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Article

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Short-sale refinancing and price adjustment speed to bad news: Evidence from a quasi-natural experiment in China

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ABSTRACT

Short selling may accelerate stock price adjustment to negative news. However, the literature provides mixed evidence for this prediction. Using short-sale refinancing and a staggered difference-in-differences (DID) model, this paper explores the effect of short selling on stock price adjustment. Our results show that (1) short-sale refinancing improves the speed of stock price adjustment to negative news. This result holds after we control for endogeneity. (2) The positive relationship between short-sale refinancing and stock price adjustment speed is significant in subsamples of stocks with higher earnings management or lower accuracy of analyst forecasts, indicating that firms with more opaque information are more likely to be targeted by short sellers. In subsamples of stocks with a higher ownership concentration or lower ownership by institutional investors, short selling is more likely to increase the speed of stock price adjustment, indicating that ownership structure may influence negative news mining. (3) As short-sale refinancing exacerbates the absorption of bad news by stock prices, it increases crash risk. This study enriches the research on the economic consequences of short selling and provides empirical evidence supporting regulations on short selling in China.

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1. Introduction

Capital markets use efficient pricing of assets to achieve an optimal allocation of resources. In an effective capital market, the stock price guides the flow of resources to the most promising projects, and managers use

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the stock price to make decisions (Durnev et al., 2004). However, these rules rely on efficient asset pricing. As an important financial innovation product, short selling may improve price discovery in a capital market by facilitating the absorption of negative news into stock prices (Miller, 1977). Short selling has existed in countries with developed capital markets for a long time. The Chinese capital market has a rather short history. Its regulations and rationality of its investors need improvement, and its conditions for short selling are immature. However, after more than 20 years of development, the Chinese capital market has developed considerably. On March 31, 2010, China officially piloted a short-sale trading mechanism, hoping that it would help stock prices better integrate investor information and better reflect intrinsic value.

Previous studies have examined the effect of short selling on the efficiency of stock pricing. Most studies using global data indicate that short selling promotes stock price absorption of negative information and improves market efficiency (Diamond and Verrecchia, 1987; Hong and Stein, 2003; Bris et al., 2007; Boehmer and Wu, 2013). Bris et al. (2007) suggest that removing short-sale restrictions makes stock prices more sensitive to negative news. Although Bris et al. (2007) control for country-specific characteristics using cross-listing and event studies, the selection of cross-listing and policy implementation is not random. The approach in Bris et al. (2007) does not completely resolve the endogeneity problem by only comparing before and after a shock. It is noteworthy that the conclusion in Bris et al. (2007) is based on evidence from a specific country and therefore may not be applicable to other countries with different institutional environments.

China has the largest emerging capital market. Previous studies on whether short selling affects pricing efficiency have shown mixed results. Chang et al. (2014), Xiao and Kong (2014), and Li et al. (2015) find that short selling can improve market efficiency. Xu and Chen (2012) provide evidence that short selling does not improve the speed of price adjustment to negative news using one-year data. However, Tang et al. (2016) extend the sample from 2007 to 2012 and suggest that short selling does indeed improve the speed of stock price adjustment to negative news by investigating the relationship between margin trading and short selling.

We propose that opposite conclusions with the same institutional background may be related to the measures of efficiency and samples used. First, previous studies are mainly based on the information content and volatility or liquidity of stock prices (Chang et al., 2014; Xiao and Kong, 2014; Li et al., 2015). However, short selling in China is different from that in other countries (Gao and Lin, 2018). The China Securities Regulatory Commission permits both short selling and margin trading of only 950 pilot firms. Short selling delivers negative information, whereas margin trading delivers positive information. Therefore, the effect of short selling may be compounded by that of margin trading. Second, regulators often take liquidity, volatility, turnover and other indicators as criteria¹ for choosing pilot firms for short selling and margin trading. As a result, pilot firms may be different from control firms (Su and Ni, 2018). Third, due to the lack of shortable securities, short selling in China is rare. Therefore, it is reasonable to draw the conclusion that short selling does not facilitate more efficient price discovery in this specific capital market.

In February 2013, a pilot program called refinancing was officially launched in China. In the refinancing project, China Securities Finance Corporation Limited (CSFC) borrows stocks from listed companies' shareholders and other lenders and makes them available to securities companies, which make them available to investors for short selling. The introduction of this trading mechanism has facilitated short selling by expanding the number of stocks that securities companies can lend to their clients. Fig. 1 shows the time trend of short-sale refinancing volume as well as short selling from 2010 to 2019. As can be seen in Fig. 1, after short-sale refinancing was officially allowed in 2013, the volume of short selling increased exponentially. This

¹ The standard for a short selling target is defined in the “detailed rules for implementation,” sorted from large to small according to weighted evaluation value, and comprehensively considers the conditions of the individual stock and market including the following factors. (1) The stock has been on the exchange for over 3 months. (2) The firm has no less than 100 million shares or no less than 500 million yuan of market value for stocks purchased through margin trading, and no less than 200 million shares or no less than 800 million yuan of market value for stocks sold through short selling. (3) The number of shareholders shall not be less than 4,000. (4) None of the following situations have occurred in the past three months: (i) the average daily turnover was less than 15% of the average daily turnover of the benchmark index, and the average daily turnover amount was less than RMB50 million; (ii) the deviation value between the average daily change and the average daily change of the benchmark index was more than 4%; or (iii) the fluctuation range was more than 5 times that of the benchmark index. (5) Stock issuing companies have completed the reform of non-tradable shares. (6) Stock transactions are not subject to special treatment by the exchange. (7) Other conditions as prescribed in the “detailed rules for implementation.”

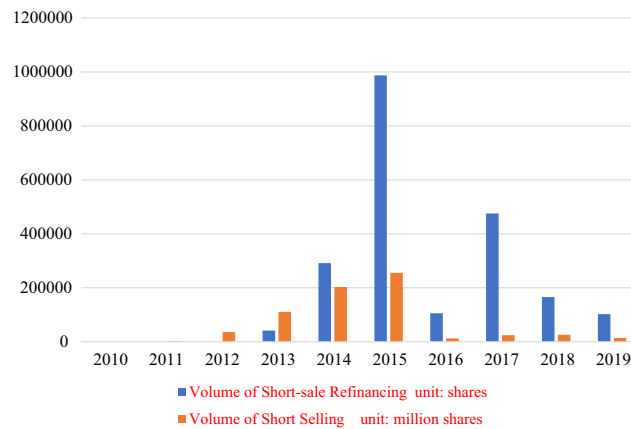


Fig. 1. Time trend of short-sale refinancing and short selling volume.

indicates that the launch of the short-sale refinancing program indeed boosted the growth of short selling. During the early period after the launch of the program, securities companies only selected some shortable securities as pilot securities, so the pilot shortable securities and other shortable securities are the treatment group and control group, respectively. As a result, the differences between the treatment and control groups in liquidity, volatility and turnover are small. Accordingly, this allows us to examine the real economic consequences of short selling. Additionally, after refinancing transactions started on August 27, 2012, margin trading has been allowed for both the control and treatment groups. However, only the treatment group is available for short-sale refinancing from February 28, 2013. Therefore, our sample, to a certain extent, may remove the confounding effect of margin trading.

Using a staggered difference-in-differences (DID) model and short-sale refinancing in China, this paper explores whether short selling affects the speed of stock price adjustment to negative information. The results show that short-sale refinancing improves price adjustment to negative news. The result holds after controlling for endogeneity, indicating that short selling improves the speed of price adjustment to negative information. We also find that the positive relationship between short-sale refinancing and the speed of price adjustment to negative information is significant in a subsample of stocks with higher earnings management or lower accuracy of analyst forecasts, indicating that firms with more opaque information are more likely to be followed by short sellers. In firms with higher ownership concentrations or lower percentages of institutional investors, short selling is more likely to increase the speed of price adjustment to negative information, indicating that ownership structure may influence negative news mining of short selling. In the end, we find that as short-sale refinancing exacerbates the absorption of bad news into stock prices, stock price crash risk increases. Investor structure may explain this result. Short selling in China has only been permitted and practiced recently; in addition, most investors are individuals and institutional investors, which exhibit herd behavior (Xu et al., 2013). These factors may cause excessive short selling due to overconfidence in private information or due to an excessively pessimistic mood. Such short selling behavior can cause negative emotions in the market to increase (Scheinkman and Xiong, 2003), trigger share prices falling and increase stock price crash risk.

Our paper contributes to the literature in several ways. First, using an exogenous event, we find that short selling in the Chinese capital market improves the speed of price adjustment to negative news. Although Bris et al. (2007) use national level data and suggest that relaxing the restriction on short selling makes the pilot firms' stock prices more sensitive to negative news; however, results based on data from one country may not be applicable to countries with different institutional environments. In addition, prior research on this topic in the Chinese context has not reached a consistent conclusion (Chang et al., 2014; Xu and Chen, 2012; Tang et al., 2016).

Second, we discover the influence of the information environment and ownership structure on the economic consequences of short selling, which enriches the literature on short sellers' bad news mining based on the characteristics of listed companies.

Third, we find that short selling in China increases stock price crash risk. Whereas this conclusion is consistent with Callen and Fang's (2015) study on US-listed companies, it is inconsistent with another study using a Chinese sample (Chu and Fang, 2016). Using short selling volume in China, Chu and Fang (2016) find that although margin trading increases stock price crash risk, short selling reduces stock price crash risk to some extent. We propose that short sellers choose companies with more accumulated negative news to short sell, so the findings based on short selling volumes may have endogeneity issues. This paper solves this problem by using whether a firm is subject to short-sale refinancing to study the effect of short selling on stock price crash risk.

Fourth, our conclusions have implications for regulators. Short selling in China helps accelerate price adjustment to negative news, but it can also increase stock price crash risk due to share price stimulation. China's policymakers should be careful in regulating short selling activities, make rigid market operational rules, make full and effective use of short selling's advantages and avoid excessive volatility caused by short selling.

The remainder of this paper is organized as follows. In Section 2, we review the literature and give research hypotheses. Section 3 reports the data sources, model interpretation, variable analysis and summary statistics of the sample. Section 4 reports and discusses the empirical results and handling of the endogeneity problem. In Section 5, we further analyze the effect of information transparency and ownership structure on the short selling effect and explore the economic consequences of short-sale refinancing on crash risk. Section 6 presents the conclusion.

2. Institutional background, literature review and hypotheses

Margin trading and short selling refer to brokers lending money to investors to buy securities or lending securities to investors to sell in anticipation of a price drop, respectively; the borrowers must deposit collateral. On March 31, 2010, a pilot program to allow margin trading and short selling was officially launched in China, allowing investors to borrow funds and securities from brokers for margin trading and short selling and ending the "unilateral market" in which short selling had been prohibited for more than 20 years. The short selling mechanism has become an important reform of the Chinese stock market; it has attracted extensive attention and brought new opportunities for investors' trading methods. The development of short selling in China is different from that in a mature capital market. The pilot has been expanded, step by step, from 90 firms available for short selling at the beginning to 950 firms on December 12, 2016. Although short selling may bring significant stock price discovery and market efficiency, its scale was restricted in the early stages due to insufficient security sources, limited capital and a high entry threshold. In addition, due to high transaction costs, transaction time and place constraints and other short selling constraints, margin trading has the dominant market role. Basically, the uneven scale of the two types of trading means that they have an asymmetric effect on market efficiency, so there is still room for development of the short selling mechanism.

To improve the margin trading and short selling mechanisms and broaden the sources of funds and securities available for margin trading and short selling, CSFC implemented a refinancing mechanism on August 27, 2012, allowing securities trading through refinancing. On February 28, 2013, CSFC officially implemented short-sale refinancing. Short-sale refinancing means that a securities finance company lends its securities to another securities company for that company's securities lending business. Fig. 2 shows the time trend of the number of pilot securities and the transaction volume of short-sale refinancing. As of December 12, 2016, when the number of pilot securities expanded to 950, equal to the number available for margin trading, the volume of short-sale refinancing achieved rapid growth. The large increase in short-sale refinancing after 2014 was due to the state council publishing "Opinions of the State Council on Further Promoting the Sound Development of Capital Markets" in May 2014. Securities lending and short selling have achieved leapfrog development through the perfecting of the capital market system and optimized short selling mechanism. Short-sale refinancing is conducive to improving securities market efficiency, meeting investor requirements for diversified investments and risk management, establishing and strengthening the investment concept of the securities market and improving securities companies' ability to manage income, innovation and risk. The gradual expansion of the number of pilot firms not only shortens the gap between the treatment and control groups in this study but also avoids the possibility of margin trading affecting the results and thus provides an ideal natural experiment to explore the economic consequences of short selling.

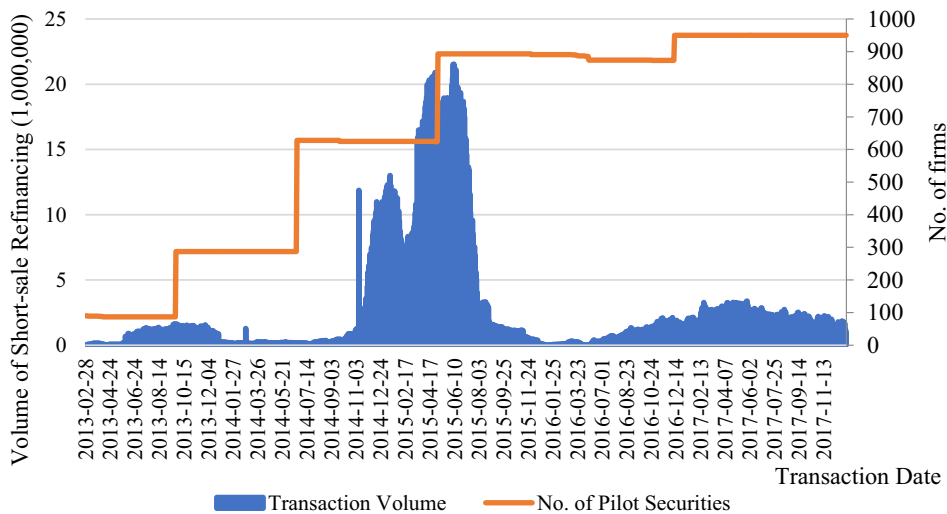


Fig. 2. Time trend for short-sale refinancing transaction volume and number of firms.

The short-sale refinancing program has important practical significance. First, the pilot program increased short selling by Chinese investors and provided them with more profit opportunities, which is conducive to investors implementing diversified investment strategies through refinancing to disperse risk. Second, the pilot program changed investment behavior and reduced risk in the Chinese securities market. When short selling is restricted due to capital market immaturity and various system shortcomings, insider trading and stock manipulation lead to continuous stock price increases. When that happens, a large number of investors often follow the trend to seek excess profits. However, the introduction of short-sale refinancing has focused short sellers' attention on overvalued stocks and optimized investment behavior in the market. Finally, the refinancing pilot has promoted the return of securities to their intrinsic value and reduced the price bubble in the market. Stocks with high share prices are more likely to attract short sellers for securities lending. Short sellers deliver relevant information to the stock market by shorting securities, thus inhibiting the price bubble and causing stock prices to return to their fundamental value, which has also been explained by prior research (Su and Ni, 2018). In practice, “black swan” events, such as Shuanghui clenbuterol and Yili melamine, have a significant effect on stock price. Black swan events may increase short-sale refinancing, which will enhance the price discovery function of the stock market. Fig. 3 shows the trend of short-sale refinancing trading in Hebei Iron and Steel from 2014 to 2017. After 2014, there was excess capacity and negative growth at Hebei. A large number of employees were laid off, and bribery occurred in 2017. This black swan event had a significant negative effect on Hebei, leading to a sharp increase in its short selling trading volume in 2015 and 2017. This example shows that a black swan event can indeed increase short selling trading volume.

Previous studies on short selling have focused on the effect of short selling on stock pricing efficiency but have not reached a consistent conclusion. Miller (1977) was the first to propose that under short selling restrictions, stock prices only reflect the attitude of optimistic investors and are overvalued because pessimistic investors cannot short sell the stock. Diamond and Verrecchia (1987) suggest that short selling restrictions reduce the efficiency of stock pricing, especially when bad news cannot be reflected timely in stock prices. However, Diamond and Verrecchia (1987) also point out that investors adjust stock price expectations in consideration of short selling restrictions, so the restrictions do not result in overvalued stock prices. This view was supported by Xu and Chen (2012) using margin trading and short selling data in China. They found that the price of target firms makes no difference to the content of negative private information or to the speed of adjustment to market downswings. The influence on pricing efficiency is still limited mainly because the mechanism is limited by factors during the pilot that led to low trading volume. After the implementation of short selling, research on short selling gradually increased. Previous studies have used empirical data to prove that short selling restrictions lead to the overvaluation of stock prices (Chang et al., 2007; Figlewski, 1981) and verified

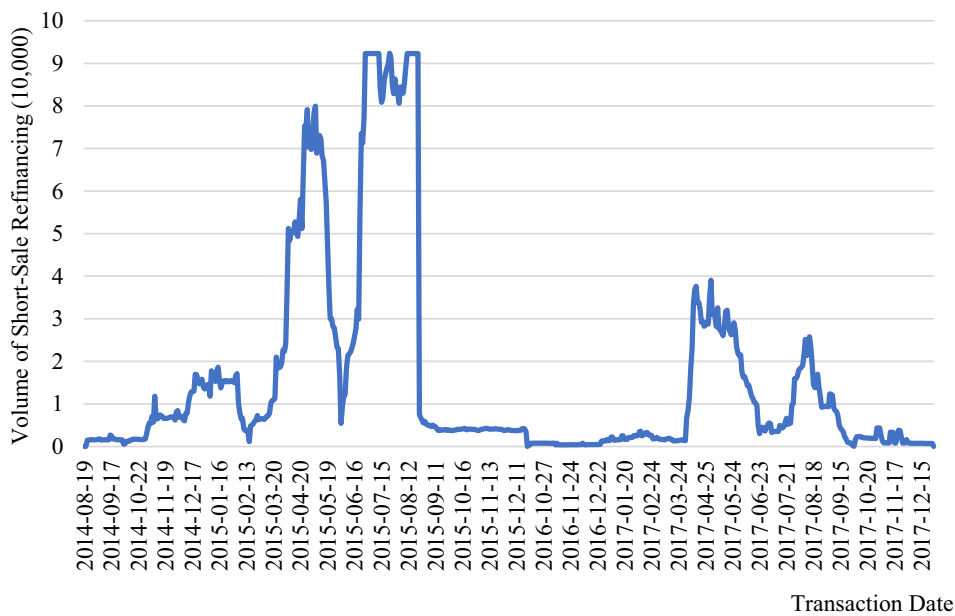


Fig. 3. Time trend of short-sale refinancing volume for Hebei iron and steel.

the hypothesis of stock price overvaluation proposed by Miller (1977). Aitken et al. (1998), using the event research method, suggest that stock prices would fall after short sales in the Australian market. Diether et al. (2009) also found that stock returns decrease after short sales. Desai et al. (2002) confirm the decline of stock prices after short sales using NASDAQ data from 1988 to 1994 and propose that the more short selling transactions, the lower the stock's return. Chang et al. (2014) find that when listed companies became pilot firms, their stock return became negative, indicating that short selling restrictions led to the overvaluation of stock. The Chinese capital market is not yet mature, and the introduction of the short selling mechanism was late, so relevant research has only recently developed. Gu and Hao (2011) find that short selling constraints lead to pricing deviation using a stochastic valuation model and panel data. Li et al. (2014) find that compared with stocks available to short, stocks restricted from short sales showed higher yields after the shock. Li et al. (2015) propose that margin trading could improve pricing efficiency by improving stock liquidity, reducing information asymmetry and increasing shareholding width. Some research proposes that short selling may reduce stock price volatility (Hong and Stein, 2003; Xiao and Kong, 2014). Chu and Fang (2016) propose that short selling improves pricing efficiency but that the possibility of reducing volatility is small while the underlying stock has little risk of crashing. Su and Ni (2018) study the relationship between short selling constraints and stock price changes from the perspective of short-sale refinancing and find that a reduction in short selling constraints can not only reduce market asymmetry and volatility but also reduce market stability and aggravate market slump.

Some papers distinguish positive news from negative news by focusing on short selling and stock pricing efficiency and study the adjustment speed of stock price to different kinds of news. Diamond and Verrecchia (1987) theoretically propose that short-selling constraints prevent negative news from being reflected in the stock price in a timely manner, thus reducing the rate of information absorption by the stock price. Bris et al. (2007) use global data to compute cross-autocorrelations between lagged one-week market returns and individual stock returns and confirm that relaxing short-selling constraints is conducive to improving the speed of adjustment to bad news. However, conclusions drawn at a national level may not apply in a different institutional environment. Saffi and Sigurdsson (2011) use the correlation coefficient of market returns on lagged stock returns, the delay of stock price reaction to market information, and the distribution of stock returns as measures of stock pricing efficiency. They show that short selling can accelerate the

speed of stock price adjustment to information, but they do not distinguish between good and bad news, which would affect short selling differently. However, [Xu and Chen \(2012\)](#) use one-year data to put forward that short sales do not improve the speed of stock price adjustment to negative news, which can be explained by the short sample period. Additionally, in 2011, when short selling was in its initial period, it could not play its significant role in such a short period. The positive relationship between short selling and speed of stock price adjustment to negative news could not be obtained due to the restrictions on underlying stock type and quantity, transaction costs and barriers to entry. [Tang et al. \(2016\)](#) use an enlarged sample range, 2007–2012, and find that short selling can indeed improve the speed of stock price adjustment to negative news. Despite using a PSM + DID method for a robustness test, the particularities of securities and the influence of margin trading could not be removed, so endogeneity problems remain. Therefore, it is necessary to consider endogeneity and explore the effect of short selling on the speed of stock price adjustment to negative news.

Short selling can affect the speed at which stock prices adjust to negative news. In short selling trading, investors who hold negative news expect a stock price to fall in the future, so they pay a margin to a broker to borrow the stock and sell it. When the stock price falls, the investor buys the stock and repays it to the broker they borrowed it from, earning money from the stock price falling. Short selling restrictions result in pessimistic investors who cannot short sell leaving the stock market ([Miller, 1977](#)); therefore, negative news is not reflected timely in stock prices. [Fama \(1965\)](#) proposed that in an efficient market, stock prices reflect historical and current information about a company's value, good or bad, and stock prices adjust according to market information timely and comprehensively. When short selling is restricted, short sellers cannot react to negative information through trading, resulting in asymmetric price adjustments to positive and negative information and delayed price adjustments to negative news. The ban on short selling also reduces the efficiency of information transmission and expression in the market ([Diamond and Verrecchia, 1987](#)), leading to a decrease in the propagation speed of bad news, whereas the introduction of short selling accelerates the speed of adjustment to negative information through trading. Thus, allowing short selling accelerates investors' search for negative news and the rate at which stock prices absorb it.

Based on that, we propose the following hypothesis:

Short selling accelerates the speed of stock price adjustment to negative news.

3. Research design

3.1. Sample construction and data sources

We choose the pilot firms for short selling from 2010 to 2017 as the sample. The research data mainly come from the CSMAR database. [Table 1](#) provides the annual adjustments in margin and short selling pilot firms and the expansion and adjustments for short-sale refinancing. On December 5, 2011; January 31, 2013; September 16, 2013; September 22, 2014; and December 12, 2016, the firms available for margin and short selling securities were expanded, ultimately reaching 950. On February 28, 2013; September 16, 2013; June 20, 2014; April 30, 2015; and December 12, 2016, the number of short-sale refinancing pilot firms increased, starting at 287 and ending at 950.

Table 1
Timetable of adjustments to short selling and short-sale refinancing firms.

Year	Short selling in	Short selling out	Total short selling	Refinancing in	Refinancing out	Total refinancing
2010	96	6	90	0	0	0
2011	190	2	278	0	0	0
2012	0	0	278	0	0	0
2013	482	60	700	299	12	287
2014	218	19	899	356	18	625
2015	0	8	891	269	3	891
2016	77	18	950	77	18	950

3.2. Model and variables

We use the method in [Bris et al. \(2007\)](#) to measure the speed of stock price adjustment to negative news:

$$\rho diff_i = \rho 0_i - \rho 1_i, \quad (1)$$

in which $\rho 0_i$ and $\rho 1_i$ are the cross-autocorrelations between market weekly returns lagged one week and individual stock weekly returns, respectively, when the market return falls or rises, reflecting different price delays when the market moves in different directions, namely the speed of stock price adjustment to negative news. [Bris et al. \(2007\)](#) point out that downside cross-autocorrelation ($\rho 0_i$) is high when there is a short-selling restriction, as stock prices cannot quickly respond to the market's downward fluctuation. In contrast, upside cross-autocorrelation ($\rho 1_i$) is low if stock prices can adjust quickly to good news when the market fluctuates upward. When short selling is allowed and market friction is removed, the asymmetric restriction between margin trading and short selling disappears, resulting in a significant drop in $\rho diff_i$. Thus, the difference in cross-autocorrelation $\rho diff_i$ can be used to measure the speed of stock price adjustment to positive and negative news.

From the short selling firms used as the sample, the short-sale refinancing firms are the treatment group and the rest are the control group. After a treatment firm can be traded through short-sale refinancing, *Shock* is 1; otherwise *Shock* is 0. We exclude the following from the sample: (1) financial companies; (2) companies with negative equity; (3) companies with annual stock trading days under six months; and (4) companies with missing variables.

[Xu and Chen \(2012\)](#) suggest that the P/E ratio is related to stock pricing efficiency from the perspective of a pricing bubble. With reference to [Tang et al. \(2016\)](#), company size (natural logarithm of total assets at the end of the year) and market-to-book value are significantly correlated with the speed of stock price adjustment to news and are selected as control variables. [Hou and Moskowitz \(2005\)](#) decompose the factors related to price delay into traditional liquidity indicators (trading days, etc.) and investor recognition or attention (number of shareholders, etc.) and believe that investor attention may explain stock price delays better than traditional liquidity indicators. In addition, we refer to [Hou and Moskowitz \(2005\)](#) to select our control variables, such as the number of employees, market beta coefficient, financial leverage and other variables related to the speed of stock price adjustment to news. [Li and Zhang \(2015\)](#) believe that earnings forecasts issued by firms not subject to the short selling restriction were more ambiguous and that the market reaction to their profit forecasts was greater, so the quality of information disclosure may affect the speed of stock price adjustment to news. On that basis, we refer to [Li and Xiao \(2015\)](#) and, based on a listed company's earnings forecast, divide its content into four types of information to use as good news: continuing profitability, profitability in advance, slight profitability and return to profitability. We count the number of good news items disclosed in quarterly earnings forecasts each year and name this variable *News*, which we use to control management earnings forecast information for the effects of price discovery. In addition, we use earnings management to control for information transparency and shareholding ratio of the largest shareholder and proportion of independent directors to control for the influence of ownership structure and governance level.

To measure the influence of short selling on the speed of stock price adjustment to news, we use firm fixed and year fixed effects models to control for company and time variants in the DID analysis ([Bertrand and Mullainathan, 2003](#)). [Armstrong et al. \(2012\)](#) use this model when studying corporate governance and information environments. Specific to the field of short selling, [Jin et al. \(2015\)](#) also use this method in their research on short selling and investment efficiency.

The basic model is as follows:

$$\rho diff_{i,t} = \alpha_i + \alpha_t + \alpha_1 Shock_{i,t} + Control_{i,t} + \varepsilon_{i,t} \quad (2)$$

in which $\rho diff_{i,t}$ is the price adjustment speed for stock i in period t , α_i is the firm fixed effect, α_t is the year fixed effect. The short-sale refinancing variable (*Shock*) measures whether a stock is allowed to be traded in short-sale refinancing. When a stock is allowed to be traded in short-sale refinancing, *Shock* is 1; before a security is allowed to be traded in short-sale refinancing and for all other control firms, *Shock* is 0. α_1 measures the speed of stock price adjustment to negative news. When the coefficient of α_1 is significantly negative, it indicates that short selling accelerates the speed of stock price adjustment to negative news. Otherwise, the opposite is true.

Table 2
Variable definitions.

Variable type	Variable definition	
Dependent variables	$\rho diff$	$\rho 0 - \rho 1$, the difference between the speed of stock price adjustment to good or bad news
	$\rho 0$	The downside cross-autocorrelation between market weekly returns lagged one week and individual stock weekly returns, representing the speed of stock price adjustment to good news
	$\rho 1$	The upside cross-autocorrelation between market weekly returns lagged one week and individual stock weekly returns, representing the speed of stock price adjustment to bad news
Independent variable	<i>Shock</i>	For treatment group firms that are allowed to be traded in short-sale refinancing, <i>Shock</i> is 1, otherwise 0.
Control variables	<i>Size</i>	Company size, natural logarithm of total assets at the end of the year
	<i>Leverage</i>	Financial leverage, the ratio of total liabilities to total assets
	<i>Sholders</i>	The natural logarithm of the number of shareholders of a company
	<i>Employees</i>	The natural logarithm of the number of employees of a company
	<i>MB</i>	Market-to-book value
	<i>Trading days</i>	The natural logarithm of the number of trading days of an individual stock
	<i>BETA</i>	Market beta coefficient, regression coefficient between stock current return and market current return
	<i>PE</i>	P/E ratio divided by 100
	<i>News</i>	Earnings forecast news, a measure of the amount of good news a company discloses during the year
	<i>EarningMgt</i>	The absolute level of earnings management, measuring the transparency of corporate information ¹
	<i>First</i>	The largest shareholder shareholding ratio
	<i>Independence</i>	Ratio of independent directors

¹ Refer to the measure of earnings management mentioned in Kothari et al. (2005).

Table 2 provides the variable definitions. Finally, to avoid the possible influence of outliers, the continuous variables are winsorized at 1%.

3.3. Descriptive statistics

Table 3 reports the descriptive statistics of the variables. It shows that the mean value of *Shock* is 0.735, indicating that 73.5% of all firms in the sample are allowed to be traded in short-sale refinancing. The quartile of $\rho diff$ is -0.063 , its maximum value is 0.590 , and its mean value is 0.255 , indicating the price delay in market adjustment to good news. The results are consistent with those of Xu and Chen (2012).

The mean value of *Size* is 23.273 , and its standard deviation is 1.327 . The mean value of financial leverage is 0.488 , which is consistent with the data in relevant literature (Chen and Ma, 2017). The quartile coefficient of market beta is 0.753 , the third quartile is 1.339 , and the mean value is 1.040 , which is consistent with Hou and

Table 3
Descriptive statistics.

Variables	Mean	Standard deviation	25th	Median	75th
$\rho diff$	0.255	0.561	-0.063	0.257	0.590
<i>Shock</i>	0.735	0.442	0.000	1.000	1.000
<i>Size</i>	23.273	1.327	22.289	23.118	24.063
<i>Leverage</i>	0.488	0.200	0.338	0.495	0.645
<i>Sholders</i>	11.090	0.891	10.474	11.026	11.644
<i>Employees</i>	8.534	1.370	7.610	8.510	9.384
<i>MB</i>	3.291	2.552	1.590	2.531	4.143
<i>Trading days</i>	5.439	0.126	5.460	5.485	5.497
<i>BETA</i>	1.040	0.421	0.753	1.067	1.339
<i>PE</i>	72.160	161.147	0.153	0.288	0.610
<i>News</i>	1.244	1.625	0.000	0.000	3.000
<i>EarningMgt</i>	0.060	0.063	0.019	0.041	0.076
<i>First</i>	0.371	0.163	0.239	0.357	0.499
<i>Independence</i>	0.377	0.058	0.333	0.364	0.429

Moskowitz (2005). The mean value and standard deviation of earnings management level are 0.060 and 0.063, respectively, and are consistent with those reported by Xin et al. (2014).

4. Empirical analysis

4.1. Short-sale refinancing and the speed of price adjustment to news

Table 4 reports the regression results of DID analysis on the sample. Column (1) reports the influence of short-sale refinancing on *Short* (the proportion of short selling, securities that are sold divided by the number of trading shares), the coefficient of *Shock* is positive and significant at the 1% level and shows that short-sale refinancing is significantly and positively related to short selling. This result indicates that short-sale refinancing promotes short selling.

Column (2) reports the effect of short-sale refinancing on price adjustment speed. The result shows that the coefficient of *Shock* is negative and significant at the 5% level, indicating that short-sale refinancing accelerates the speed of price adjustment to negative news. Hypothesis 1 is proven. From the perspective of the control variables, the larger the company, the smaller the financial leverage, the larger the market-to-book ratio, and the more trading days, the slower the speed of price adjustment to negative news.

The in and out of firms in the short-sale refinancing program during the sample period may affect the regression results. To ensure robustness of the results, a robustness test is carried out and the results are reported in columns (3) and (4) of Table 4. In column (3), the portion of the treatment group that have changed status within 6 months are moved to the control group. In column (4), the portion of the treatment group

Table 4
Analysis of short-sale refinancing and speed of price adjustment to news.

Variables	(1) <i>Short</i>	(2) <i>pdiff</i>	(3) <i>pdiff</i>	(4) <i>pdiff</i>
<i>Shock</i>	0.007*** (19.77)	−0.073** (−2.12)	−0.156*** (−4.13)	−0.228*** (−4.79)
<i>Size</i>		0.102** (2.32)	0.110** (2.49)	0.094** (2.00)
<i>Leverage</i>		−0.330** (−2.37)	−0.343** (−2.47)	−0.296** (−2.01)
<i>Sholders</i>		−0.098*** (−3.59)	−0.094*** (−3.42)	−0.067** (−2.27)
<i>Employees</i>		−0.005 (−0.16)	−0.005 (−0.17)	−0.011 (−0.35)
<i>MB</i>		0.032*** (4.31)	0.033*** (4.40)	0.034*** (4.40)
<i>Trading days</i>		0.212*** (2.68)	0.207*** (2.63)	0.242*** (2.96)
<i>BETA</i>		0.077*** (2.81)	0.091*** (3.30)	0.081*** (2.66)
<i>PE</i>		0.005 (0.67)	0.005 (0.68)	0.005 (0.72)
<i>News</i>		−0.019*** (−2.64)	−0.021*** (−2.83)	−0.023*** (−2.93)
<i>EarningMgt</i>		−0.102 (−0.60)	−0.100 (−0.59)	−0.096 (−0.55)
<i>First</i>		−0.276 (−1.27)	−0.280 (−1.29)	−0.370 (−1.61)
<i>Independence</i>		−0.06 (−0.22)	−0.043 (−0.15)	0.023 (0.08)
Firm	Control	Control	Control	Control
Year	Control	Control	Control	Control
R ²	0.412	0.040	0.043	0.052
Observations	4475	4475	4475	3876

that have changed status within 6 months are removed from the sample. Then, the DID analysis is repeated. The results show that after adjusting the sample, the coefficient of *Shock* is still negative and significant in each column, consistent with the previous DID analysis results and ensuring the robustness of the conclusion.

4.2. Endogenous problem processing: PSM-DID

As for the selection rules of the refinancing pilot, according to the refinancing business rules of China Securities Finance Co., Ltd. (trial) published as early as August 2012, CSFC can adjust the firms included in the refinancing securities pilot program under some circumstances, such as price fluctuation, change of operations or management status, and merger or acquisition.² On February 28, 2013, when refinancing was officially announced, the characteristics of the 90 pilot firms were not mentioned, but the underlying stocks were of higher market value and good liquidity. On June 20, 2014, the pilot expansion announcement clearly pointed out that current market value and turnover were the main factors for selection. Therefore, to avoid the possible influence of biased securities on our conclusion, we conduct propensity score matching (PSM) between the treatment and control groups and conduct further DID analysis.

First, we select variables, such as turnover and the logarithm of the circulation market value of securities, that would affect stocks in the short-sale refinancing pilot and other stocks in the industry at the same time. We run a probit model during each sample year to test whether a firm is in the treatment or control group. Then, the treatment and control groups are matched using calipers of 0.05 and 0.01 according to the propensity score neighbor matching method with replacement. Finally, the matched samples are analyzed to test the balance panel data hypothesis and the common supporting hypothesis. Panel A of Table 5 shows the difference between the control and experimental groups after PSM. After matching with calipers of 0.01 and 0.05, the mean difference of the paired variables between the control and experimental groups is not significant, indicating that PSM corrected the distribution deviation of the two groups' sample values, and the values of the paired variable of the two groups were close to the same.

Columns (1) and (2) of Panel B in Table 5 report the regression results of the DID analysis on the matched sample. Column (1) reports a 1:1 match with a matched caliper of 0.05, and column (2) reports a 1:1 match with a matched caliper of 0.01. The coefficient of *Shock* is still negative and significant in columns (1) and (2), which is consistent with the regression results with the full sample. In conclusion, the results of PSM-DID analysis show that short selling can improve the speed of price adjustment to negative information. By accelerating the price sensitivity to bad news in the market, negative news can be timely reflected in stock prices, which is conducive to improving the pricing efficiency of the capital market. Therefore, the hypothesis is valid.

4.3. Parallel trend test

That the treatment and control groups have a parallel trend before short selling is an important prerequisite for using the DID model. Only when there is no significant difference between the treatment and control groups before the experiment can the treatment effect of short selling with the DID model be true. To ensure the robustness of the DID regression results, we refer to the studies of Chen and Ma (2017), Ni and Zhu (2017), the following regression model for a parallel trend test:

$$pdiff_{i,t} = a + bPOST(-2) + cPOST(-1) + dPOST(0,1) + ePOST(2,3) + control_{i,t} + \varepsilon_{i,t} \quad (3)$$

The dummy variables are set according to the periods in which short-sale refinancing is allowed. Two years before short-sale refinancing is allowed for a security, *POST*(-2) is 1; otherwise, it is 0. The year before

² Article 18 of the refinancing business rules of China Securities Finance Co., Ltd. (trial) states, "The company shall, according to the relevant management rules and market conditions of the underlying securities, reasonably determine the list of the underlying securities and publish it before the opening of each trading day." Article 19 states, "The company may adjust the list of underlying securities in the following circumstances: (1) abnormal fluctuation of price of the underlying securities happens; (2) there are major changes in the operation and management of the listed company corresponding to the underlying securities; (3) merger, acquisition or material assets reorganization of the listed company corresponding to the underlying securities happens; (4) the underlying securities of margin lending and short selling are temporarily adjusted by the stock exchange; (v) other circumstances that the company needs to be adjusted necessarily."

Table 5
Analysis of PSM-DID and parallel trend test.

Panel A: T-test of matched variables						
Caliper	Paired variable	Control group number	Mean	Treatment group number	Mean	Difference of mean
0.01	Circulation Market Value	63	16.347	63	16.342	0.005
	Turnover		18.187		19.212	−1.026
0.05	Circulation Market Value	71	16.443	71	16.394	0.049
	Turnover		16.737		19.148	−2.411
Panel B:Analysis of PSM+DID and parallel trend test						
Variable	(1) Caliper is 0.05 $\rho diff$	(2) Caliper is 0.01 $\rho diff$	(3) Parallel Trend Test $\rho diff$			
$Post(-2)$			0.034 (1.28)			
$Post(-1)$			−0.024 (−0.56)			
$Post(0,1)$			−0.091** (−2.35)			
$Post(2,3)$			−0.086** (−2.28)			
$Shock$	−0.207** (−2.11)	−0.193* (−1.81)				
$Control\ Variables$	Control	Control	Control			
Year	Control	Control	Control			
Firm	Control	Control	Control			
R ²	0.098	0.082	0.041			
Observations	431	380	4475			

refinancing is allowed, *POST*(–1) is 1, otherwise 0. The year a stock becomes eligible for refinancing and the year after, *POST*(0,1) takes 1, otherwise 0. *POST*(2,3) is 1 when a pilot security is within two to three years after refinancing is allowed, otherwise 0. The coefficients of *b*, *c*, *d* and *e* in the model are the main regression coefficients. The regression results of the parallel trend test are listed in column (3) of Panel B in Table 5. The results show that the coefficients *b* and *c* are not significant, indicating that the parallel trend hypothesis of the DID method is valid. Compared with the control group, the price sensitivity to bad news of firms in the treatment group did not improve before they became a pilot firm for short selling. However, *d* and *e* are negative and significant, indicating that, compared with the control group, price sensitivity to bad news improved after firms in the experimental group became pilot firms for short-sale refinancing and their stock prices could absorb negative news more effectively and reduce the degree of information asymmetry.

5. Additional analysis

5.1. The influence of information transparency on the short-sale refinancing effect

We find that short selling accelerates the speed of stock price adjustment to negative news, indicating that short sellers may mine the negative news of listed companies, thus accelerating the transmission of such news. If this is true, then for firms in the sample with low information transparency, short sellers are more likely to mine negative news, leading to faster stock price adjustment to negative news. Based on this, we refer to the study of Xin et al. (2014) and measure the information transparency of enterprises using the absolute level of earnings management and accuracy of analyst earnings forecasts (Wang et al., 2015) and then explore the role of information transparency in the effect of short-sale refinancing. Higher levels of earnings management may indicate that companies want to hide negative news, leading to less transparency. Higher earnings forecasting accuracy alleviates the degree of information opacity.

Table 6 reports the main analysis results. Columns (1) and (2) report the results after dividing the sample according to the median of absolute value of earnings management. The coefficient of *Shock* is negative and

Table 6
The influence of information transparency on the short-sale refinancing effect.

Variables	(1) ρ_{diff}	(2) ρ_{diff}	(3) ρ_{diff}	(4) ρ_{diff}
	Earnings management		Accuracy of analyst earnings forecast	
	LOW	HIGH	HIGH	LOW
<i>Shock</i>	−0.066 (−1.21)	−0.090* (−1.65)	0.002 (0.04)	−0.178*** (−2.83)
<i>Control Variables</i>	Control	Control	Control	Control
Year	Control	Control	Control	Control
Firm	Control	Control	Control	Control
R ²	0.038	0.053	0.079	0.076
Observations	2226	2249	1797	17,96 ¹

¹ Table 6 (3) and (4) show a difference in the number of observations from the main regression sample due to the exclusion of samples with missing accuracy of analyst earnings forecast.

significant at the 10% level when earnings management is higher, indicating that the greater the earnings management, the greater the information opacity, so price discovery is faster. Columns (3) and (4) report the results after dividing the sample according to the median of analyst forecast accuracy. The coefficient of *Shock* is negative and significant at the 1% level when analyst earnings forecast accuracy is poor, which shows that the worse the analyst earnings forecast accuracy, the greater the information opacity, so price discovery is faster. In conclusion, the results in Table 6 show that the greater the information opacity, the more likely short sellers are to dig for negative news and thus accelerate the speed of price adjustment to negative news.

5.2. The influence of ownership structure on the short-sale refinancing effect

Under different ownership structures, the severity of the agency problem and hiding of negative news by managers may differ, which may affect the short-sale refinancing effect. Based on this, we explore the influence of short-sale refinancing on the speed of stock price adjustment to negative news from the perspective of ownership structure. The shareholding structure of listed companies in China is relatively concentrated, and companies are at risk of being invaded by controlling shareholders (Stulz, 2005). Major shareholders may grab resources from listed companies by hiding negative news, which will lead to short sellers digging for negative news and a stronger short selling effect. In addition, the higher the ratio of institutional shareholders, the more supervision management receives from institutional investors, and the smaller the agency problem with shareholders will be (Du and Xiu, 2009). Management may have little motivation to hide bad news, so the effect of short-sale refinancing will be smaller. Therefore, the shareholding ratio of the largest shareholder is used to measure the degree of ownership concentration and the shareholding ratio of institutional investors is used to measure the degree of supervision of firm management to explore the influence of short-sale refinancing on the speed of stock price adjustment to negative news under different ownership structures.

Table 7
The Influence of ownership structure on the short-sale refinancing effect.

Variable	(1) ρ_{diff}	(2) ρ_{diff}	(3) ρ_{diff}	(4) ρ_{diff}
	Largest shareholder		Institutional investors	
	LOW	HIGH	LOW	HIGH
<i>Shock</i>	−0.062 (−1.20)	−0.082* (−1.72)	−0.115** (−2.12)	−0.039 (−0.73)
<i>Control variable</i>	Control	Control	Control	Control
Year	Control	Control	Control	Control
Firm	Control	Control	Control	Control
R ²	0.037	0.058	0.053	0.061
Observations	2236	2239	2234	2241

Table 7, columns (1) and (2) report the results after grouping by the largest shareholder ratio as a measure of ownership concentration, and it shows that in the group with higher ownership concentration, the coefficient of *Shock* is negative and significant at the 10% level, indicating that the higher the ownership concentration, the greater the information opacity. Therefore, short-sale refinancing is likely to accelerate the speed of stock price adjustment to negative news. Columns (3) and (4) report the results of the groups divided by the median shareholding ratio of institutional investors, and show that short-sale refinancing has a more obvious effect on the speed of stock price adjustment to negative news in companies with a low shareholding ratio of institutional investors. The results show that short-sale refinancing's effect varies across ownership structures. When ownership concentration is high or the proportion of institutional investors is low, the corporate governance mechanism is poor and short-sale refinancing's effect appears to be concentrated, reducing noise trading and increasing the speed of stock price adjustment to negative news.

5.3. Economic consequences: Short-sale refinancing and crash risk

Short sellers' search for bad news accelerates the rate at which stock prices adjust to negative news, potentially leading to a higher crash risk. Therefore, we introduce crash risk to explore the economic consequences of short selling. We use Chen et al. (2001) as a reference to measure the crash risk with two indicators, namely, the negative skew of stock returns of (NCSKEW) and the difference between the volatility of rising and falling stock prices (DUVOL). Following Chen et al. (2001), Chu and Fang (2016) and Jiang et al. (2015), the control variables are *RET*, annual stock return rate; *SIGMA*, the standard deviation of a stock's weekly return; *Size*, the natural logarithm of total assets; *Leverage*, the ratio of total liabilities to total assets; *MB*, market-to-book value; *ROA*, ratio of net profit to total assets; *EarningMgt*, earnings management level and *MHOLD*, management shareholding ratio. Table 8 shows the regression results of short selling on stock price crash risk. It shows that the coefficient of *Shock* is significantly positive at the 1% and 5% levels, indicating that stock price crash risk significantly increases due to short selling transactions.

Table 8
Short-sale refinancing and crash risk.

Variable	(1) NCSKEW	(2) DUVOL
<i>Shock</i>	0.111*** (2.82)	0.064** (2.10)
<i>RET</i>	−12.566*** (−6.52)	−10.102*** (−6.77)
<i>SIGMA</i>	−1.106 (−1.27)	−0.572 (−0.85)
<i>Size</i>	−0.075* (−1.65)	−0.073** (−2.08)
<i>Leverage</i>	0.109 (0.63)	0.076 (0.57)
<i>MB</i>	0.035*** (3.26)	0.016* (1.92)
<i>EarningMgt</i>	0.177 (0.92)	0.018 (0.12)
<i>ROA</i>	0.057 (0.15)	−0.080 (−0.26)
<i>MHOLD</i>	3.231* (1.75)	2.764* (1.94)
Year	Control	Control
Firm	Control	Control
R ²	0.073	0.083
Observations	42,70 ¹	4270

¹ The decrease in sample size is caused by the absence of the stock price crash variable.

Chu and Fang (2016) use short selling volume to measure short selling and show that short selling can reduce stock price crash risk to a certain extent. However, short sellers choose companies with more concentrated bad news to trade, so there may be some sample selection bias in this conclusion. Bris et al. (2007) find that the market's negative bias rate increases after the deregulation of short selling, which indicates that stock price crash risk may increase after deregulation of short selling. Callen and Fang (2015) reach similar conclusions. We also find that the relaxation of short selling restrictions in China leads to crash risk. China allowed short selling late and as a result, investors are mainly individuals, and among institutional investors herd behavior is significant (Xu et al., 2013). Immature investors may engage in excessive short selling with overconfidence in private information or engage in short selling due to an excessively pessimistic mood, eventually leading to share prices falling and increasing crashes (Scheinkman and Xiong, 2003).

6. Conclusion

Short selling allows investors holding negative news to trade in a timely manner, thus accelerating the speed of stock price adjustment to negative news (Bris et al., 2007). However, inconsistent conclusions have been drawn regarding this effect in China. Short-sale refinancing, launched in February 2013, expanded the sources of securities available for borrowing and facilitated short selling. In the early pilot period, securities financial companies selected only some stocks as pilots. The pilot and non-pilot short selling firms are our treatment and control groups, respectively. To a certain extent, this minimizes the differences between the treatment and control groups in terms of liquidity, volatility and turnover, and provides an opportunity to investigate the economic consequences of short selling.

Based on this, we use the DID method to explore the influence of Chinese short selling on the speed of price adjustment to negative information. We find that short selling is conducive to the timely and effective reflection of negative news in stock prices. Through short selling, stock prices can quickly adjust and react to negative news in the market to accelerate the speed of price adjustment to negative information, reduce stock price delay and improve pricing efficiency. In addition, investors are more likely to conduct short selling by mining bad news in an environment with less information transparency. Short-sale refinancing has different effects under different firm ownership structures. In addition, short selling is more likely to encourage short sellers to dig for negative news, ultimately raising crash risk. The results will help short sellers play their market role and improve pricing efficiency.

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