Daily Equity Returns and Price Limit in China's Stock Market

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Abstract: The purpose of this paper is to get a conclusion whether the price limits have C-H effects on return series on limit-hitting days in China. I compare the volatilities between the non-limiting return series and return series with price limit. 'Estimating the effect of price limits on limit-hitting days' is the main reference published in 2005 by Chung Jeff and Li Gan. The model I use is normal distribution.

1 INTRODUCTION

Price limit is an established amount in which a price may increase or decrease in any single trading day from the previous day's settlement price. It limits the extent that how far the price can move up or down. The purpose of Price limits is to control price fluctuation and make an orderly market. Price limit has two effects: ceiling effect, C-H effect. As I will use return series instead of only limit-hitting days' returns, there is no ceiling effect. The C-H effect is called cooling-off and heating-up effect. It assumes that price limit may cool off or heat up price behavior. If it has effect, I can use price limit as a tool to achieve certain purposes.

Around half of the world's stock exchanges use price limit tool. For example, In China, Stock exchange limit the price changes to 10% in mid-1997, but now the price limits decline to 5%. We can see that price limits will also change according to the economy status.

There are many references I can use. In the paper used as the main reference, the main conclusion is that price limit will have some cooling off effect in normal iid distribution. But the effect is not significant in mixture normal distribution. The model I use is the one introduced in the reference. In 'Price limit performance: Evidence from the Tokyo Stock Exchange', there are three hypothesis of effect: volatility spillover hypothesis (prevent price change and immediate correction), delayed price discovery hypothesis (the block on price may force stock to discover until next trading day), trading interference hypothesis (people want to sell or buy at equilibrium price and they will wait). They use daily stock price data of four years. In the first hypothesis, they use a 21-day event window, day -10 to +10. Day 0 represents the limit-hit day. Then they calculate volatility of each day for the 21-day period surrounding the event day 0. However, the empirical results show: volatility returns to normal level not that quickly; price still change and even more frequently; trading volume is larger than before. As a conclusion, none of them established. Price limits almost have no effect.

In 'Price limits and volatility: a new approach and some new empirical evidence from the Tokyo stock exchange', it examines Day-of-the-week effect of limit hits which is first introduced ever. They use the data from DataStream. It uses EGARCH model which allows for the information asymmetry and parameters to be negative. When seasonally occurred price limit days is associated with seasonally occurred high stock returns, it means that price limit hits are not due to noise trading entirely. It also shows that high volatility exists when there are high price limit hits; low volatility exists when there are low price limit hits.

In 'The impact of trading halts on liquidity and price volatility: evidence from the Australian stock exchange', it examines the behavior of liquidity and volatility around trading halts. There contains four hypothesis: Trading volume for halted stocks is abnormally high immediately after a trading halt; Price volatility is also abnormally high after a trading halt; bid-ask spreads are abnormally wide; Market depth at the best-quotes is abnormally low immediately after a trading halt. In order to observe the behavior of both liquidity and volatility, they set up a natural experiment: there are two identical

11

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firms: one has trading halts, another don't have. They want to know the trading behavior after trading halts by releasing good news and bad news. The result is that trading behaviors act more abnormally when bad news are released than good news.

In 'Characteristics of stocks that frequently hit price limits: empirical evidence from Taiwan and Thailand', They find that volatile stocks, actively traded stocks and small market capitalization stocks hit price limits more often than other stocks. The stocks are all from Taiwan Stock Exchange and the Stock Exchange of Thailand. It calculates the number of limit hits by using year, month, day-of-the week and industry categories. The purpose of this paper is to find out that if some certain stocks with certain characteristics hit limits more often than others. They do this kind of research because that this area is underdeveloped right now. It examines four possible factors: beta, residual risk, trading volume, firm size and the book-to-market value of equity. Then it calculates the autocorrelation between limit-hits and the four factors.

In 'Using American Depository Receipts to identify the effect of price limits', it use a natural experiment: same stock is traded in two different exchanges. One has price limit and the other does not have. In this way, we can observe the effect of price limit very clearly. The conclusion of this paper stands for the point that price limit does not have significant effect on means nor variances.

There are some other related literatures I have not mentioned here, but I will give reference information at the end of the whole project. To sum up, most supported opinion in previous years is that price limits have cooling-off effect. But most recent empirical work shows that the effect turns to be heating-up. I will do this empirical work according to Chinese recent information and status.

The paper is organized as follows: The Data and Model will be included in Section 2. I will estimate stocks using normal distribution model in Section 3. Section 4 will be the conclusion.

2 DATA AND MODEL

The data is from 'Wind information'. It contains four stocks from 09/02/2011 to 09/03/2012. We get the daily stock prices and returns from 'Wind'.

Next, I calculate the adjusted stock return and use the +5% and -5% as the upper and down limits and find out how many times of limit hits. Then I divide the sample into many subsamples, named Sj, which contains j+1 day. S0 means there is no limit-hitting day, and S1 means there is one limit-hitting day and contains next day just after the hitting day. For example, there is a return series (0,1,0,1,1,0,1,1,1,0). 0 represents that price doesn't hit the limit and 1 represents that price dose hit the limit. 1 belongs to S0 because there is no price limit hits. And 2and3 belong to S1. 4,5 and 6 belong to S2. If there is no limit hits, I will just use the return data, but if the return hits the limit, I will use the average return of this day and next trading day as the adjusted return of both of them. And sometimes they just hit the limit in continuous days. The adjusted return will be the average return of these limit-hitting returns and the following day's return. Now I have the adjusted data.

Table 1: Days that limits are hit.

	Sheng run	Gan hua	Sih uan	Guo yao
Up limit hits	32	14	13	17
Down limit his	23	11	12	11
Total limit his	55	25	25	28

There are enough limit hits for me to do the research and observe the effect of price limits. In this way, the stock price returns to the equilibrium on j+1 day and I can get rid of ceiling effect. In this paper, the purpose is to observe if the price limit has effect on volatility of stock prices.

Table 2: Frequency of limit hits in continuous days.

Continuous days of limit hits	
0	1495
1	111
2	15
3	5
4	2
Total trading days	1628
Percentage of limit hit days	8.17%

rt*means an unobserved return series assuming no price limit. rt means unobserved return series assuming only the C-H effect. rt^ will be estimated rt and rt0 will be the observed return series.

12

Daily Equity Returns and Price Limit in China’s Stock Market

$$r_t^{\hat{}} = \begin{cases} r_t^0 & if\ t \in S_0 \\ \frac{1}{j+1} \sum_t r_t^0 & if\ t \in S_j \end{cases} \qquad (1)$$

I use normal distribution to do the research. The hypothesis is that price limit has a significant effect on mean and volatility of stock returns.

The model is:

$$f(r_t^*) = \frac{1}{\sqrt{2\Pi}\sigma_0} exp\left\{-\frac{(r_t^* - \mu_0)^2}{2\sigma_0{}^2}\right\} \qquad (2)$$

Now rewrite the function:

$$f(r_t^{\hat{}}) = \frac{1}{\sqrt{2\Pi}S_0} exp\left\{-\frac{(rt^{\wedge} - m_0)^2}{2S_0{}^2}\right\} \qquad (3)$$

2.1 When the State S Is S−, It Means that Return Hits the Down Limit

$$m_0=\mu_0+\gamma \qquad (4)$$

$$s_0^2=\sigma_0^2(1+\zeta_-)*(1+j) \qquad (5)$$

2.2 When the State S Is S+, It Means that Return Hits the Upper Limit

$$m_0=\mu_0+\gamma \qquad (6)$$

$$s_0^2=\sigma_0^2(1+\zeta_-)*(1+j) \qquad (7)$$

In this rewrite model, (γ-,γ+)and (ζ-,ζ+) two pairs reflect the effect of price limits on stock returns. I use the Normal Distribution to run the regression and see if these parameters are significant or not. If the (γ-,γ+) are significant, it means that price limits have effect on mean value. If the (ζ-,ζ+) are significant, it means that price limits have effect on variance.

All these parameters are not significant. This means that price limits barely have. effect on mean and variance under Normal Distribution Model. Mixture Normal Distribution Model:

$$f(r_t^*) = \sum_{i=1}^{3} f(r_{t,}^* s_t = i)$$

$$= \frac{p_-}{\sqrt{2\Pi}\sigma_-} exp\left\{-\frac{(r_t^*-\mu_-)^2}{2\sigma_-^2}\right\}$$

$$+ \frac{p_0}{\sqrt{2\Pi}\sigma_0} exp\left\{-\frac{(r_t^* - \mu_0)^2}{2\sigma_0^2}\right\}$$

$$+ \frac{p_+}{\sqrt{2\Pi}\sigma_+} exp\left\{-\frac{(r_t^* - \mu_+)^2}{2\sigma_+^2}\right\} \qquad (8)$$

In this paper, I only use normal density to estimate stock returns to see if the volatilities between non-limiting returns and adjusted returns with price limits change after limit-hitting days. Mixture Normal Distribution can be used when price limits are not reached consecutively on more than one day. It is more difficult.

2.3 MLE Estimates and Effect of Price Limits

In order to get the conclusion of the effect of price limits on limit-hitting days, I use Maximum Likelihood Estimation, which has been introduced in previous part. Now I use ‘R’ program to do the estimation. The detailed estimation results are listed in table 3. I estimated six parameters: mean, variance, mean effect +, mean effect -, variance effect + and variance effect -. If I use gragh to explain the main idea, it would be that observed data obeys the Normal density and the adjusted data can be drawd with fatter tails. First, I calculate the mean and variance of observed stock returns and their standard error . Second, I estimate the six variables and their standard errors of adjusted data which contains price limits. If the parameters are significant, it means that they should be added into the model and it also means that price limits have effect on mean and variance. Third, I can get the effect by using the formula introduced below. In this way, the effect of price limits can be calculated and I can make our conclusion depending on the result.

Table 3: Result of MLE.

	mean		variance	
Shengrun	-2.07e-03(1.87e-03)		7.24e-04(8.20e-05)	
Ganhua	-7.85e-04(1.18e-03)		4.95e-04(5.15e-05)	
Sihuan	-2.15e-04(4.4e-04)		1.31e-03(5.57e-05)	
Guoyao	-4.17e-04(4.4e-04)		1.08e-03(4.63e-05)	
Stock	Shengrun	Ganhua	Sihuan	Guoyao
μ mean	-3.7e-03 (2.1e-03)	-8.33e-04 (1.15e-03)	-1.87e-04 (1.37e-03)	-4.7e-04 (1.1e-03)
σ2 variance	7.0e-04 (1.1e-04)	4.78e-04 (5.34e-05)	4.46e-04 (6.4e-05)	4.4e-04 (5.2e-05)
γ- mean effect	-0.033 (3.7e-03)	-0.0278 (3.4e-03)	-0.032 (2.2e-03)	-0.032 (2.5e-03)
γ+ mean effect	0.042 (2.7e-03)	0.031 (2.8e-03)	0.026 (3.3e-03)	0.027 (1.9e-03)
ζ- var effect	-0.81 (0.052)	-0.81 (6.37e-02)	-0.94 (0.02)	-0.87 (0.039)
ζ+ var effect	-0.92 (0.020)	-0.86 (4.32e-02)	-0.78 (0.069)	-0.92 (0.020)

13

The data in the brackets is standard error which can be compared with the p-value to figure out whether the variable is significant or not. I can conclude from table 3 that 'variance effect ' is significant. So it means that price limits have a negative effect on variance. This is so called cooling-off effect.

Now I want to know what the particular extent of effect is. The effect of price limits is the percentage change of both mean and variance when price hits the limits.

Mean effect

$$= \frac{E(r_t|r_t > b) - E(r_t|r_t > b, r_{+,-} = 0, \zeta_{+,-} = 0)}{E(r_t|r_t > b, r_{+,-} = 0, \zeta_{+,-} = 0)} * 100$$

Variance effect

$$= \frac{Var(r_\tau|r_\tau > b) - Var(r_\tau|r_\tau > b, r_{+,-} = 0, \zeta_{+,-} = 0)}{Var(r_t|r_t > b, r_{+,-} = 0, \zeta_{+,-} = 0)} * 100$$

Table 4: Effect of price limits on limit-hitting days.

	Mean		Variance	
	+	-	+	-
Shengrun	42%	26%	-95%	-51%
Ganhua	73%	35%	-93%	-55%
Sihuan	83%	57%	-90%	-86%
Guoyao	75%	74%	-98%	-69%

From table 4, we can see that the effects of price limits in four stocks are similar. Also, it is apparent that price limits have a positive effect on mean and a negative effect on variance. This is so called cooling-off effect which means volatility declines after price limit hitting days. According to the result, we can conclude that price limits have cooling-off effect when using Normal density.

3 CONCLUSION

The main target of this paper is to see whether price limits have effect or not. As we all know, price limits have two effects: ceiling effect and C-H effect. In this paper I only focus on C-H effect.

The sample is divided into many subsamples Sj, which contains j+1 days. J represents days that hit price limits. Then take the average of j days' high returns and next trading day's return as the new returns for j+1 days. The new returns will be the sample used in the model. Through this way, all subsamples will not have any ceiling effect. The data is four ST stocks' returns. The model I use is Normal density. After MLE estimation, the results show that price limits have some cooling-off effect. Variance declines after price limits are set.

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14