Finance Research Letters xxx (xxxx) xxxx

Contents lists available at ScienceDirect

Finance Research Letters

journal homepage: www.elsevier.com/locate/frl

Market stability analysis after the circuit breaker for the CSI 300 energy index

Zhou Wei, Rao Wanying*, Lu Shuai

School of Finance, Yunnan University of Finance and Economics, Kunming 650221, PR China

ARTICLE INFO

Keywords:
Circuit breaker
Regression discontinuity design
Volatility
CSI 300 energy index
Energy industry

ABSTRACT

In order to deal with the herd effect and the risk contagions in the stock market, China officially took the circuit breaker mechanism for the CSI 300 index on the first trading day in 2016. However, this mechanism was abolished just in 4 days. Therefore, this paper attempts to empirically investigate the circuit breaker mechanism and the CSI 300 energy index based on the regression discontinuity design method. The empirical results show the energy index is more volatile after the discontinuity compared with which before it, indicating that the circuit breaker mechanism has not achieved the expected effect in China's energy industry. The ineffectiveness of this mechanism is proved in the CSI 300 energy index, which also happens to the CSI 300 index. Therefore, the CSI 300 energy index can be considered as a pilot to examine the improved circuit breaker mechanism in the future.

1. Introduction

The global financial crisis would cause sharp fluctuations in commodity prices, accompanied by the collapse of the stock market (Zhang and Broadstock, 2018). From June to August 2015, the Chinese security market suffered a severe decline due to the impact of the stock market crash. For this reason, the Chinese Securities Regulatory Commission set up the circuit breaker to curb excessive volatility in the stock market on January 4, 2016. However, this mechanism was proved to be a failure after launching for only four days. It is found that many related studies only aim at investigating this circuit breaker's impact on the CSI 300 Index. However, what are the reactions for other industries during these four days? Is the circuit breaker mechanism absolutely ineffective for all the industry? To address these two issues, in this paper, we empirically study the market stability of the CSI 300 energy index after the circuit breaker mechanism, compare different results that happen to some industries and derive several interesting conclusions from the perspective of individual industries.

As an institutional practice already be used in financial market, the circuit breaker mechanism has been widely concerned (Apergis, 2016). Because of its effects on restraining excessive market volatility, extensive investigations were conducted which mainly focus on the stochastic behavior of large movements (Booth, 1998) and market volatility (Subrahmanyam, 1994). In addition, some scholars consider the circuit breaker mechanism has a positive effect to curb the stock market volatility, which can reduce investors' short-term trading frenzy for certain stocks (Wu et al., 2017). In terms of the applicability. Some scholars find that the circuit breaker mechanism can cope with the fluctuations of stock price (Ackert et al., 2008), and many empirical studies were carried out (Goldstein, 2015). Also, the circuit breaker mechanism can cause suspension or termination of financial transactions (Subrahmanyam, 1994), increase the price volatility and affect investor sentiment (Broadstock and Zhang, 2019). However, most of

* Corresponding author.
E-mail address: rao_yanssic@163.com (W. Rao).

https://doi.org/10.1016/j.frl.2019.101348
Received 22 June 2019; Received in revised form 21 October 2019; Accepted 2 November 2019

these resaerch focused on the effect of the circuit breaker of the whole market. Unlike this viewpoint, in this paper, we empirically study the circuit breaker mechanism and the CSI 300 index from the respective of individual industries so that more conclusions and suggestions can be provided.

In addition, with the development of globalization, the importance and complexity of energy issues have become increasingly prominent (Ji et al., 2018; Xia et al., 2019), and the price index of energy products have attracted considerable attention (Ji et al., 2019; Ma et al., 2019). The role of energy in the world market largely determines national interests. Meanwhile, with respect to the related publications, we find that many scholars studied China's circuit breaker mechanism and the CSI 300 index. Their results show that China's circuit breaker mechanism on the CSI 300 index is ineffective and unsuccessful (Fang and Zhao, 2018). However, these results cannot show how to improve the circuit breaker mechanism and which industry is more suitable to introduce the improved circuit breaker mechanism. Therefore, in this paper we explore the policy effect of the circuit breaker mechanism from the perspective of a single industry rather than the CSI 300 index.

To do that, the remainder of this paper is organized as follows: Section 2 presents the methodology. Section 3 analyzes the empirical data. Section 4 derives some interesting empirical results. Finally, the conclusions are given in Section 5 .

2. Methodology

The method of regression discontinuity design (RDD) was first proposed by Thistlethwaite and Campbell (1960) . The RDD method can provide a good local random experiment for causal inference (Lee and Lemieux, 2010). Therefore, using the RDD method is appropriate to study the causal effect of the circuit breaker mechanism. Generally, the RDD can be divided into the sharp regression discontinuity (SRD) and the fuzzy regression discontinuity (FRD) according to the situation whether the probability of the individuals entering the treatment group equals to 1. The feature of SRD is that the probability of an individual entering the treatment group at the breakpoint jumps from 0 to 1, while the feature of FRD is that the probability of an individual entering the treatment group at the breakpoint jumps from a to b. Since the circuit breaker mechanism was implemented on an accurate day namely January 4, 2016, rather than a time interval, this paper uses SRD to estimate the impact of the circuit breaker mechanism on the CSI 300 energy index.

In order to reveal the impact of circuit breaker mechanism on the energy industry and the CSI 300 energy index, we first introduce the dummy variables as follows:

$$D_t = 0 if t < 0; or D_t = 1 if t \geq 0, \tag{1}$$

where D_t is the policy dummy variable. If $t < 0$, then the dummy variable is set as a value of 0, indicating that it is not affected by the circuit breaker. If $t \geq 0$, then the dummy variable takes the value of 1, denoting that it is affected by the circuit breaker. By measuring the difference between the two groups, we can estimate the independent effect of the policy. Hence, the effectiveness of the circuit breaker for the energy industry can be known by the setting of D_t. In this paper, the historical volatility before implementing the circuit breaker is utilized as the control group, while the historical volatility after implementing the circuit breaker is considered as the experimental group to observe the effectiveness of the circuit breaker for the energy industry.

In Eq. (1), the causal effect of the circuit breaker mechanism on variable y_t can be obtained by the following Eq. (2):

$$y_t = \alpha + \beta t + \gamma D_t + e_t \tag{2}$$

where y_t is the degree of financial asset price volatility which measures the uncertainty of return on assets. α represents the intercept of this equation and it is the actual volatility when $t = 0$, namely the policy implementation day. t represents the time and β represent the time-varying volatility change. e_t is residual and it involves the impacts of the factors that are not measurable on the volatility changes. γ describes the effect of policy implement on volatility because when $D_t = 1$, the values of γ is the difference between the two groups.

For values near $t = 0$, we have $y_\varepsilon \sim y_{-\varepsilon} \sim y_0$ where $\varepsilon \sim 0$ and $[0 - \varepsilon, 0 + \varepsilon]$ is a very small time range, there is little systematical difference between these values. Then, this range can be randomly grouped. Moreover, we set y_0 and y_1 to represent the situations before and after implementing the circuit breaker accordingly. Therefore, the local average treatment effect (LATE) near $t = 0$ can be estimated as follows:

$$\begin{aligned} LATE &= E(y_1 - y_0 | t = 0) = E(y_1 | t = 0) - E(y_0 | t = 0) \\ &= \lim_{t \to 0^+} E(y_1 | t = 0) - \lim_{t \to 0^-} E(y_0 | t = 0) \end{aligned} \tag{3}$$

where, $\lim_{t \to 0^+}$ and $\lim_{t \to 0^-}$ represent taking limits from the right and left sides of 0, respectively. In the last step of derivation, we assume that functions $E(y_1 | t = 0)$ and $E(y_0 | t = 0)$ are continuous, thus their limit value is equal to the value of the function.

Because the LATE is used in the RDD estimation, the empirical research is mainly based on the individual samples which are "just" affected by the implementation of the circuit breaker mechanism for a certain period of time, thus the estimated value of policy effect may be different from that of the whole sample, which will be shown in the empirical study.

3. Data analysis

In China's stock market, the circuit breaker mechanism is designed to dampen the volatility of the CSI 300 index. As mentioned before, it has been proved that this mechanism did not achieve this purpose. However, if the research object is subdivided into various industry indices under the CSI 300 index, the effect could be different. Therefore, this paper selects four kinds of volatility of the CSI 300 energy industry indices namely hv5, hv15, hv30 and hv50[1] for the empirical research due to the reason that the volatilities calculated according to four kinds of cycles contain a wider range of information. The longer the cycle, the more the information it contains.

This paper selects the working days from November 2, 2015 to February 24, 2016 for empirical research, excluding weekends and statutory holidays. The first trading day after the implementation of the circuit breaker mechanism, namely January 4, 2016, is defined as 0, the dates after it gradually increase in chronological order, while the previous dates gradually decrease in chronological order. The range of running variables for the whole sample is (−44, 32). As for the subsequent estimates, we change the bandwidth to observe the robustness of the results. Note that all the data in this paper are from the Wind database,[2] which is a well-knowen financial database and it can timely show all the financial data in China's financial markets. In China, more than 90% of financial enterprises use the Wind database as an information platform. In the international market, 75% of qualified foreign institutional investors (QFII) institutions approved by China securities regulatory commission use the Wind database as an information platform.

Moreover, we have conducted a further investigation of nine representative industry indices including the energy industry in CSI 300 index using the RDD method, we can find that it is appropriate for the CSI 300 energy index to be a pilot to test the effect of the improved circuit breaker mechanism in the future.

Fig. 1 depicts the four kinds of historical volatility of the CSI 300 energy index. The centered "0″ represents the implementation of the circuit breaker on January 4, 2016. It can be found that the historical volatilities have significantly increased since the circuit breaker mechanism was officially launched, especially for the hv5 and hv15. In order to know whether there is a breakpoint in the volatility of the energy industry after implementing the circuit breaker mechanism, we give an empirical analysis in the next section.

4. Empirical analysis

4.1. Empirical results

Fig. 2 shows the relationship between time and volatility before and after the circuit breaker mechanism. It depicts the fitting effect of the four kinds of historical volatility before and after the breakpoint with the shaded portion representing the 95% confidence interval. We can find that there is an obvious breakpoint on the volatility when the circuit breaker was launched. A significant upward jump appears after the breakpoint, which indicates that the circuit breaker greatly impacts the energy industry, making the short-cycle volatility sharply increase in a short period of time. However, the volatility after the circuit breaker finally shows a downward trend, especially the hv5 and hv15. It can be concluded that the circuit breaker has a significant influence on the energy industry, especially in the short term.

Based on the above analysis, we further carry out the RDD analysis and estimate the policy effects of the circuit breaker. The RDD analysis for the four kinds of historical volatility using the optimal bandwidth and triangular core are shown in Fig. 3. It can be found that:

- ➢ The four kinds of historical volatility jump upward sharply at a breakpoint $t = 0$.
- ➢ The circuit breaker greatly increases the volatility of the energy industry in a short time.

We can find that the hv5 and hv15 present a growing trend at first and then decline after the implementation, whereas for the hv30 and hv50, the rising trends last longer, then gradually decline.

Table 1 shows the parametric estimated results of Fig. 3. It can be found that near the breakpoint, the hv5 increases by 20.8%, the hv15 increases by 12.3%, the hv30 increases by 5.2% and the hv50 increases by 3.5%, which are significant at the 1% of the statistical level, suggesting that the circuit breaker increases the volatility of the energy industry. The hv5 and hv15 increase obviously, while the hv30 and hv50 change relatively small.

4.2. Robustness test

Table 2 shows the estimated results calculated by the RDD method for the four kinds of volatility based on the three given bandwidths. It is found that the results are significant. The coefficients of the RDD method using optimal bandwidths of 1, 0.5 or 2 times are positive with small changes. For instance, the coefficients of hv5 are 0.208, 0.245 and 0.212, respectively.

According to Table 2, the changes of these values are so small that can be neglected with the changes of bandwidths, suggesting that the estimated values have little dependence on the bandwidth. The above analysis further proves the robustness of the aforementioned regression results based on different bandwidths.

4.3. The comparison of estimation results between OLS method and RDD method

According to Eq. (3), we have $y_\varepsilon \sim y_{-\varepsilon} \sim y_0$ where $\varepsilon \sim 0$. Therefore, the only reason causing the jump of volatility is the processing effect of D_t. Therefore, an OLS regression is further used in Eq. (2). Table 3 shows the regressed results. As we can see from

[1] The volatility in the Wind is calculated by $\{\Sigma[(R_i - \Sigma R_i/N)^2]/(N-1)\}^{0.5}$ where R_i is the logarithmic rate of return within the interval.
[2] https://www.wind.com.cn/newsite/edb.html.

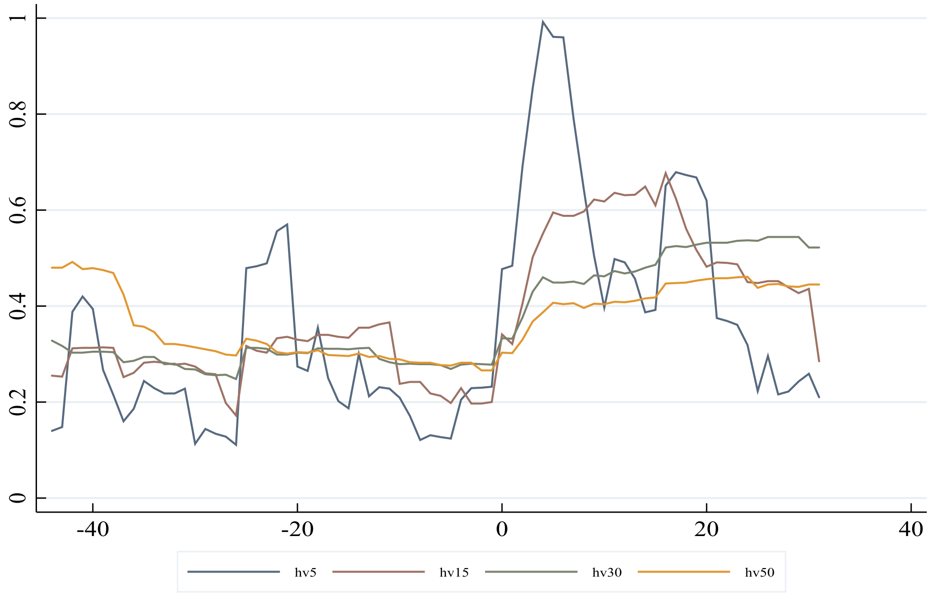

Fig. 1. The four kinds of historical volatility of the CSI 300 energy index.

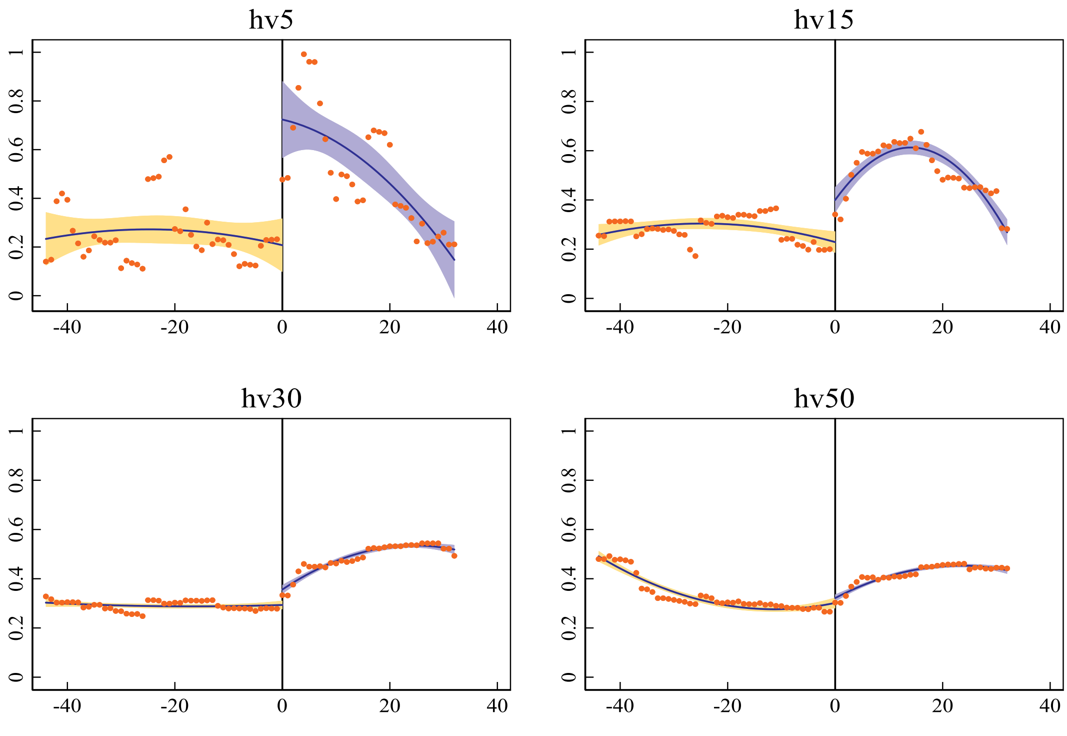

Fig. 2. Fitting results of the four kinds of historical volatility after breakpoint.

Table 3, the hv5 increases by 49.5%, the hv15 increases by 30.2%, the hv30 increases by 14.7% and the hv50 increases by 16.7%. The coefficient of the time variable is negative, indicating that the overall volatility is in a slight decreasing trend.

Besides, by comparing Tables 1 and 3, we can find that the estimation results by using the OLS method and the RDD method are different. One of the main important reasons is that the sample includes the volatility data are far from the breakpoint when the OLS method is used, making it difficult to strip off the influence of other factors on the volatility. However, the estimation process of the RDD method excludes the interference of such factors. Therefore, the RDD method is more reasonable than the OLS method in this case.

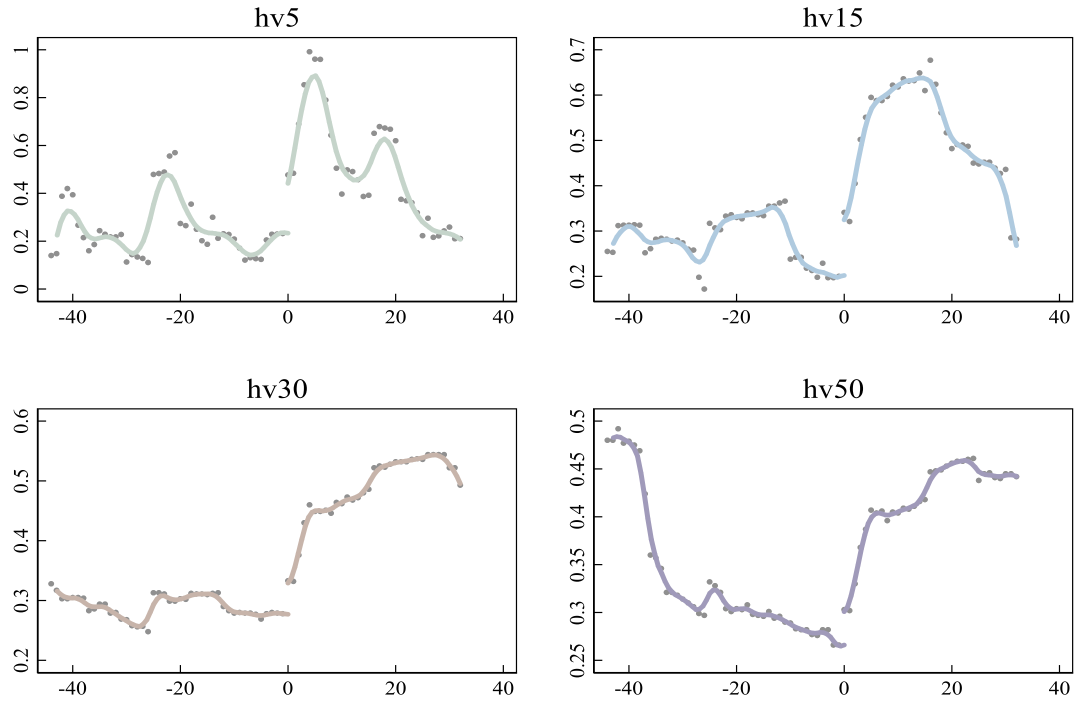

Fig. 3. The RDD fitting results of the four kinds of historical volatility.

Table 1
The RDD results of the four kinds of volatility under optimal bandwidth.

hv5		hv15	
Lwald	0.208*** (0.0560)	Lwald	0.123*** (0.0266)
hv30		hv50	
Lwald	0.052*** (0.0092)	Lwald	0.035*** (0.0055)

(***Notes:*** *Lwald denotes the optimal bandwidth, standard errors are in the brackets,* ***$p < 0.01$, **$p < 0.05$*and* *$p < 0.1$.).

Table 2
The RDD results of the four kinds of historical volatility under different bandwidths.

	hv5	hv15	hv30	hv50
Lwald	0.208*** (0.056)	0.123*** (0.027)	0.052*** (0.010)	0.035*** (0.006)
Lwald50	0.245*** (/)	0.141*** (/)	0.055*** (/)	0.000*** (/)
Lwald200	0.212*** (0.046)	0.118*** (0.030)	0.042*** (0.014)	0.036*** (0.011)

(***Notes:*** *Lwald represents the optimal bandwidth, lwald50 represents half of the optimal bandwidth, and lwald200 represents twice the optimal bandwidth, standard errors are in the brackets.* ***$p < 0.01$, **$p < 0.05$*and* *$p < 0.1$.).

5. Conclusions

By utilizing the RDD method, this paper has investigated the effectiveness of the circuit breaker mechanism on the CSI 300 energy index based on the historical volatility of the CSI 300 industry index from November 2, 2015 to February 24, 2016. Some conclusions are derived and summarized as follows: (1) The launch of the circuit breaker has led to a significant breakpoint on the index volatility of the energy industry, and the volatility shows a sharp upward jump. (2) After the establishment of the circuit breaker, the index volatility of the energy industry increases, and the effect is strong. Additionally, this impact even maintained for a period after the suspension of the mechanism. (3) It should be pointed out that we have carried out a further investigation of nine representative

Table 3
The OLS regression results of the four kinds of historical volatility.

Variable	hv5	Variable	hv15
Constant	0.107** (0.044)	constant	0.239*** (0.021)
t	−0.006*** (0.001)	t	−0.002** (0.000)
D_t	0.495*** (0.073)	D_t	0.302*** (0.036)
Variable	hv30	Variable	hv50
Constant	0.319*** (0.010)	constant	0.286*** (0.015)
t	−0.001*** (0.000)	t	−0.002*** (0.000)
D_t	0.147*** (0.017)	D_t	0.167*** (0.024)

(***Notes:*** *Standard Errors are in the brackets.* ***$p < 0.01$, **$p < 0.05$*and* *$p < 0.1$.).

industry indices including the energy industry in the CSI 300 index using the RDD method. The energy industry presents a medium to low performance, indicating that the energy industry is appropriate to be selected as a pilot to test the effect of the improved circuit breaker mechanism in the future because this industry usually presents a relatively lower sensibility than other ones. Therefore, the same response leads the energy industry become a good pilot to examine the improved circuit breaker mechanism in the future. In summary, the circuit breaker mechanism does not work in the CSI 300 energy index. This response to the circuit breaker is similar to that in the CSI 300 index. Therefore, the implementation of the circuit breaker mechanism will increase the fluctuation of CSI 300 index and the energy industry index. It could be feasible to take the CSI 300 energy index as a pilot to examine the improved circuit breaker mechanism in the future, rather than directly implementing it on the whole CSI 300, which can avoid huge losses.

It is pointed out that there are still some limitations to this study. The sensitivity of the policy cannot be analyzed to provide suggestions that further improve the mechanism. In addition, because of the sudden abolishment of the mechanism, this paper only considers the RDD method rather than other methods such as the instrumental variable method and difference-in-difference method. Compared with other methods, RDD is closer to randomized trials and thus better to identify causal relationships. Therefore, we only choose a small amount of volatility data near the breakpoint, it is difficult to deduce whether the circuit breaker mechanism is sustained effective in Chinese market in the long term.

Acknowledgments

This work was supported by the Natural Science Foundation of China [Nos. 71561026 and 71840001].

References

Ackert, L.F., Church, B.K., Ely, K., 2008. Biases in individual forecasts: experimental evidence. J. Behav. Financ. 9 (2), 53–61.
Apergis, N., 2016. The role of circuit breakers in the oil futures market. J. Econ. Financ. 4 (10), 1–16.
Booth, G.G., Broussard, J.P., 1998. Setting NYSE circuit breaker triggers. J. Financ. Serv. Res. 13 (3), 187–204.
Broadstock, D.C., Zhang, D.Y., 2019. Social-media and intraday stock returns: the pricing power of sentiment. Financ. Res. Lett. 30, 116–123.
Fang, X.M., Zhao, Z.J., 2018. Does there exist magnetic effect in the circuit breaker mechanism? Evidence from China's stock market. J. Cent. Univ. Financ. Econ. (6), 22–36.
Goldstein, M.A., 2015. Circuit breakers, trading collars, and volatility transmission across markets: evidence from NYSE rule 80A. Financ. Rev. 50 (3), 459–479.
Ji, Q., Li, J.P., Sun, X.L., 2019. Measuring the interdependence between investor sentiment and crude oil returns: new evidence from the CFTC's disaggregated reports. Financ. Res. Lett. 30, 420–425.
Ji, Q., Liu, B.Y., Zhao, W.L., Fan, Y., 2018. Modelling dynamic dependence and risk spillover between all oil price shocks and stock market returns in the Brics. Int. Rev. Financ. Anal. https://doi.org/10.1016/j.irfa.2018.08.002.
Lee, D.S., Lemieux, T., 2010. Regression discontinuity designs in economics. J. Econ. Lit. 48 (2), 281–355.
Ma, Y.R., Zhang, D.Y., Ji, Q., Pan, J.F., 2019. Spillovers between oil and stock returns in the US energy sector: does idiosyncratic information matter. Energy Econ. 81, 536–544.
Subrahmanyam, A., 1994. Circuit breakers and market volatility: a theoretical perspective. J. Financ. 49 (1), 237–254.
Thistlethwaite, D.L., Campbell, D.T., 1960. Regression-discontinuity analysis: an alternative to the ex post facto experiment. J. Educ. Psychol. 51 (6), 309–317.
Wu, T., Wang, Y., Li, M.X., 2017. Post-hit dynamics of price limit hits in the Chinese stock markets. Physica A 465, 464–471.
Xia, T.S., Ji, Q., Zhang, D.Y., Han, J.H., 2019. Asymmetric and extreme influence of energy price changes on renewable energy stock performance. J. Clean. Prod. 241, 118338.
Zhang, D.Y., Broadstock, D.C., 2018. Global financial crisis and rising connectedness in the international commodity markets. Int. Rev. Financ. Anal. 08, 003. https://doi.org/10.1016/j.irfa.2018.