The Empirical Analysis of the Effect of Circuit Breaker on China Stock Market

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Abstract. Since the circuit breakers were carried out in China Stock Market on January 2016, there was sharp fluctuation in the stock market, which forced CSRS to halt the circuit breaker. In order to analyze the influence of circuit breaker on stock market, GARCH model was conducted. It is found that after the carrying out of circuit breakers the fluctuation was significantly larger; the stock market was easily affected by the previous shock; the stock market was more sensitive to the negative shock.

Introduction

Since October of 1988, U.S. Securities and Exchange Commission has approved circuit breakers in New York stock exchange. Circuit breakers are a mechanism that as long as the changes in stock prices or price indexes exceed the upper limit, the stock exchange or future exchange will be halted or can only proceed in a specific price interval. Circuit breakers aim to provide time for investors to calm down when there are sudden changes in prices in order to prevent investors from overreaction.

In 2015, there were substantial changes in prices in China stock exchange market. China Securities Regulatory Commission (CSRC) approved the circuit breakers to carry out since 1st of January 2016. Shanghai and Shenzhen 300 index is taken as the benchmark for the mechanism of circuit breakers. As long as the changes in benchmark index exceed 5%, the stock exchange market will be halted for 15 minutes. If the changes in benchmark index exceed 5% after 14:30 or the changes exceed 7% anytime in a trading day, the exchange market will be closed [1].

On 4th of January 2016, the first day the circuit breakers carried out, Shanghai and Shenzhen 300 index decreased by more than 5%, dropped to 3500, which made the circuit breakers activated, the exchange market halted for 15 minutes. When the exchange market resumed after 15 minutes, the benchmark index continued decreasing to 7%, which made the exchange market closed for the remaining trading time. On 7th of January, the benchmark index continued downward trend. At 9:59, the benchmark index decreased by more than 7%, initiating the circuit breakers to close down the exchange market, which made it the shortest trading time since the exchange market was established. It was reflected that the enforcement of circuit breakers was inconsistent with expectation, which enhanced the fluctuation of the exchange market. Therefore, the circuit breakers were called off immediately after 7th of January [2].

Based on the experiences in other countries related to circuit breakers, the mechanism of circuit breakers is effective in reducing the fluctuation in stock exchange market. However, according to the observation of the exchange market during the trading days with the implementation of circuit breakers, it was found that circuit breakers did not accommodate well in China. As a result, this paper intended to find out whether there is influence of circuit breakers on China stock exchange market. In order to make a detailed analysis of how and why circuit breaker affects the exchange market, GARCH model will be constructed.

Model

Data. As Shanghai and Shenzhen 300 index is taken as the benchmark for circuit breakers, and it is market representative, therefore, it is selected as the sample index. The sample period covered from
1st of December 2015 to 31st January 2016. There were 2064 5-minute high-frequency data of sample index collected for the empirical test. Due to the circuit breakers carried out during 4th to 7th of January 2016, the sample can be separated into 2 subsamples depending on whether the circuit breakers were implemented. As a result, the samples during December of 2015 were categorized as a phase before the circuit breakers were implemented; the remaining samples were categorized as a phase with the implementation of circuit breakers.

In order to analyze the influence of circuit breakers on China stock exchange market, the standard deviation of rate of return is chosen to measure the fluctuation of prices. Therefore, the standard deviation of the return on Shanghai and Shenzhen 300 index is selected to be the measurement of fluctuation of stock exchange market. The rate of return is represented by the first difference of nature log on price index. The rate of return on Shanghai and Shenzhen price index at time t is denoted by $R_t$. Shanghai and Shenzhen price index at time t is denoted by $S_t$. The rate of return is calculated by Eq. 1.

$$R_t = (\ln S_t - \ln S_{t-1}) \times 100\% \quad (1)$$

**GARCH Model.** In this paper, ARMA (1,1) - GARCH (1,1) is constructed to make analysis on the fluctuation of stock exchange market. It means that the rate of return on price index is captured by ARMA (1,1) model, while the fluctuation of price index is captured by GARCH (1,1) model. The completed model can be written as Eq. 2 and Eq. 3.

$$R_t = a_1 R_{t-1} + \varepsilon_t + b_1 \varepsilon_{t-1} \quad (2)$$

$$\sigma_t^2 = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \beta_1 \sigma_{t-1}^2 \quad (3)$$

In the conditional mean equation, the rate of return of price index $R_t$ is explained by itself in previous periods $R_{t-1}$ and a combination of current and previous values of error terms, $\varepsilon_t$ and $\varepsilon_{t-1}$. In the conditional variance equation, the conditional variance $\sigma_t^2$ is explained by itself in previous period $\sigma_{t-1}^2$ and square value of error term in previous period $\varepsilon_{t-1}^2$. It can be interpreted from GARCH (1,1) model that the current fitted variance $\sigma_t^2$, as a weighted function of a long-term average value $\alpha_0$, information about volatility during the previous period $\alpha_1 \varepsilon_{t-1}^2$ and the fitted variance from the model $\beta_1 \sigma_{t-1}^2$ during the previous period.

**Dummy Variable.** In order to make the model to reflect the influence of circuit breakers, a dummy variable $D_t$ represented the enforcement of circuit breakers was putted into the model to separate the samples when the circuit breakers are implemented from all the samples [3]. After the introducing the dummy variable, the completed model can be written as Eq. 2 and Eq. 4.

$$R_t = a_1 R_{t-1} + \varepsilon_t + b_1 \varepsilon_{t-1} + \lambda D_t \quad (2)$$

$$\sigma_t^2 = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \beta_1 \sigma_{t-1}^2 + \lambda D_t \quad (4)$$

With the input of dummy variable, the conditional variance $\sigma_t^2$ is explained by itself in previous period $\sigma_{t-1}^2$, square value of error term in previous period $\varepsilon_{t-1}^2$ and the dummy variable represented the implementation of circuit breakers. In terms of the dummy variable, if the circuit breakers were implemented at time t, the dummy variable $D_t = 1$; if it is not implemented, $D_t = 0$.

The influence of circuit breakers on stock exchange market can be determined by the significance of coefficient $\lambda$. If $\lambda$ is significant and negative, the implementation of circuit breakers reduces the volatility of stock exchange market because of the lower conditional variance. Conversely, if $\lambda$ is significant and positive, the implementation of circuit breaker raises the volatility of stock exchange market. Moreover, if it is insignificant, the volatility of stock exchange market is indifferent no matter whether the circuit breakers are implemented.

**Empirical Results**

**Stationary Test.** The GARCH model assumes that the series of rate of return of price index must be stationary; therefore, the stationary test must be conducted first. In this paper, the volatility of
stock exchange market is represented by the standard deviation of the return on Shanghai and Shenzhen 300 index; thus, argument Dickey-Fuller test (ADF test) will be conducted on the series of rate of return of the price index to ensure it is stationary.

Table 1. The result of stationary test on series of return on Shanghai and Shenzhen 300 index.

<table>
<thead>
<tr>
<th>ADF Statistics</th>
<th>Critical Value at 1% Significant Level</th>
<th>Critical Value at 5% Significant Level</th>
<th>Critical Value at 10% Significant Level</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>${R_t}$</td>
<td>-45.07</td>
<td>-3.43</td>
<td>-2.86</td>
<td>-2.56</td>
</tr>
</tbody>
</table>

According to the result in Table 1, the ADF statistics of $R_t$ is lower than the critical value at 1% significant level -3.43 and p-value is also lower than 1%, which means that the series of return on price index is stationary at 1% significant level.

**GARCH Model with Dummy Variable.** When the series of return on price index passed the stationary test, GARCH model can be conducted in order to analyze the influence of circuit breakers on stock exchange market. The completed GARCH model with the dummy variable represented the implementation of circuit breakers is shown by Eq. 2 and Eq. 4.

Table 2. Estimation Results of ARMA(1,1)-GARCH(1,1) Model.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Statistics</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conditional Mean Equation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$R_{t-1}$</td>
<td>-0.583344</td>
<td>0.210948</td>
<td>-2.765337</td>
<td>0.0057</td>
</tr>
<tr>
<td>$\varepsilon_{t-1}$</td>
<td>0.595463</td>
<td>0.209320</td>
<td>2.844751</td>
<td>0.0044</td>
</tr>
</tbody>
</table>

| Conditional Variance Equation |
| $\alpha_0$ | 1.03E-07 | 1.46E-08 | 7.053770 | 0.0000   |
| $\varepsilon_{t-1}^2$ | 0.080145  | 0.004967 | 16.13591 | 0.0000   |
| $\sigma_{t-1}^2$ | 0.905309  | 0.004177 | 216.7609 | 0.0000   |
| $D_t$ | 1.04E-06 | 9.47E-08 | 10.66587 | 0.0000   |

According to the result in Table 2, in conditional mean equation, the coefficients $a_1$ and $b_1$ are significant as both of the p-values are lower than 1%. It means that ARMA (1,1) model fits the changes in price index well. In terms of conditional variance equation, the coefficients $a_1$ and $b_1$ are also significant, which means that the fitting of GARCH model on the volatility of price index is good. What’s more, the combination of coefficients $a_1$ and $b_1$ equal to 0.98, therefore, the GARCH model is stationary. In terms of the dummy variable, it is evident by the significance and positive sign of $\lambda$ that the volatility of stock exchange market was larger during the time period when implementing the circuit breakers, compared to the time period without the circuit breakers.

**GARCH Model in 2 Phases.** In order to step further in analysis on how the circuit breakers affect the volatility of stock exchange market, GARCH model would be conducted before and after the implementation of circuit breakers. In the first phase (December of 2015) before the implementation of circuit breakers, the common GARCH model without dummy variable would be conducted on the series of return on Shanghai and Shenzhen 300 index. The model used in the first phase is written as Eq.2 and Eq.3. In the second phase (January of 2016) after the implementation of circuit breakers, GARCH model with a dummy variable would be conducted in two steps. Specifically, the common GARCH model in the first phase was conducted firstly. The error terms and conditional variance terms were taken out in the first step, and then combined with the dummy variable together in the GARCH model, which were conducted on the price index again. The model in the second step is written as Eq. 2 and Eq. 5.

$$R_t = a_1 R_{t-1} + \varepsilon_t + b_1 \varepsilon_{t-1} \quad (2)$$

$$\sigma_t^2 = \alpha_0 + a_1 \varepsilon_{t-1}^2 + \beta_1 \sigma_{t-1}^2 + a_2 D_t \varepsilon_{t-1}^2 + \beta_2 D_t \sigma_{t-1}^2 + \lambda D_t \quad (5)$$

According to the result in Table 3, it was evident by the significance of coefficients that GARCH model fitted well in the series of return on Shanghai and Shenzhen 300 index. In the second phase, the estimated coefficients $a_1$ and $a_2$ were 0.16 and 0.12, which means that after the implementation of
circuit breakers the coefficient of square of error term in previous time increased from 0.069 to 0.28. In terms of the first lag of conditional variance, the coefficient in phase 2 decreased from 0.89 to 0.41 because of the insignificance of $\beta_2$. It can be concluded that after implementation of circuit breakers, the volatility of stock exchange market was more easily affected by the previous shocks in the price as the coefficient of $\varepsilon_{t-1}^2$ was substantially larger. Such change was caused by the implementation of circuit breakers, because $\alpha_2$ which is the coefficient of dummy variable related to $\varepsilon_{t-1}^2$, was significant and positive. Besides, in second phase the coefficient of dummy variable $\lambda$ was almost offset by the intercept $\alpha_0$. It could be interpreted that the volatility was not simply enhanced by the implementation of circuit breakers, which was contradicted to the result in the last part. More exactly, it was the implementation of circuit breakers made the stock exchange market more easily affected by the previous shock in prices, which enabled greater volatility in price changes.

Table 3. Estimation Results on GARCH Model in two phases.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Phase 1 Coefficient</th>
<th>T-Statistics</th>
<th>P-value</th>
<th>Phase 2 Coefficient</th>
<th>T-Statistics</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\alpha_0$</td>
<td>1.39E-07</td>
<td>3.049538</td>
<td>0.0023</td>
<td>5.81E-06</td>
<td>18.47722</td>
<td>0.0000</td>
</tr>
<tr>
<td>$\varepsilon_{t-1}^2$</td>
<td>0.068872</td>
<td>4.226376</td>
<td>0.0000</td>
<td>0.159779</td>
<td>5.560784</td>
<td>0.0000</td>
</tr>
<tr>
<td>$D_t\varepsilon_{t-1}^2$</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.120855</td>
<td>10.92407</td>
<td>0.0000</td>
</tr>
<tr>
<td>$\sigma_{t-1}^2$</td>
<td>0.889238</td>
<td>34.49375</td>
<td>0.0000</td>
<td>0.409484</td>
<td>15.0999</td>
<td>0.0000</td>
</tr>
<tr>
<td>$D_t\sigma_{t-1}^2$</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.002526</td>
<td>0.415414</td>
<td>0.6778</td>
</tr>
<tr>
<td>$D_t$</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-5.83E-08</td>
<td>-17.08576</td>
<td>0.0000</td>
</tr>
</tbody>
</table>

The Asymmetric Effect. It could be observed from the trading days with the implementation of circuit breakers that the triggering of circuit breakers was failed to prevent the price index from decreasing after resuming so that the continued downward trend triggered the circuit breakers again to make the exchange market closed for the remaining time. Therefore, it was found that the circuit breakers were not effective in stabilizing the stock exchange market, however, it seemed to make the exchange market more panic, accelerating the downward trend. In order to test whether circuit breakers made the stock exchange market more sensitive to the negative shock, asymmetric GARCH model is conducted.

Similarly with the steps in the last part, the asymmetric GARCH model is conducted on the series of return on Shanghai and Shenzhen 300 index before and after the implementation of circuit breakers. The asymmetric GARCH model is a GARCH model with an asymmetric dummy variable $I_t$. If there is any pessimistic news coming into the market ($\varepsilon_{t-1} < 0$), $I_t = 1$; otherwise, $I_t = 0$. The asymmetric GARCH model can be written as Eq. 2, Eq. 6 and Eq. 7.

\[
R_t = a_0 R_{t-1} + \varepsilon_t + b_3 \varepsilon_{t-1} \quad (2)
\]
\[
\sigma_t^2 = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \beta \sigma_{t-1}^2 + \gamma \varepsilon_{t-1} I_{t-1} \quad (6)
\]
\[
I_{t-1} = \begin{cases} 
1 & \text{if } \varepsilon_{t-1} < 0 \\
0 & \text{if } \varepsilon_{t-1} \geq 0 
\end{cases} \quad (7)
\]

If the coefficient is significant and positive, the volatility of return on price index is more easily affected by negative impacts. Conversely, the significant and negative sign of reflects that the volatility of return on price index is less affected by negative impacts. Otherwise, if it is insignificant, it is not evident that there is asymmetric effect existing.

In the first phase (December of 2015) before the implementation of circuit breakers, the common asymmetric GARCH model would be conducted on the series of return on Shanghai and Shenzhen 300 index. The model used in the first phase is written as Eq. 2, Eq. 6 and Eq. 7. In the second phase (January of 2016) after the implementation of circuit breakers, asymmetric GARCH model with a dummy variable represented the implementation of circuit breakers would be conducted in two steps. Specifically, the common asymmetric GARCH model in the first phase was conducted firstly. The error terms and conditional variance terms were taken out in the first step, and then combined with the
dummy variable $D_t$ together in the asymmetric GARCH model, which were conducted on the price index again. The model in the second step is written as Eq. 2, Eq. 7 and Eq. 8.

\[
R_t = a_0 R_{t-1} + \varepsilon_t + b_1 \varepsilon_{t-1}
\]

\[
\sigma_t^2 = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \beta_1 \sigma_{t-1}^2 + \alpha_2 D_t \varepsilon_{t-1}^2 + \beta_2 D_t \sigma_{t-1}^2 + \lambda D_t + \gamma \varepsilon_{t-1} I_{t-1}
\]

\[
I_{t-1} = \begin{cases} 
1 & \text{if } \varepsilon_{t-1} < 0 \\
0 & \text{if } \varepsilon_{t-1} \geq 0 
\end{cases}
\]

Table 4. Estimation Results on asymmetric GARCH Model in two phases.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>T-Statistics</th>
<th>P-value</th>
<th>Coefficient</th>
<th>T-Statistics</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$a_0$</td>
<td>1.40E-07</td>
<td>3.022805</td>
<td>0.0025</td>
<td>6.35E-06</td>
<td>93.99317</td>
<td>0.0000</td>
</tr>
<tr>
<td>$\varepsilon_{t-1}^2$</td>
<td>0.070475</td>
<td>3.556490</td>
<td>0.0004</td>
<td>0.069447</td>
<td>2.604974</td>
<td>0.0092</td>
</tr>
<tr>
<td>$D_t \varepsilon_{t-1}^2$</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.131279</td>
<td>12.54488</td>
<td>0.0000</td>
</tr>
<tr>
<td>$\sigma_{t-1}^2$</td>
<td>0.888728</td>
<td>34.14755</td>
<td>0.0000</td>
<td>0.352320</td>
<td>14.19009</td>
<td>0.0000</td>
</tr>
<tr>
<td>$D_t \sigma_{t-1}^2$</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.015068</td>
<td>1.821870</td>
<td>0.0685</td>
</tr>
<tr>
<td>$D_t$</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-6.48E-05</td>
<td>-9320.576</td>
<td>0.0000</td>
</tr>
<tr>
<td>$\varepsilon_{t-1}^2 I_{t-1}$</td>
<td>-0.002857</td>
<td>-0.144058</td>
<td>0.8855</td>
<td>0.222630</td>
<td>3.818169</td>
<td>0.0001</td>
</tr>
</tbody>
</table>

According to the result in Table 4, before the implementation of circuit breakers, the coefficient was insignificant at 5% significant level. It was reflected that without the circuit breakers the negative effects impacting on volatility of stock exchange market were indifferent with the positive effects. However, after the implementation of circuit breakers, the coefficient was significant and positive. It was evident by the result that the negative impacts made for higher volatility in stock exchange market. Therefore, it can explain why downward trend continued to larger than 7% to trigger the circuit breakers again just after resuming from the halting triggered by the circuit breakers. The intention of the 15 minutes when the exchange market is halted is to provide time for investors to calm down and gather more information. However, China stock exchange market is participated more by individual investors who are not professional and experienced in investment. The halt in exchange market might be more likely to be a negative signal for such individual investors, which makes them more panic. As a result, when the market resumes from the halt, the negative effects impact more on the volatility of stock exchange market, which raises the possibility in triggering the circuit breakers again.

Conclusion

It can be concluded from the empirical results that the volatility of stock exchange market was substantially larger when the circuit breakers were implemented. Moreover, it was also evident that the implementation of circuit breakers made for the stock exchange market more easily affected by previous price shocks, which initiated greater volatility. Last but not the least, the implementation of circuit breakers enabled the stock exchange market more sensitive to the negative impacts, which raised the volatility in the exchange market especially in the adverse status.

The reasons for the failure of circuit breakers in China stock exchange market can be concluded in two aspects. Firstly, the threshold levels of the circuit breakers in China were set too low and the difference between threshold levels was too narrow. The threshold levels of circuit breakers in U.S. and Korea stock exchange market are set at 7%/15%/20%, compared to the counterparties in our countries were 5%/7% [4]. Moreover, the volatility of China stock exchange market is substantially larger than that in the developed countries such as U.S. and Korea. Therefore, the higher volatility in exchange market but with lower threshold levels of circuit breakers makes the circuit breakers frequently triggered, which interrupts the regular operation of the stock exchange market. Secondly, the investors in China stock exchange market are dominant by individual investors instead of institutional investors compared to other well-developed stock exchange market. The purpose of circuit breakers is that when stock exchange market fluctuates violently, the halt in trading provides...
time for investors to gather information and think calmly in order to make rational decisions. However, most of the individual investors prefer to purchase when the prices increase and sell when declining. Such individual investors cannot calm down during the halt of trading when the circuit breakers are triggered, as they cannot sell since the market already has experienced decrease by 5%. When the exchange market resumes, the investors would be more likely to accelerate their selling orders, which gets the market continue declining. As a result, the implementation of circuit breakers makes for more panic among the individual investors, which raises the volatility in the exchange market.

Summary

In conclusion, the volatility of stock exchange market was substantially larger when the circuit breakers were implemented. Moreover, it was also evident that the implementation of circuit breakers made for the stock exchange market more easily affected by previous price shocks, which initiated greater volatility. Furthermore, the implementation of circuit breakers enabled the stock exchange market more sensitive to the negative impacts, which raised the volatility in the exchange market especially in the adverse status. Last but not the least, the inappropriate threshold levels and the different structure of investors are attributed to the failure of circuit breakers.

References


