicate significantly greater than at the 1% and 5% significance levels respectively under the Wilcoxon signed-rank test.

Table 4.*Volatility Spillover Hypothesis Test on the 2008 to 2009 Stock Sample*

Stock Sample during the 2008 Financial Crisis (2008 to 2009)											
Upward Price Movement						Downward Price Movement					
Day Window	Hit		0.9 Hit		0.8 Hit	Day Window	Hit		0.9 Hit		0.8 Hit
-10	1.717		1.848	<<	2.008	-10	2.508		2.511	>>	2.297
-9	1.900	>>	1.741	>>	1.566	-9	2.068		1.949	>>	1.729
-8	2.181		2.242		2.310	-8	2.146		2.168	>	2.022
-7	1.930	<<	2.296	<<	2.647	-7	2.329		2.242	>>	1.981
-6	1.507	<	1.586	<	1.673	-6	3.249	>>	2.627	>>	2.214
-5	1.670		1.645		1.509	-5	2.589	>	2.255	>>	1.852
-4	1.718		1.772	<	1.806	-4	2.309	>>	2.189		2.048
-3	1.996		1.998		1.774	-3	2.158		2.042	>>	1.880
-2	2.210	<<	2.404		2.373	-2	2.361	>	2.306		2.320
-1	2.619		2.592	>>	1.994	-1	2.299	>>	2.066	>>	1.762
0	9.150	>>	8.730	>>	6.585	0	11.164	>>	10.372	>>	7.825
1	2.829	>>	2.455	>>	1.750	1	2.494	>>	2.081	>>	1.720
2	2.940	>>	2.496	>>	1.687	2	2.699	>>	2.331	>>	1.758
3	2.131		2.098	>	1.825	3	2.011	>>	1.839	>>	1.764
4	1.954	<<	2.112		2.071	4	2.367		2.207	>>	1.843
5	1.859		1.842		1.710	5	1.254	>	1.191		1.207
6	2.082	>>	1.995		2.007	6	1.942	>	1.813	>>	1.594
7	1.755	<	1.822		1.815	7	1.845	<	1.993		1.995
8	1.698		1.686		1.571	8	2.046		2.046		2.108
9	1.732		1.740		1.594	9	1.885	>>	1.704		1.525
10	2.314	>	2.172	>>	1.618	10	2.402		2.342	>>	1.956
Total Observations	6508		5891		3031	Total Observations	2484		5631		4009

Note: The stock categories are based on the magnitude of their price movements on the event day of a 21-day window. Day 0 represents the day when *Hit* reach the price limits. *0.9Hit* denotes stocks that experience a price change of at least 9% from the previous day's close, but do not reach the price limit on Day 0. *0.8Hit* denotes stocks that experience a price change of between 8% and 9%. Daily squared returns times 100 are used as the volatility measure. >> and > indicate significantly greater than at the 1% and 5% significance levels respectively under the Wilcoxon signed-rank test.

Table 5. *Volatility Spillover Hypothesis Test on the 2004 -2006 Sample*

Stock Sample in the Tranquil Period (2004 to 2006)											
Upward Price Movement						Downward Price Movement					
Day Window	Hit		0.9 Hit		0.8 Hit	Day Window	Hit		0.9 Hit		0.8 Hit
-10	1.231		1.350		1.329	-10	1.886		1.561	>>	1.237
-9	1.370	>	1.290	>>	1.142	-9	1.469		1.557	>>	1.155
-8	1.471		1.468	>>	1.186	-8	1.312		1.232	>	1.154
-7	1.426		1.452	>>	1.138	-7	1.375		1.352	>	1.210
-6	1.401	>	1.350	>	1.141	-6	1.665		1.476	>	1.491
-5	1.443		1.527	>>	1.132	-5	2.354		1.813	>>	1.512
-4	1.646		1.792	>>	1.272	-4	2.383		1.888	>>	1.390
-3	1.888		1.581	>	1.281	-3	1.871		1.534	>>	1.415
-2	1.951	>	1.720	>>	1.306	-2	1.953		1.749	>	1.522
-1	2.717	>	2.372	>>	1.435	-1	2.145		2.028		1.693
0	9.172	>>	8.731	>>	6.596	0	11.186	>>	10.406	>>	7.825
1	2.903	>>	2.584	>>	1.366	1	2.595	>>	1.802	>>	1.236
2	2.378	>>	2.091	>>	1.570	2	1.945		1.564	>>	1.146
3	2.240	>>	1.865	>>	1.367	3	1.485		1.366	>>	1.126
4	2.162		2.043	>>	1.516	4	1.790		1.409		1.193
5	2.151		1.903	>>	1.439	5	1.597		1.529	>>	1.250
6	2.042		2.108	>>	1.463	6	1.405		1.250		1.136
7	1.756		1.808	>	1.338	7	1.468		1.210		1.122
8	1.884		1.675	>	1.334	8	1.282		1.142	>	1.007
9	1.679		1.468	>>	1.179	9	1.171		1.136		1.023
10	1.603	>	1.472	>>	1.242	10	1.549	>	1.315	>	1.134
Total Observations	4065		3634		2030	Total Observations	1455		2759		2067

Note: The stock categories are based on the magnitude of their price movements on the event day of a 21-day window. Day 0 represents the day when *Hit* reach the price limits. *0.9Hit* denotes stocks that experience a price change of at least 9% from the previous day's close, but do not reach the price limit on Day 0. *0.8Hit* denotes stocks that experience a price change of between 8% and 9%. Daily squared returns times 100 are used as the volatility measure. >> and > indicate significantly greater than at the 1% and 5% significance levels respectively under the Wilcoxon signed-rank test.

3.2 Test of the Delayed Price Discovery Hypothesis

Lee, Ready and Seguin (1994) study the delayed price discovery hypothesis, which states that trading often halts when shares reach their price limits, consequently deterring the discovery of the intrinsic value. In other words, price limits prevent share prices from moving smoothly in one trading day to reach the equilibrium price (intrinsic value). Once price limits stop the movements of share prices, the share prices continue their movements in the following period (at least for one trading day) to reach the equilibrium price. Kim and Rhee (1997) find that price limits delay an effective price discovery process in the Tokyo Stock Exchange. Huang, Fu and Ke (2001) suggest that the opening price in the following day after reaching the limits is partially affected by overreaction.

To identify price continuation and reversal a day after a price limit is hit, following previous studies, we examine the daytime or open-to-close returns r $(O_t C_t) \equiv \ln(C_t/O_t)$ and the overnight or close-to-open returns r$(C_t O_{t+1}) \equiv \ln(O_{t+1}/C_t)$. In these equations, O_t and C_t denote opening and closing prices respectively, and t represents the day. Specifically, we examine r$(O_0 C_0)$ and r$(C_0 O_1)$ for all stock categories where the first measure considers the daytime return for Day 0, and the second measure considers the immediate following overnight return. Stock returns can be positive, negative, or zero, denoted as (+), (−) and (0), respectively. Nine cases are observed, namely, [+,+], [+, 0], [+,−], [0,+], [0, 0], [0,−], [−,+], [−, 0] and [−,−] where the first and second returns represent r$(O_0 C_0)$ and r$(C_0 O_1)$, respectively. For upper limit hits, we classify [+,+] and [0,+] as price continuation, [+,−], [0,−], [−,+], [−, 0], and [−,−] as price reversal, and [+, 0] and [0,0] as no change. For lower limit hits, we classify [−,−] and [0,−] as price continuation, [−,+], [0,+], [+,−], [+, 0], and [+,+]as price reversal, and [−, 0] and [0, 0] as no change.

Price continuation is consistent with the delayed informed trading hypothesis of Roll (1989), whereas the price reversal phenomenon is in line with overreaction implied by Ma, Rao and Sears (1989). We can only conclude that price limits delay the price discovery process when abnormally large percentages of price continuation for $Stock_{hit}$ relative to $Stock_{0.9hit}$ and $Stock_{0.8hit}$ are observed. Table 6 presents the total percentages of price continuation, reversal and no change for each stock group in different time periods. Note that stocks hitting the limits have dominant percentages of continuation rather than reversal in the three periods. Stocks hitting upper limit report 83.1%, 70.9% and 71.5% of continuation price movement for the Asian crisis, the 2008 financial crisis, and the tranquil trading period, respectively. The percentage difference between continuation and reversal ranges from the smallest value of 47.1% for the case of 2008 financial crisis to as high as 72.3% for the case of Asian crisis. The difference between continuation and no change is even larger with next day price movement being classified as no change always having the lowest percentages. In comparison, stocks not hitting the upper price limit, $Stock_{0.8hit}$, was dominated by price reversal having values of 67.3% for the 2008 financial crisis and 58.9% for the tranquil trading period. The same conclusion can be made for the downward price movement. This result demonstrates that the price limit delays the efficient price discovery for upward and downward price movements.

Table 6. *Delayed Price Discovery Hypothesis Test*

The Asian Financial Crisis (1997 to 1998)							
Upward Price Movement				Downward Price Movement			
Price Trend	Hit	0.9 Hit	0.8 Hit	Price Trend	Hit	0.9 Hit	0.8 Hit
Continuation	0.831	0.621	0.482	Continuation	0.864	0.673	0.526
No Change	0.061	0.090	0.150	No Change	0.045	0.052	0.082
Reversal	0.108	0.288	0.368	Reversal	0.091	0.275	0.392
The 2008 Financial Crisis (2008 to 2009)							
Price Trend	Hit	0.9 Hit	0.8 Hit	Price Trend	Hit	0.9 Hit	0.8 Hit
Continuation	0.709	0.520	0.271	Continuation	0.822	0.706	0.599
No Change	0.053	0.056	0.056	No Change	0.056	0.073	0.089
Reversal	0.238	0.424	0.673	Reversal	0.122	0.221	0.312
The Tranquil Period (2004 to 2006)							
Price Trend	Hit	0.9 Hit	0.8 Hit	Price Trend	Hit	0.9 Hit	0.8 Hit
Continuation	0.715	0.558	0.248	Continuation	0.910	0.788	0.642
No Change	0.109	0.113	0.163	No Change	0.054	0.107	0.174
Reversal	0.176	0.329	0.589	Reversal	0.036	0.105	0.185

This table reports the total proportions of continuation, reversal, and no change for each stock subgroup in the three time periods. Stocks are categorized into three groups based on the magnitude of their price movement on Day 0 (the event day). *Hit* represents stocks that reach their daily price limit. *0.9Hit* denotes stocks that experience a price change of at least 90%from the previous closing day, but do not reach the price limit. *0.8Hit* denotes stocks that experience a price change between 80% and 90%.

3.3 Test of the Trading Interference Hypothesis

Lauterbach and Ben-Zion (1993) and Fama (1989) investigate the trading interference hypothesis. According to the trading interference hypothesis, market liquidity would be drained and trading would not occur if price limits interfered with trading on the event day. The trading volume should increase substantially in subsequent days when trading is resumed, whereas shares in other control panels would not have such a performance. Lehmann (1989) suggests that when price limits interfere with the trading of stocks that hit the limits on the event day, impatient investors tend to trade at unfavorable prices, whereas patient investors will wait for prices to reach their equilibrium levels following the event day.

Trading activity (TA) is measured by a market-adjusted turnover ratio, where we divide the daily trading volume by the daily total shares outstanding and adjust for market turnover for each stock j on Day t. For each day, we report the logarithmic percentage change in trading activity from the previous day as

$$\text{Trading Change} = \ln(TA_{j,t}/TA_{j,t\text{-}1}) \times 100.$$

When share prices increase, all the three stock groups experience a significant increase in the share turnover rate on the event day, as shown in Tables 7, 8 and 9, respectively. The increments are similar for both limit hitting and non-hitting stocks with over 80% increases in trading activities on Day 0 during the Asian financial crisis and the tranquil period. The 2008 financial crisis on the other hand leads to 57% to 60% jumps in trading activities for the three groups. All the stock groups in those three different time periods experience an increase on

Day 1 and a decline thereafter. This implies that investors' behavior to "go after the upward limit close" can only last for one trading day.

During the Asian financial crisis, the downward price movement had the same result as that in the upward price movement. Trading activity increases on Day 1 and declines thereafter. However, the increments of the limit hitting stocks on Day 0 and 1 are not significantly different from the ones not hitting the limit, $Stock_{0.9}$, at the 5% level. During the 2008 financial crisis, trading activity decreases significantly on Days 0, 1, 4, and 5 and an almost 10% drop in trading activities is reported five days after hitting the lower limit. It indicates that the price limit does not interfere with the trading activity in 2008 and 2009. Similarly, during the tranquil period (2004 – 2006), trading activity also progressively declines after Day 0 and accumulated over 38% drop only three days after the limit hitting event. This suggests that the price limit does not interfere with trading activity in the downward price movement. This can be attributed to the fact that the Asian financial crisis does not considerably affect the Chinese stock market it was still immature and inactive in 1997 and 1998. In sum, in the case of the lower price limit, the price limit of the Chinese stock market does not interfere with the trading activity. Such finding is inconsistent with the trading interference hypothesis of Lauterbach and Ben-Zion (1989).

Table 7. *Trading Interference Hypothesis Test in the 1997 to 1998 Stock Sample*

Stock Sample in the Asian Financial Crisis (1997 to 1998)											
Upward Price Movement						Downward Price Movement					
Day Window	Hit		0.9 Hit		0.8 Hit	Day Window	Hit		0.9 Hit		0.8 Hit
-5	4.924		6.783	>	0.588	-5	-3.191	>>	-12.088		-9.567
-4	-0.026		3.101		6.378	-4	-15.831		-16.932		-13.522
-3	7.461		6.582		2.790	-3	23.402	>>	13.731	>>	-0.217
-2	10.186		12.111		7.895	-2	-14.185	<<	-10.629	<<	-0.345
-1	16.685		12.456		16.411	-1	8.432		10.987		11.921
0	86.547		87.277		83.200	0	23.284	<	31.365		33.416
1	21.444	>>	-2.371	>>	-22.144	1	14.460		0.284	>>	-9.434
2	-55.052	<<	-46.657	>>	-36.891	2	-12.751	<<	-2.807	>>	-12.152
3	-19.773	<<	-12.828		-12.904	3	9.441	>>	-0.512	>>	-10.396
4	-15.342		-15.961		-10.986	4	-9.507	>>	-13.451		-15.746
5	-13.163	<	-8.515		-8.210	5	-9.817		-11.698		-13.371
Total Observations	1009		1009		805	Total Observations	396		709		551

Note : Day -1 represents the day before Day 0, which is the event day of when the price limit hit. Trading activity is measured by a market-adjusted turnover ratio. For each day, we report the percentage change in trading activity from the previous day, which is defined as, $\ln(TA_{j,t}/TA_{j,t-1}) \times 100$. We calculate this percentage change for each stock j and report the daily means. >> and > indicate significantly greater than at the 1% and 5% significance levels respectively under the Wilcoxon signed-rank test.

Table 8*.Trading Interference Hypothesis Test in the 2008 to 2009 Stock Sample*

Stock Sample in the 2008 Financial Crisis (2008 to 2009)											
Upward Price Movement						Downward Price Movement					
Day Window	Hit		0.9 Hit		0.8 Hit	Day Window	Hit		0.9 Hit		0.8 Hit
-5	-1.998		-1.383		-2.684	-5	2.597		1.191		0.040
-4	2.368		1.256		3.731	-4	-2.478	<	0.081		0.607
-3	8.388		7.808	>>	3.945	-3	12.355	>	9.249	>>	6.200
-2	2.705		3.315		1.659	-2	2.429		0.915		1.684
-1	11.794	>>	6.868	>>	2.023	-1	3.669	>	-1.011		-1.615
0	56.935	<	60.518	>>	57.461	0	-0.196	<	3.010	>>	-0.736
1	28.684	>>	12.465	>>	-10.547	1	-16.101	>>	-23.786	>>	-29.699
2	-35.694	<<	-32.408	<<	-25.154	2	2.254		2.308		1.872
3	-15.471	<<	-11.683	<<	-4.944	3	0.672		1.250	<<	4.091
4	-0.884		-0.882		-2.077	4	-10.243	<<	-5.374	<<	-1.703
5	-10.343	<	-9.088	<<	-5.613	5	-9.908	<<	-6.589	<<	-0.898
Total Observations	6508		5891		3031	Total Observations	2484		5631		4009

Note : Day -1 represents the day before Day 0, which is the event day of when the price limit hit. Trading activity is measured by a market-adjusted turnover ratio. For each day, we report the percentage change in trading activity from the previous day, which is defined as, $\ln(TA_{j,t}/TA_{j,t-1}) \times 100$. We calculate this percentage change for each stock j and report the daily means. >> and > indicate significantly greater than at the 1% and 5% significance levels respectively under the Wilcoxon signed-rank test.

Table 9.*Trading Interference Hypothesis Test in the 2004 to 2006 Stock Sample*

Stock Sample in Tranquil Period (2004 to 2006)												
Upward Price Movement						Downward Price Movement						
Day Window	Hit		0.9 Hit		0.8 Hit	Day Window	Hit		0.9 Hit		0.8 Hit	
-5	1.009		2.018		-0.949	-5	3.943		3.452		2.835	
-4	4.822		6.369		6.000	-4	2.502		2.177		2.317	
-3	3.987		2.572		3.066	-3	-0.176		0.715		-1.433	
-2	6.189	>	3.147		5.940	-2	-4.397	<	-0.561		-1.384	
-1	9.456		14.166		13.740	-1	3.530		2.551		4.862	
0	83.017		81.895		83.840	0	36.173		39.043		37.559	
1	25.625	>>	9.468	>>	-25.793	1	-6.354	>>	-26.637	>>	-41.442	
2	-37.605	<<	-35.999	<<	-29.729	2	-25.794	<<	-24.674	<<	-19.940	
3	-17.650	<	-16.313	<<	-12.606	3	-11.990	<<	-8.154	<<	-4.104	
4	-7.876		-7.452		-6.989	4	1.241		0.758	<<	4.438	
5	-8.646		-8.016		-5.416	5	-4.247	<<	-1.571	>	-4.587	
Total Observations	4065		3634		2030	Total Observations	1455		2759		2067	

Note : Day -1 represents the day before Day 0, which is the event day of when the price limit hit. Trading activity is measured by a market-adjusted turnover ratio. For each day, we report the percentage change in trading activity from the previous day, which is defined as, $\ln(TA_{j,t}/TA_{j,t-1}) \times 100$. We calculate this percentage change for each stock j and report the daily means. >> and > indicate significantly greater than at the 1% and 5% significance levels respectively under the Wilcoxon signed-rank test.

4. Stocks that Hit the Limits

We will identify the characteristics of the Chinese stocks that frequently hit the price limits during market turmoils. Previous studies suggest that volatile stocks, actively-traded stocks, and small market capitalization stocks tend to hit the price limits more frequently. For example, Kim and Limpaphyayom (2000) showed that volatile, actively-traded and small stocks are prone to hitting the price limits in Thai and Taiwanese stock markets. Chen et al. (2005) find that actively-traded stocks hit the limits more frequently in bearish markets in China. Stocks with high book-to-market values hit the upper price limits more often, while stocks with more tradable shares tend to hit the price limits less frequently. In our sample, a logit regression model for stock i is estimated as follows:

$$log\left(\frac{hits_i}{1-hits_i}\right) = \alpha_0 + \beta_1 * Beta_i + \beta_2 * BM_i + \beta_3 * Size_i + \beta_4 * RR_i$$
$$+\beta_5 * TV_i + \beta_6 * State_i + \beta_7 * Dummy_i + \varepsilon_i \quad (2)$$

where $hits_i$ is the frequency of stock i hitting the price limits and is computed as the number of days Stock i hits the limits over the total number of trading days;

Beta represents a measure of the stock's correlation with the market,

BM denotes the average book-to-market value of the stock;

Size denotes the logarithm of the average market capitalization;

RR is the residual risk;

TV is the turnover ratio;

State represents the percentage of state-owned shares over the total outstanding shares.

Dummy is an industry dummy variable for stock i, which takes the value of 1 if the stock belongs to a particular industry, and 0 otherwise. Six industries (finance, utility, properties, conglomerates, industrial and commerce) are included.

We obtain the estimates of Beta and RR from the following model

$$R_{it} = \alpha_1 + \beta_2 R_{mt} + \varepsilon_{it}, \qquad (3)$$

where R_{it} is the excess return of Stock i and R_{mt} is the market excess return (index return). We can estimate Beta by β_1 and RR by the standard deviation of the residuals.

Table 10 shows the estimates of the model for the sample during the 2008 financial crisis. We also identify the different attributes in the upward and downward movements separately. For the whole sample and the upward and downward subsamples, the coefficients of TV (Turnover Ratio), Beta and the property industry dummy are significantly positive at the 1% level. Comparing the two subsamples shows that the marginal effects of TV, Beta, and the property industry dummy are larger for the upward price limit. The coefficients of Beta and Property industry dummy from upward limit subsample are 0.0170 and 0.00999 which are almost twice as large as the ones from downward limit subsample. The result suggests that an actively-traded stock with a higher positive correlation with the market in the property industry tends to hit the price limits more frequently. Note that the coefficient of the industrial sector dummy is significantly positive for the whole sample and the upward subsample. This suggests that industrial stocks are more likely to hit the upper price limits when the market releases positive news during market turmoils. Industrial stocks in China are mostly those issued by state-owned firms serving the domestic market. Therefore, they are less likely to be affected by the global financial crisis.

The results also show that the coefficients of the BM value and RR are significantly negative at the 1% level. Such finding is consistent with those of Kim and Limphayom (2000) and Chen et al. (2005), where firms with a higher BM value have relatively low likelihood in reaching the price limits. This is because most of them are value firms which perform steadily during market turmoil. We also find that the coefficient of the market size is significantly negative in both the whole sample and the upward subsample but not significantly positive for the downward price movement. This shows that larger firms are less likely in hitting upper price limits rather than lower limits. An explanation for this finding is that firms with large market sizes often have sufficient capital and stable business performance, which may be regarded as a low-risk investment and do not likely fluctuate markedly during market turmoil.

We expect that state-owned firms will not be affected by market turmoils and these firms will hardly hit the price limit in the downward price movement. Note from Table 10 that the coefficient of state ownership is positive but not significant in all cases. This suggests that stocks of state-owned firms have the same chance of hitting the price limits as other firms during market turmoil.

For all the three cases, stocks in the property industry are more likely to hit the price limits. Note also that in the upward subsample, the coefficients of conglomerates and industrial sector dummies are also significantly positive. However, except for property, other industry dummy variables are not significant in the downward subsample.

***Table 10**.GMM Estimation Results of Stocks that Hit the Limit*

Characteristics of Limit-hitting Stocks in the 2008 Financial Crisis (2008 to 2009)			
	Full Sample	Upward Limit Subsample	Downward Limit Subsample
BM	-0.0377***	-0.0269***	-0.0145***
State	0.00375	0.00182	0.00120
TV	0.205**	0.260***	0.207***
Size	-0.00426***	-0.00287***	0.000214
Beta	0.0205***	0.0170***	0.00812***
RR	-0.0202**	-0.0190**	-0.0111***
dummy1 (Finance)	0.00675	0.00511	0.000159
dummy2 (Utilities)	0.00199	0.00287	0.000560
dummy3 (Properties)	0.0133***	0.00999***	0.00555**
dummy4 (Conglomerates)	0.00502*	0.00767***	-0.000903
dummy5 (Industrials)	0.00691***	0.00675***	0.00126
Constant	-0.731***	-0.776***	-0.854***
Number of Stocks	1464	1433	1117

*, **, and *** denote 5%, 1%, and 0.1% levels of significance, respectively.

5. Conclusions

The effectiveness of price limits has been a controversial issue in the literature. Most previous studies focus on tranquil periods. In light of the increasing integration of China into the global markets, this paper explores the effect of price limits in China during global market turmoils. We also examine the characteristics of Chinese stocks that frequently hit the limits. Some important results are obtained. First, it is found that during the 2008 financial crisis, the price limit system increased and prolonged the volatility significantly, especially during downward price movement. However, during the tranquil period, the price limit reduces the volatility during the downward price movement. Second, our results show that the price limit delays the efficient price discovery during market turmoils. Third, it is found that during the upward price movement, the price limit interferes with trading activities for one day after hitting the limits. Finally, it is found that actively-traded stocks in the property and industrial sectors that have a high positive correlation with the entire market tend to hit the price limits more frequently. Meanwhile, stocks with a higher BM value and a larger market size hardly hit the upper limits during market turmoils.

References

Berkman, H. and J. B. Lee, 2002, "The Effectiveness of Price Limits in an Emerging Market: Evidence from the Korean Stock Exchange", *Pacific-Basin Finance Journal* 10, pp. 517–530.

Chan, S. H., Kim, K. A. and S. G. Rhee, 2005. "Price Limit Performance: Evidence from Transactions Data and the Limit Order Book", *Journal of Empirical Finance* 12(2) pp. 269–290.

Chen, G.M., Rui, O. M. and S. S. Wang, 2005. "The Effectiveness of Price Limits and Stock Characteristics: Evidence from the Shanghai and Shenzhen Stock Exchanges", *Review of Quantitative Finance and Accounting* 25(2), pp. 159–182.

Chiang, R., Wei, K. C. J. and R. Wu, 1990. "Price Limits in Taiwan and Risk-Return Estimation", *Pacific Capital Market Research* 1, pp. 173–183.

Chowdhry, B. and V. Nanda, 1998. "Leverage and Market Stability: The Role of Margin Rules and Price Limits", *Journal of Business* 71, pp. 179–210.

Fama, E. F., 1989. "Perspectives on October 1987, or What did We Learn from the Crash?" in R.W. Kamphuis et al. (Eds.), Black Monday and the Future of the Financial Markets, Irwin, Homewood, Ill.

Fama, E. F. and French, K. R., 1992. "The Cross-Section of Expected Stock Returns", *Journal of Finance* 47, pp. 427–465.

Harris, L., 1998. "Circuit Breakers and Program Trading Limits: What Have We Learned?", in Litan, R. E. and Santomero, A. M. (Eds.), Brooking-Wharton Papers on Financial Services, Brooking Institutions Press, Washington DC, pp.17–63.

Huang, Y., Fu, T., and Ke, M., 2001. "Daily Price Limits and Stock Price Behavior: Evidence from the Taiwan Stock Exchange", *International Review of Economics and Finance* 10, pp. 263–288.

Kim, K. A., 2001. "Price Limit and Stock Volatility", *Economic Letters* 71, pp. 131–136.

Kim, K. A. and P. Limpaphayom, 2000. "Characteristics of Stocks that Frequently Hit Price Limits: Empirical Evidence from Taiwan and Thailand", *Journal of Financial Markets*, 3, pp. 315–332.

Kim, K. A. and J. Park, 2010. "Why do Price Limits Exist in Stock Markets? A Manipulation–Based Explanation", *European Financial Management* 16, pp. 296–318.

Kim, K. A. and S. G. Rhee, 1997. "Price Limit Performance: Evidence from the Tokyo Stock

Exchange”, *Journal of Finance*, 52, pp. 885–901.

Kim, Y. H. and J. J. Yang, 2004. “What Makes Circuit Breakers Attractive to Financial Markets? A survey”, *Financial Markets, Institutions, and Instruments* 13, pp. 109–146.

Kuhn, B. A., Kurserk, G. J. and P. Locke, 1991. “Do Circuit Breakers Moderate Volatility? Evidence from October 1989”, *Review of Futures Markets* 10, pp. 136–175.

Lauterbach, B. and U. Ben-Zion, 1993. “Stock Market Crashes and the Performance of Circuit Breakers: Empirical Evidence”, *Journal of Finance* 48, pp. 1909–1925.

Lee, C. F. and O. M. Rui, 2000. “Does Trading Volume Contain Information to Predict Stock Returns? Evidence from China’s Stock Markets”, *Review of Quantitative Finance and Accounting* 14, pp. 341–360.

Lee, C. M. C., Ready, M. J. and P. J. Seguin, 1994. “Volume, Volatility, and New York Stock Exchange Trading Halts”, *Journal of Finance* 49, pp. 183–214.

Lee, S. B. and J. S. Chung, 1996. “Price Limits and Stock Market Efficiency”, *Journal of Business Finance and Accounting* 23, pp. 585–601.

Lee, S. B. and K. J. Kim, 1995. “The Effects of Price Limits on Stock Price Volatility: Empirical Evidence in Korea”, *Journal of Business Finance and Accounting* 22, pp. 257–267.

Lehmann, B. N., 1989. “Commentary: Volatility, Price Resolution, and the Effectiveness of Price Limits”, *Journal of Financial Services Research* 3, pp. 205–209.

Ma, C. K., Rao, R. P. and S. R. Sears, 1989. “Volatility, Price Resolution, and the Effectiveness of Price Limits”, *Journal of Financial Service Research* 3, pp. 165–199.

Roll, R., 1989. “Price Volatility, International Market Links, and their Implications for Regulatory Policies”, *Journal of Financial Services Research* 3, pp. 211–246.